Unofficial Translation

For Reference Use Only

The People's Republic of China
First Biennial Transparency Report on Climate Change

December 2024

Foreword

Climate change is a common challenge facing all humanity. The government of the People's Republic of China (hereinafter referred to as "China") attaches great importance to addressing climate change, adheres to the principles of equity, common but differentiated responsibilities and respective capabilities (CBDR–RC), firmly upholds multilateralism, and facilitates the joint implementation of the *United Nations Framework Convention on Climate Change* (hereinafter referred to as the "UNFCCC") and its *Paris Agreement*. The Chinese Government has submitted four National Communications (NCs) and three Biennial Update Reports (BURs), comprehensively reporting on China's actions, progress, and achievements in implementing the objectives of the UNFCCC.

Under the UNFCCC, its Paris Agreement further established an Enhanced Transparency Framework (ETF), requiring Parties to submit Biennial Transparency Reports (BTRs) every two years, building upon existing work under the UNFCCC. According to Decision 18/CMA.1, Parties are required to submit their first Biennial Transparency Report no later than the end of 2024. As a developing country, China initiated the GEF project application process in 2020 and began preparing the People's Republic of China First Biennial Transparency Report on Climate Change (hereinafter referred to as the "1BTR") in 2022. The preparation and submission of the 1BTR has received support from GEF's "Enabling China to Prepare Its Fourth National Communication, and Biennial Update Reports on Climate Change" and "Enabling China to Prepare Its First Biennial Transparency Reports on Climate Change under UNFCCC" Capacity Building Projects, and “China Capacity Building for Enhanced Transparency Phase I” Project under Capacity-Building Initiative for Transparency (CBIT).

This report fully complies with the requirements of the Modalities, Procedures and Guidelines (MPGs) for the ETF and Common Reporting Tables under the Paris Agreement. It comprehensively reports on China's actions and progress in achieving the objectives of the UNFCCC and its Paris Agreement, including chapters on National Greenhouse Gas (GHG) Inventory, Progress in Nationally Determined Contribution, Climate Change Impacts and Adaptation, Support Needed and Received, Information of Hong Kong Special Administrative Region (hereinafter referred to as "HKSAR") on Climate Change, and Information of Macao Special Administrative Region (hereinafter referred to as "MSAR") on Climate Change.

The preparation of this report was led by the Ministry of Ecology and Environment (MEE) and jointly complied by relevant departments. The information of HKSAR and MSAR on climate change in this report was provided by Environmental Protection Department (EPD) of the HKSAR Government and Macao Meteorological and Geophysical Bureau (DSMG) of the MSAR Government, respectively. After being approved by the State Council, the report was officially submitted to the UNFCCC Secretariat. China will, as always, join hands with all parties to address climate change and make concerted efforts to protect the common home of mankind.

Contents

Part I National GHG Inventory

The National GHG Inventory for 2020-2021 includes emissions and removals of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) from five categories: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste. According to the implementation rules of the Paris Agreement, starting from 2024, the National GHG Inventories submitted by Parties should be prepared with reference to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories [1](hereinafter referred to as the "2006 IPCC Guidelines") and the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (hereinafter referred to as the "2013 IPCC Wetlands Supplement"), and reported using the 100-year time-horizon GWP values from the IPCC Fifth Assessment Report (AR5). The inventory for the base year (2005 for China) of Nationally Determined Contribution (NDC) was updated using the same methodology and data sources as those for 2020-2021. The current inventory was prepared in accordance with the above requirements. Activity data were mainly sourced from official statistics, and the emission factors were primarily based on country-specific parameters.

Chapter 1 Institutional Arrangements

The Chinese government attaches great importance to the compilation of the National GHG Inventory (hereinafter referred to as the "National Inventory"), establishing a working model where the Ministry of Ecology and Environment (MEE), as the national lead authority for climate change, coordinates with the National Bureau of Statistics (NBS) and other relevant government departments and industry associations, while multiple research institutions carry out the specific compilation work.

MEE is mainly responsible for organizing and coordinating inventory-related work. Funded with international grants, MEE established a dedicated Project Management Office (hereinafter referred to as "PMO"), which selects the responsible organizations for inventories on each sector through an open bidding process. The lead and main participating organizations for inventory compilation in each category is shown in Table 1-1. After the completion of category -specific inventories, the National Center for Climate Change Strategy and International Cooperation (NCSC) will take the lead in preparing and compiling a synthesis inventory. Following expert review and departmental consultation, this inventory will be submitted to the State Council as a key component of the report. Upon approval by the State Council, it will be submitted to the UNFCCC Secretariat. See Figure 1-1 and Figure 1-2 for details on the institutional arrangements and timeline of the inventory compilation.

[1] IPCC: Intergovernmental Panel on Climate Change

Table 1-1 National Inventory Compilation Organizations

Sector	Lead and main participating organizations
Energy	NCSC; Energy Research Institute (ERI), National Development and Reform Commission (NDRC); Institute of Energy, Environment, and Economy (3E), Tsinghua University (TSU); China Building Materials Federation (CBMF); China Nonferrous Metals Industry Association (CNIA); China National Petroleum Corporation (CNPC); Sinopec Group; China National Offshore Oil Corporation (CNOOC); Shaanxi Yanchang Petroleum (Group) Co., Ltd. (YCPC); and PipeChina, etc.
IPPU	TSU-3E; Foreign Environmental Cooperation Center (FECO), MEE; College of Electromechanical Engineering, Qingdao University of Science and Technology; CBMF; China Petroleum and Chemical Industry Federation (CPCIF) and CNIA, etc.
Agriculture	Institute of Environment and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agricultural Sciences (CAAS); Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS); National Animal Husbandry Services; Animal Husbandry Technology Extension Stations in major farming provinces; China Agricultural University (CAU); Henan Agricultural University; Inner Mongolia Agricultural University (IMAU); Rural Energy and Environment Agency, Ministry of Agriculture and Rural Affairs (MARA); Satellite Application Center for Ecology and Environment, MEE; and Institute of Agricultural Resources and Regional Planning, CAAS, etc.
LULUCF	Ecology and Nature Conservation Institute, Chinese Academy of Forestry (CAF); Land Consolidation and Rehabilitation Center, Ministry of Natural Resources (MNR); China Institute for Geo-Environmental Monitoring; CAS-IAP; CAAS-IEDA; Institute of Ecological Conservation and Restoration, CAF; Research Institute of Forestry, CAF; and Academy of Inventory and Planning, National Forestry and Grassland Administration (NFGA), etc.
Waste	Chinese Research Academy of Environmental Sciences (CRAES); Research Center for Eco-Environmental Sciences (RCEES), CAS; China Association of Urban Environmental Sanitation (CAUES); Environmental and Sanitation Engineering Center (ESEC) under the Ministry of Housing and Urban-Rural Development (MOHURD); China Urban Construction Design & Research Institute Co., Ltd. (CUCD); Satellite Application Center for Ecology and Environment, MEE; China National Environmental Monitoring Centre (CNEMC); Institute of Urban Environment (IUE), CAS; Guangzhou Institute of Energy Conversion (GIEC), CAS; Institute of Process Engineering (IPE), CAS; Institute of Rock and Soil Mechanics (IRSM), CAS; TSU; Renmin University of China (RUC); Beijing Normal University (BNU); China Everbright Environment Group Limited; and Beijing Enterprises Water Group Limited (BEWG), etc.

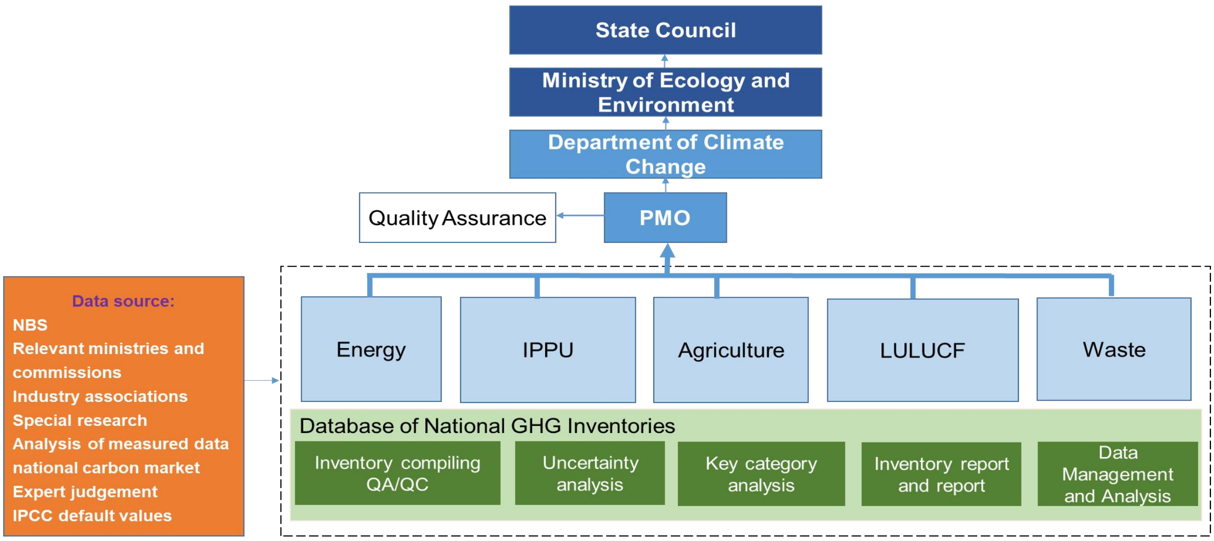


Figure 1-1 Institutional Arrangements for Inventory compilation

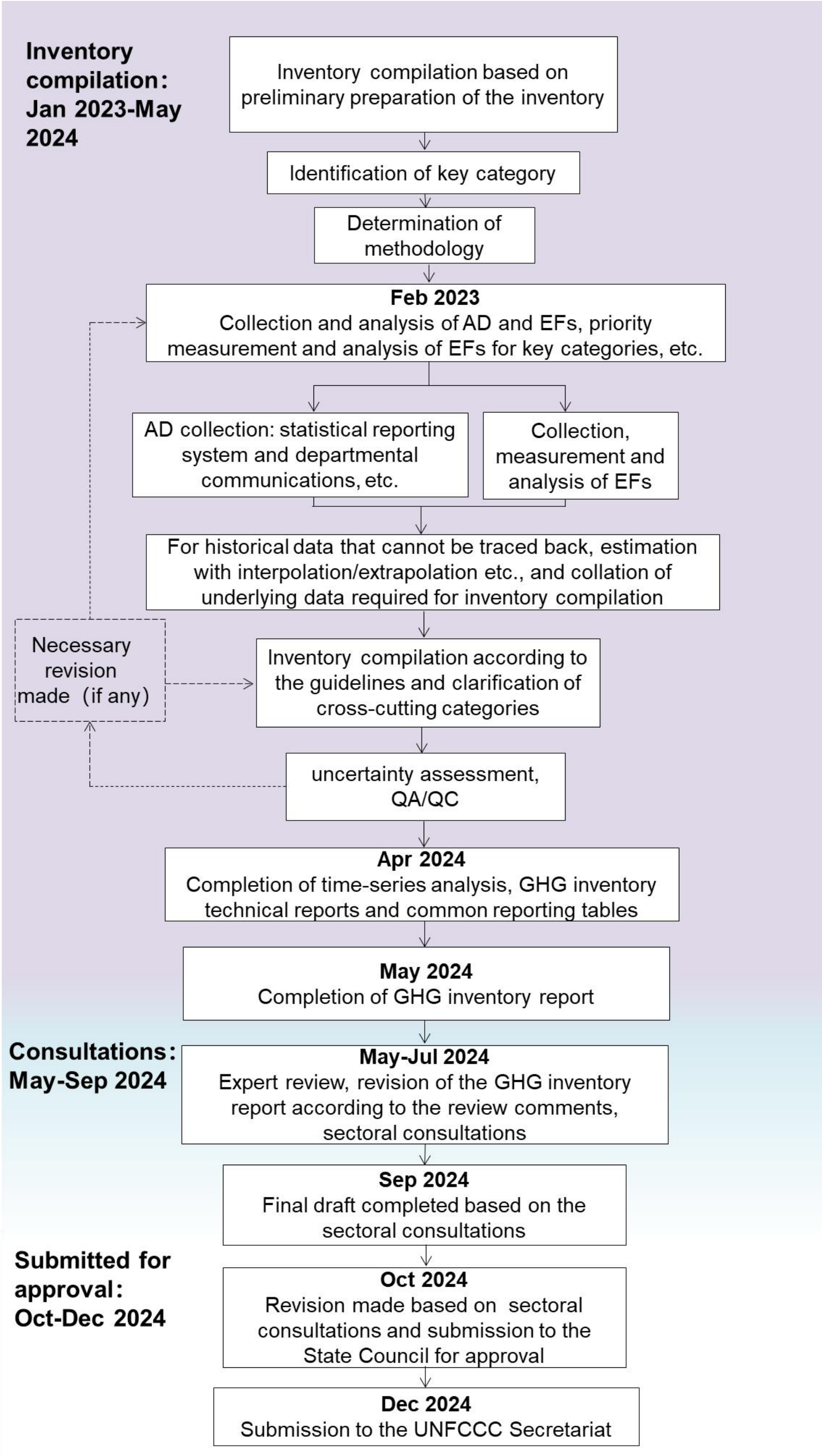


Figure 1-2 Timeline of inventory compilation

To improve the accuracy of inventory compilation, the inventory team compiled the inventory based on key category analysis results, with key categories preferably using higher-tier methods and country-specific emission factors.

Activity data were primarily from relevant government departments and organizations including NBS, National Energy Administration (NEA), MARA, MNR, NFGA, Civil Aviation Administration of China (CAAC), and China State Railway Group Co., Ltd.. To establish a regular data collection mechanism, China issued the *Notice on Carrying Out Statistical Work for Climate Change* in 2013, and developed the *Statistical Reporting System for Climate Change by Sectors (Trial)* and the *Form of Statistical Data Requirements for Climate Change in the Integrated Government Statistical System*. As the inventory compilation process evolves, the required underlying statistics also change. The statistical reporting system for climate change was revised in 2020.

Emission factors were primarily obtained through special research, statistics, and test analyses conducted by the inventory team and other relevant organizations. For non-key categories, default emission factors from guidelines were used. With the steady progress of the national carbon market, there has been a gradual increase in facility-level measured data from industries such as thermal power and improvement in data quality. Drawing from international experience, enterprise-level data are gradually being applied to inventory compiling and related quality assurance and quality control processes.

China emphasizes the management of data documentation during the inventory compilation process, promptly preserving supporting materials. Meanwhile, inventory is electronically managed and archived in the database system of national GHG inventories.

Quality control (QC) is carried out throughout the entire inventory compilation process by different members of the inventory team, covering aspects such as methodology determination, activity data, emission factors, inventory calculation and uncertainty assessment, and inventory reporting. This includes trend analysis, completeness checks, data entry error and unit conversion checks, and archiving. Quality assurance (QA) includes independent analysis and review by personnel not directly involved in the inventory compilation process, providing strong support for ensuring the quality of inventory results. In addition, opinions and suggestions from other domestic research institutions and experts are extensively sought through technical seminars and other forms.

During the current inventory compilation process, due to limitations in underlying data statistics and other issues, the following sources/sinks were not included: CO_2 transport and storage; uncontrolled combustion and burning coal dumps; other process uses of carbonates; emissions from agricultural soils due to application of lime and dolomite, etc.; N_2O emissions from wetlands; and nitrogen trifluoride (NF_3) emissions.

Chapter 2 National GHG Emissions and Removals

I. Key Category Analysis

According to the 2006 IPCC Guidelines, Approach 1 level and trend assessment were used to identify key categories in the 2020-2021 inventory. The results show that there were 76 key categories in the 2020-2021 inventory, with detailed information on key categories shown in Table 1-2.

Table 1-2a Key Category Analysis Results of Inventories from 2005 to 2021*

No.	Category	Category	GHGs	Key Category or not (with LULUCF)			Key Category or not (without LULUCF)		
				Level assessment		Trend assessment	Level assessment		Trend assessment
				2005	2021	2005-2021	2005	2021	2005-2021
1	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	CO_2	√	√	√	√	√	√
2	Energy	1.A.1.b-Fuel combustion - petroleum refining - solid fuels	CO_2	√	√	√	√	√	√
3	Energy	1.A.1.c-Fuel combustion - manufacture of solid fuels and other energy industries - solid fuels	CO_2	√	√	√	√	√	√
4	Energy	1.A.2.a-Fuel combustion - iron and steel - solid fuels	CO_2	√	√	√	√	√	
5	Energy	1.A.2.b-Fuel combustion - non-ferrous metals - solid fuels	CO_2	√	√	√	√	√	√
6	Energy	1.A.2.c-Fuel combustion - chemicals - solid fuels	CO_2	√	√	√	√	√	√
7	Energy	1.A.2.d-Fuel combustion - pulp, paper and print - solid fuels	CO_2	√	√	√	√	√	√
8	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - solid fuels	CO_2	√	√	√	√	√	√
9	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - solid fuels	CO_2	√	√	√	√	√	√
10	Energy	1.A.2.g-Fuel combustion - manufacturing of transport equipment - solid fuels	CO_2			√			√
11	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - solid fuels	CO_2	√		√	√		√
12	Energy	1.A.2.i-Fuel combustion - mining (excluding fuels) and quarrying - solid fuels	CO_2	√		√	√		√
13	Energy	1.A.2.j-Fuel combustion - wood and wood products - solid fuels	CO_2			√			√
14	Energy	1.A.2.l-Fuel combustion - textile and leather - solid fuels	CO_2	√		√	√		√
15	Energy	1.A.2.m-Fuel combustion - other industries - solid fuels	CO_2	√		√	√		√
16	Energy	1.A.4.a-Fuel combustion -commercial/institutional - solid fuels	CO_2	√	√	√	√	√	√
17	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CO_2	√	√	√	√	√	√
18	Energy	1.A.4.c -Fuel combustion -agriculture/forestry/fishing - solid fuels	CO_2	√	√	√	√	√	√
19	Energy	1.A.1.a-Fuel combustion - public electricity and heat production - liquid fuels	CO_2	√		√	√		√
20	Energy	1.A.1.b-Fuel combustion - petroleum refining - liquid fuels	CO_2	√	√	√	√	√	√
21	Energy	1.A.1.c-Fuel combustion - manufacture of solid fuels and other energy industries - liquid fuels	CO_2	√		√	√		√

No.	Category	Category	GHGs	Key Category or not (with LULUCF)			Key Category or not (without LULUCF)		
				Level assessment		Trend assessment	Level assessment		Trend assessment
				2005	2021	2005-2021	2005	2021	2005-2021
22	Energy	1.A.2.c-Fuel combustion - chemicals - liquid fuels	CO_2	√	√	√	√	√	√
23	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - liquid fuels	CO_2	√	√	√	√	√	√
24	Energy	1.A.2.k -Fuel combustion -construction - liquid fuels	CO_2	√		√	√		√
25	Energy	1.A.3.a Fuel combustion -domestic aviation - liquid fuels	CO_2		√	√		√	√
26	Energy	1.A.3.b-Fuel combustion - road transportation - liquid fuels	CO_2	√	√	√	√	√	√
27	Energy	1.A.3.c -Fuel combustion - railway - liquid fuels	CO_2			√			√
28	Energy	1.A.3.d-Fuel combustion -Domestic Navigation - liquid fuels	CO_2	√	√		√	√	
29	Energy	1.A.4.a-Fuel combustion - commercial/institutional - liquid fuels	CO_2		√	√		√	√
30	Energy	1.A.4.b-Fuel combustion - residential - liquid fuels	CO_2	√	√	√	√	√	√
31	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - liquid fuels	CO_2	√	√		√	√	
32	Energy	1.A.1.a -Fuel combustion -public electricity and heat production - gaseous fuels	CO_2		√	√		√	√
33	Energy	1.A.1.b-Fuel combustion - petroleum refining - gaseous fuels	CO_2			√			√
34	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - gaseous fuels	CO_2		√			√	
35	Energy	1.A.2.a-Fuel combustion - iron and steel - gaseous fuels	CO_2			√			√
36	Energy	1.A.2.c-Fuel combustion - chemicals - gaseous fuels	CO_2		√	√		√	√
37	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - gaseous fuels	CO_2						√
38	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - gaseous fuels	CO_2		√	√		√	√
39	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - gaseous fuels	CO_2		√	√		√	√
40	Energy	1.A.2.l-Fuel combustion - textile and leather - gaseous fuels	CO_2						√
41	Energy	1.A.3.b-Fuel combustion - road transportation - gaseous fuels	CO_2		√	√		√	√
42	Energy	1.A.4.b-Fuel combustion - residential - gaseous fuels	CO_2		√	√		√	√
43	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CH_4	√		√			√

No.	Category	Category	GHGs	Key Category or not (with LULUCF)			Key Category or not (without LULUCF)		
				Level assessment		Trend assessment	Level assessment		Trend assessment
				2005	2021	2005-2021	2005	2021	2005-2021
44	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	N_2O	√	√	√	√	√	√
45	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - municipal solid waste (MSW)	CO_2			√			√
46	Energy	1.A.4.b-Fuel combustion - residential - biomass	CH_4	√		√	√		√
47	Energy	1.A.4.b-Fuel combustion - residential - biomass	N_2O			√			√
48	Energy	1.B.1.a.i-Solid fuels - underground mines (excl. recovered)	CH_4	√	√	√	√	√	√
49	Energy	1.B.1.a.ii-Solid fuels - surface mines	CH_4			√			√
50	Energy	1.B.2.b-Fugitive emissions from oil and natural gas systems - natural gas	CH_4			√			√
51	IPPU	2.A.1-Mineral industry - cement production	CO_2	√	√	√	√	√	√
52	IPPU	2.A.2-Mineral industry - lime production	CO_2	√	√		√	√	
53	IPPU	2.B.1-Chemical industry - ammonia production	CO_2	√	√	√	√	√	√
54	IPPU	2.B.3-Chemical industry - adipic acid production	N_2O		√	√		√	√
55	IPPU	2.B.8.a-Chemical industry - methanol production	CO_2		√	√		√	√
56	IPPU	2.B.8.b-Chemical industry -ethylene production	CO_2		√	√		√	√
57	IPPU	2.B.9-Chemical industry - fluorochemical production	HFCs	√		√	√		√
58	IPPU	2.C.1-Metal industry - iron and steel production	CO_2	√	√	√	√	√	√
59	IPPU	2.C.2-Metal industry - ferroalloys production	CO_2	√	√		√	√	
60	IPPU	2.C.3-Metal industry - aluminium production	CO_2		√	√		√	√
61	IPPU	2.F-Product uses as substitutes for ozone depleting substances	HFCs		√	√		√	√
62	IPPU	2.G.1-Other product manufacture and use	SF_6		√	√		√	√
63	Agriculture	3.A-Enteric fermentation	CH_4	√	√	√	√	√	√
64	Agriculture	3.B-Manure management	CH_4	√	√		√	√	
65	Agriculture	3.B-Manure management	N_2O	√	√	√	√	√	√

No.	Category	Category	GHGs	Key Category or not (with LULUCF)			Key Category or not (without LULUCF)		
				Level assessment		Trend assessment	Level assessment		Trend assessment
				2005	2021	2005-2021	2005	2021	2005-2021
66	Agriculture	3.C-Rice cultivation	CH_4	√	√	√	√	√	√
67	Agriculture	3.D-Agricultural soils	N_2O	√	√	√	√	√	√
68	LULUCF	4.A.1-Forest land - forest land remaining forest land	CO_2	√	√	√			
69	LULUCF	4.A.2-Forest land-land converted to forest land	CO_2	√	√	√			
70	LULUCF	4.B.1-Cropland-cropland remaining cropland	CO_2	√	√	√			
71	LULUCF	4.C.1-Grassland -Grassland remaining grassland	CO_2	√	√	√			
72	LULUCF	4.G-Harvested wood products	CO_2	√	√	√			
73	LULUCF	4.H-Other biomass	CO_2		√	√			
74	Waste	5.A-Solid waste disposal	CH_4	√	√	√	√	√	√
75	Waste	5.D-Wastewater treatment and discharge	CH_4	√	√	√	√	√	√
76	Waste	5.D-Wastewater treatment and discharge	N_2O	√			√		√

Note: 1) Based on key category analysis, this table lists key categories for level or trend assessment according to the 95% threshold. Non-key categories are not included in this table.
2) Shaded cells do not require entries.

Table 1-2b Results of the Level Analysis of Key Categories in the 2021 Inventory (with LULUCF)

No.	Category	Category	GHGs	Level assessment	Accumulative contribution in level assessment
1	Energy	1.A.1.a -Fuel combustion -public electricity and heat production - solid fuels	CO_2	27.8%	27.8%
2	Energy	1.A.2.a-Fuel combustion - iron and steel - solid fuels	CO_2	9.5%	37.3%
3	IPPU	2.A.1-Mineral industry - cement production	CO_2	5.1%	42.4%
4	Energy	1.A.3.b-Fuel combustion - road transportation - liquid fuels	CO_2	4.9%	47.3%
5	Energy	1.B.1.a.i-Solid fuels - underground mines (excl. recovered)	CH_4	4.2%	51.5%
6	LULUCF	4.A.1-Forest land - Forest land remaining forest land	CO_2	3.5%	55.0%
7	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - solid fuels	CO_2	2.9%	57.9%
8	Energy	1.A.1.b-Fuel combustion - petroleum refining - liquid fuels	CO_2	2.3%	60.2%
9	LULUCF	4.A.2-Forest land-land converted to forest land	CO_2	2.1%	62.3%
10	Agriculture	3.A-Enteric fermentation	CH_4	2.1%	64.3%
11	IPPU	2.F-Product uses as substitutes for ozone depleting substances	HFCs	2.0%	66.3%
12	Energy	1.A.2.c-Fuel combustion - chemicals - solid fuels	CO_2	1.9%	68.2%
13	Energy	1.A.2.b-Fuel combustion - non-ferrous metals - solid fuels	CO_2	1.9%	70.0%
14	Agriculture	3.C-Rice cultivation	CH_4	1.6%	71.6%
15	Agriculture	3.D-Agricultural soils	N_2O	1.2%	72.8%
16	IPPU	2.A.2-Mineral industry - lime production	CO_2	1.2%	74.0%
17	LULUCF	4.H-Other biomass	CO_2	1.1%	75.1%
18	Energy	1.A.1.b-Fuel combustion - petroleum refining - solid fuels	CO_2	1.1%	76.2%
19	IPPU	2.B.1-Chemical industry - ammonia production	CO_2	0.9%	77.1%
20	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - gaseous fuels	CO_2	0.9%	78.0%
21	Waste	5.A- Solid waste disposal	CH_4	0.8%	78.8%
22	Energy	1.A.4.b-Fuel combustion - residential - gaseous fuels	CO_2	0.8%	79.6%
23	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CO_2	0.8%	80.4%
24	IPPU	2.B.3-Chemical industry- adipic acid production	N_2O	0.8%	81.2%
25	IPPU	2.B.8.a-Chemical industry - methanol production	CO_2	0.8%	82.0%
26	Energy	1.A.1.c-Fuel combustion - Manufacture of solid fuels and other energy industries - solid fuels	CO_2	0.7%	82.7%
27	LULUCF	4.B.1-Cropland-cropland remaining cropland	CO_2	0.7%	83.4%
28	Agriculture	3.B-Manure management	CH_4	0.7%	84.1%
29	LULUCF	4.G-Harvested wood products	CO_2	0.7%	84.7%

No.	Category	Category	GHGs	Level assessment	Accumulative contribution in level assessment
30	IPPU	2.G.1-Other product manufacture and use	SF_6	0.6%	85.4%
31	Energy	1.A.2.c-Fuel combustion - chemicals - gaseous fuels	CO_2	0.6%	86.0%
32	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - liquid fuels	CO_2	0.6%	86.6%
33	Energy	1.A.4.b-Fuel combustion - residential - liquid fuels	CO_2	0.6%	87.1%
34	Energy	1.A.4. a-Fuel combustion -commercial/institutional - solid fuels	CO_2	0.5%	87.7%
35	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	N_2O	0.5%	88.2%
36	Energy	1.A.3.d-Fuel combustion -domestic navigation - liquid fuels	CO_2	0.5%	88.7%
37	Energy	1.A.3.b-Fuel combustion - road transportation - gaseous fuels	CO_2	0.4%	89.1%
38	Energy	1.A.3.a Fuel combustion - domestic aviation - liquid fuels	CO_2	0.4%	89.6%
39	IPPU	2.C.1-Metal industry - iron and steel production	CO_2	0.4%	90.0%
40	Energy	1.A.2.d-Fuel combustion - pulp, paper and print - solid fuels	CO_2	0.4%	90.4%
41	LULUCF	4.C.1-Grassland -grassland remaining grassland	CO_2	0.4%	90.8%
42	Waste	5.D-Wastewater treatment and discharge	CH_4	0.4%	91.2%
43	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - liquid fuels	CO_2	0.4%	91.6%
44	Agriculture	3.B-Manure management	N_2O	0.4%	92.0%
45	Energy	1.A.2.f-Fuel combustion -non-metallic minerals - gaseous fuels	CO_2	0.4%	92.4%
46	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - solid fuels	CO_2	0.4%	92.7%
47	IPPU	2.C.3-Metal industry - aluminium production	CO_2	0.3%	93.1%
48	Energy	1.A.2.c-Fuel combustion - chemicals - liquid fuels	CO_2	0.3%	93.4%
49	IPPU	2.C.2-Metal industry - ferroalloys production	CO_2	0.3%	93.8%
50	Energy	1.A.4. a-Fuel combustion - commercial/institutional - liquid fuels	CO_2	0.3%	94.1%
51	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - gaseous fuels	CO_2	0.3%	94.3%
52	IPPU	2.B.8.b-Chemical industry-ethylene production	CO_2	0.3%	94.6%
53	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - solid fuels	CO_2	0.2%	94.8%
54	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - gaseous fuels	CO_2	0.2%	95.0%

Table 1-2c Results of the Level Analysis of Key Categories in the 2021 Inventory (without LULUCF)

No.	Category	Category	GHGs	Level assessment	Accumulative contribution in level assessment
1	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	CO_2	30.5%	30.5%
2	Energy	1.A.2.a-Fuel combustion - iron and steel - solid fuels	CO_2	10.4%	40.9%
3	IPPU	2.A.1-Mineral industry - cement production	CO_2	5.6%	46.5%
4	Energy	1.A.3.b-Fuel combustion - road transportation - liquid fuels	CO_2	5.4%	51.9%
5	Energy	1.B.1.a.i-Solid fuels - underground mines (excl. recovered)	CH_4	4.7%	56.5%
6	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - solid fuels	CO_2	3.2%	59.7%
7	Energy	1.A.1.b-Fuel combustion - petroleum refining - liquid fuels	CO_2	2.5%	62.2%
8	Agriculture	3.A-Enteric fermentation	CH_4	2.3%	64.5%
9	IPPU	2.F-Product uses as substitutes for ozone depleting substances	HFCs	2.2%	66.6%
10	Energy	1.A.2.c-Fuel combustion – chemicals - solid fuels	CO_2	2.1%	68.7%
11	Energy	1.A.2.b-Fuel combustion - non-ferrous metals - solid fuels	CO_2	2.0%	70.7%
12	Agriculture	3.C-Rice cultivation	CH_4	1.7%	72.5%
13	Agriculture	3.D-Agricultural soils	N_2O	1.3%	73.8%
14	IPPU	2.A.2-Mineral industry - lime production	CO_2	1.3%	75.1%
15	Energy	1.A.1.b-Fuel combustion - petroleum refining - solid fuels	CO_2	1.2%	76.3%
16	IPPU	2.B.1-Chemical industry- ammonia production	CO_2	1.0%	77.3%
17	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - gaseous fuels	CO_2	1.0%	78.2%
18	Waste	5.A-Solid waste disposal	CH_4	0.9%	79.2%
19	Energy	1.A.4.b-Fuel combustion - residential - gaseous fuels	CO_2	0.9%	80.1%
20	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CO_2	0.9%	80.9%
21	IPPU	2.B.3-Chemical industry - adipic acid production	N_2O	0.8%	81.8%
22	IPPU	2.B.8.a-Chemical industry - methanol production	CO_2	0.8%	82.6%
23	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - solid fuels	CO_2	0.8%	83.4%
24	Agriculture	3.B-Manure management	CH_4	0.7%	84.1%
25	IPPU	2.G.1-Other product manufacture and use	SF_6	0.7%	84.9%
26	Energy	1.A.2.c-Fuel combustion - chemicals - gaseous fuels	CO_2	0.6%	85.5%
27	Energy	1.A.2.f-Fuel combustion -non-metallic minerals - liquid fuels	CO_2	0.6%	86.2%
28	Energy	1.A.4.b-Fuel combustion - residential - liquid fuels	CO_2	0.6%	86.8%
29	Energy	1.A.4. a-Fuel combustion - commercial/institutional - solid fuels	CO_2	0.6%	87.3%

No.	Category	Category	GHGs	Level assessment	Accumulative contribution in level assessment
30	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	N_2O	0.6%	87.9%
31	Energy	1.A.3.d-Fuel combustion -domestic navigation - liquid fuels	CO_2	0.5%	88.5%
32	Energy	1.A.3.b-Fuel combustion - road transportation - gaseous fuels	CO_2	0.5%	89.0%
33	Energy	1.A.3.a Fuel combustion -domestic aviation - liquid fuels	CO_2	0.5%	89.4%
34	IPPU	2.C.1-Metal industry - iron and steel production	CO_2	0.5%	89.9%
35	Energy	1.A.2.d-Fuel combustion - pulp, paper and print - solid fuels	CO_2	0.5%	90.4%
36	Waste	5.D-Wastewater treatment and discharge	CH_4	0.4%	90.8%
37	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - liquid fuels	CO_2	0.4%	91.2%
38	Agriculture	3.B-Manure management	N_2O	0.4%	91.7%
39	Energy	1.A.2.f-Fuel combustion -non-metallic minerals - gaseous fuels	CO_2	0.4%	92.1%
40	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - solid fuels	CO_2	0.4%	92.5%
41	IPPU	2.C.3-Metal industry - aluminium production	CO_2	0.4%	92.9%
42	Energy	1.A.2.c-Fuel combustion - chemicals - liquid fuels	CO_2	0.4%	93.2%
43	IPPU	2.C.2-Metal industry - ferroalloys production	CO_2	0.4%	93.6%
44	Energy	1.A.4. a-Fuel combustion - commercial/institutional - liquid fuels	CO_2	0.3%	93.9%
45	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - gaseous fuels	CO_2	0.3%	94.2%
46	IPPU	2.B.8.b-Chemical industry-ethylene production	CO_2	0.3%	94.5%
47	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - solid fuels	CO_2	0.3%	94.7%
48	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - gaseous fuels	CO_2	0.3%	95.0%

Table 1-2d Results of the Trend Analysis of Key Categories in Inventories from 2005 to 2021 (with LULUCF)

No.	Category	Category	GHGs	Trend assessment	Contribution in trend assessment	Accumulative contribution in trend assessment
1	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	CO_2	10.7%	13.2%	13.2%
2	LULUCF	4.A.1-Forest land - Forest land remaining forest land	CO_2	5.0%	6.2%	19.4%
3	Energy	1.A.2.f-Fuel combustion -non-metallic minerals - solid fuels	CO_2	4.8%	6.0%	25.4%
4	IPPU	2.F-Product uses as substitutes for ozone depleting substances	HFCs	3.3%	4.1%	29.5%
5	LULUCF	4.A.2-Forest land-land converted to forest land	CO_2	2.8%	3.5%	32.9%
6	Energy	1.A.2.c-Fuel combustion - chemicals - solid fuels	CO_2	2.7%	3.3%	36.2%
7	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CO_2	2.7%	3.3%	39.6%
8	Agriculture	3.A-Enteric fermentation	CH_4	2.3%	2.9%	42.4%
9	Energy	1.B.1.a.i-Solid fuels - underground mines (excl. recovered)	CH_4	2.0%	2.5%	44.9%
10	Energy	1.A.2.b-Fuel combustion - non-ferrous metals - solid fuels	CO_2	1.9%	2.4%	47.2%
11	LULUCF	4.H-Other biomass	CO_2	1.8%	2.2%	49.5%
12	IPPU	2.B.9-Chemical industry- fluorochemical production	HFCs	1.8%	2.2%	51.7%
13	Energy	1.A.4. a-Fuel combustion - commercial/institutional - solid fuels	CO_2	1.6%	1.9%	53.6%
14	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - gaseous fuels	CO_2	1.5%	1.8%	55.4%
15	Agriculture	3.D-Agricultural soils	N_2O	1.4%	1.7%	57.2%
16	Energy	1.A.2.l-Fuel combustion - textile and leather - solid fuels	CO_2	1.3%	1.6%	58.7%
17	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - solid fuels	CO_2	1.3%	1.6%	60.3%
18	Energy	1.A.3.b-Fuel combustion - road transportation - liquid fuels	CO_2	1.3%	1.6%	61.9%
19	Agriculture	3.C-Rice cultivation	CH_4	1.2%	1.5%	63.4%
20	IPPU	2.A.1-Mineral industry - cement production	CO_2	1.1%	1.4%	64.8%
21	IPPU	2.B.8.a-Chemical industry - methanol production	CO_2	1.1%	1.4%	66.2%
22	Energy	1.A.4.b-Fuel combustion - residential - gaseous fuels	CO_2	1.1%	1.4%	67.5%
23	LULUCF	4.B.1-Cropland-cropland remaining cropland	CO_2	1.1%	1.3%	68.9%
24	IPPU	2.B.3-Chemical industry - adipic acid production	N_2O	1.0%	1.3%	70.1%
25	IPPU	2.G.1-Other product manufacture and use	SF_6	1.0%	1.2%	71.3%

No.	Category	Category	GHGs	Trend assessment	Contribution in trend assessment	Accumulative contribution in trend assessment
26	Energy	1.A.4.b-Fuel combustion - residential - biomass	CH_4	1.0%	1.2%	72.6%
27	LULUCF	4.G-Harvested wood products	CO_2	0.9%	1.2%	73.7%
28	IPPU	2.B.1-Chemical industry - ammonia production	CO_2	0.8%	1.0%	74.7%
29	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - solid fuels	CO_2	0.8%	1.0%	75.7%
30	Energy	1.A.2.c-Fuel combustion - chemicals - gaseous fuels	CO_2	0.8%	1.0%	76.6%
31	Energy	1.A.3.b-Fuel combustion - road transportation - gaseous fuels	CO_2	0.8%	0.9%	77.5%
32	Energy	1.A.2.d-Fuel combustion - pulp, paper and print - solid fuels	CO_2	0.7%	0.9%	78.4%
33	Energy	1.A.1.a-Fuel combustion - public electricity and heat production - liquid fuels	CO_2	0.7%	0.9%	79.3%
34	Agriculture	3.B-Manure management	N_2O	0.7%	0.8%	80.2%
35	Waste	5.A- Solid waste disposal	CH_4	0.7%	0.8%	81.0%
36	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - solid fuels	CO_2	0.7%	0.8%	81.8%
37	Energy	1.A.2.f-Fuel combustion -non-metallic minerals - liquid fuels	CO_2	0.6%	0.7%	82.5%
38	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - gaseous fuels	CO_2	0.6%	0.7%	83.2%
39	LULUCF	4.C.1-Grassland -grassland remaining grassland	CO_2	0.5%	0.7%	83.9%
40	Energy	1.A.2.k -Fuel combustion -construction - liquid fuels	CO_2	0.5%	0.7%	84.6%
41	Energy	1.A.2.c-Fuel combustion - chemicals - liquid fuels	CO_2	0.5%	0.6%	85.2%
42	Energy	1.A.1.b-Fuel combustion - petroleum refining - solid fuels	CO_2	0.5%	0.6%	85.8%
43	Energy	1.A.1.b-Fuel combustion - petroleum refining - liquid fuels	CO_2	0.5%	0.6%	86.4%
44	Energy	1.A.2.m-Fuel combustion - other industries - solid fuels	CO_2	0.4%	0.5%	86.9%
45	Energy	1.A.3.a Fuel combustion - domestic aviation - liquid fuels	CO_2	0.4%	0.5%	87.4%
46	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - gaseous fuels	CO_2	0.4%	0.5%	87.8%
47	IPPU	2.C.3-Metal industry - aluminium production	CO_2	0.4%	0.4%	88.3%
48	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	N_2O	0.3%	0.4%	88.7%
49	Energy	1.A.4. a-Fuel combustion - commercial/institutional - liquid fuels	CO_2	0.3%	0.4%	89.1%
50	Energy	1.A.2.g-Fuel combustion - transport equipment manufacturing - solid fuels	CO_2	0.3%	0.4%	89.5%
51	Energy	1.A.2.a-Fuel combustion - iron and steel - gaseous fuels	CO_2	0.3%	0.4%	89.9%

No.	Category	Category	GHGs	Trend assessment	Contribution in trend assessment	Accumulative contribution in trend assessment
52	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - liquid fuels	CO_2	0.3%	0.4%	90.2%
53	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - solid fuels	CO_2	0.3%	0.3%	90.6%
54	Energy	1.A.4.b-Fuel combustion - residential - biomass	N_2O	0.3%	0.3%	90.9%
55	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - municipal solid waste (MSW)	CO_2	0.3%	0.3%	91.3%
56	Energy	1.A.2.a-Fuel combustion - iron and steel - solid fuels	CO_2	0.3%	0.3%	91.6%
57	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CH_4	0.3%	0.3%	91.9%
58	Energy	1.B.1.a.ii-Solid fuels - surface mines	CH_4	0.2%	0.3%	92.2%
59	Energy	1.A.1.b-Fuel combustion - petroleum refining - gaseous fuels	CO_2	0.2%	0.3%	92.5%
60	Energy	1.B.2.b-Fugitive emissions from oil and natural gas system - natural gas	CH_4	0.2%	0.3%	92.8%
61	Energy	1.A.3.c -Fuel combustion - railway transport - liquid fuels	CO_2	0.2%	0.3%	93.1%
62	IPPU	2.C.1-Metal industry - iron and steel production	CO_2	0.2%	0.3%	93.4%
63	IPPU	2.B.8.b-Chemical industry-ethylene production	CO_2	0.2%	0.3%	93.7%
64	Energy	1.A.2.j-Fuel combustion - wood and wood products - solid fuels	CO_2	0.2%	0.3%	94.0%
65	Energy	1.A.2.i-Fuel combustion - mining (excluding fuels) and quarrying - solid fuels	CO_2	0.2%	0.3%	94.3%
66	LULUCF	4.D.2-Wetlands - land converted to wetlands	CO_2	0.2%	0.3%	94.5%
67	Waste	5.D-Wastewater treatment and discharge	CH_4	0.2%	0.3%	94.8%
68	Energy	1.A.4.b-Fuel combustion - residential - liquid fuels	CO_2	0.2%	0.2%	95.0%

Table 1-2e Results of the Trend Analysis of Key Categories in Inventories from 2005 to 2021 (without LULUCF)

No.	Category	Category	GHGs	Trend assessment	Contribution in trend assessment	Accumulative contribution in trend assessment
1	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	CO_2	11.4%	15.3%	15.3%
2	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - solid fuels	CO_2	5.4%	7.2%	22.5%
3	IPPU	2.F-Product uses as substitutes for ozone depleting substances	HFCs	3.6%	4.8%	27.3%
4	Energy	1.A.2.c-Fuel combustion - chemicals - solid fuels	CO_2	3.0%	4.0%	31.3%
5	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CO_2	3.0%	4.0%	35.3%
6	Agriculture	3.A-Enteric fermentation	CH_4	2.6%	3.4%	38.7%
7	Energy	1.B.1.a.i-Solid fuels - underground mines (excl. recovered)	CH_4	2.2%	3.0%	41.8%
8	Energy	1.A.2.b-Fuel combustion - non-ferrous metals - solid fuels	CO_2	2.1%	2.8%	44.5%
9	IPPU	2.B.9-Chemical industry - fluorochemical production	HFCs	2.0%	2.7%	47.2%
10	Energy	1.A.4.a-Fuel combustion - commercial/institutional - solid fuels	CO_2	1.7%	2.3%	49.5%
11	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - gaseous fuels	CO_2	1.6%	2.1%	51.6%
12	Agriculture	3.D-Agricultural soils	N_2O	1.6%	2.1%	53.7%
13	Energy	1.A.2.l-Fuel combustion - textile and leather - solid fuels	CO_2	1.4%	1.9%	55.6%
14	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - solid fuels	CO_2	1.4%	1.9%	57.5%
15	Agriculture	3.C-Rice cultivation	CH_4	1.4%	1.8%	59.4%
16	Energy	1.A.3.b-Fuel combustion - road transportation - liquid fuels	CO_2	1.3%	1.8%	61.2%
17	IPPU	2.B.8.a-Chemicalindustry - methanol production	CO_2	1.2%	1.6%	62.8%
18	Energy	1.A.4.b-Fuel combustion - residential - gaseous fuels	CO_2	1.2%	1.6%	64.4%
19	IPPU	2.A.1-Mineral industry- cement production	CO_2	1.2%	1.6%	66.0%
20	IPPU	2.B.3-Chemical industry - adipic acid production	N_2O	1.1%	1.5%	67.5%
21	IPPU	2.G.1-Other product manufacture and use	SF_6	1.1%	1.4%	68.9%
22	Energy	1.A.4.b-Fuel combustion - residential - biomass	CH_4	1.1%	1.4%	70.3%
23	IPPU	2.B.1-Chemical industry - ammonia production	CO_2	0.9%	1.2%	71.5%
24	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - solid fuels	CO_2	0.9%	1.2%	72.7%
25	Energy	1.A.2.c-Fuel combustion - chemicals - gaseous fuels	CO_2	0.9%	1.1%	73.8%

No.	Category	Category	GHGs	Trend assessment	Contribution in trend assessment	Accumulative contribution in trend assessment
26	Energy	1.A.3.b-Fuel combustion - road transportation - gaseous fuels	CO_2	0.8%	1.1%	74.9%
27	Energy	1.A.2.d-Fuel combustion - pulp, paper and print - solid fuels	CO_2	0.8%	1.1%	76.0%
28	Energy	1.A.1.a-Fuel combustion - public electricity and heat production - liquid fuels	CO_2	0.8%	1.0%	77.1%
29	Agriculture	3.B-Manure management	N_2O	0.8%	1.0%	78.1%
30	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - solid fuels	CO_2	0.7%	1.0%	79.1%
31	Waste	5.A- Solid waste disposal	CH_4	0.7%	1.0%	80.0%
32	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - liquid fuels	CO_2	0.6%	0.8%	80.9%
33	Energy	1.A.2.k -Fuel combustion -construction - liquid fuels	CO_2	0.6%	0.8%	81.7%
34	Energy	1.A.2.f-Fuel combustion - non-metallic minerals - gaseous fuels	CO_2	0.6%	0.8%	82.5%
35	Energy	1.A.2.c-Fuel combustion - chemicals - liquid fuels	CO_2	0.6%	0.8%	83.3%
36	Energy	1.A.1.b-Fuel combustion - petroleum refining - solid fuels	CO_2	0.5%	0.7%	84.0%
37	Energy	1.A.1.b-Fuel combustion - petroleum refining - liquid fuels	CO_2	0.5%	0.7%	84.6%
38	Energy	1.A.2.m-Fuel combustion - other industries - solid fuels	CO_2	0.4%	0.6%	85.2%
39	Energy	1.A.3.a Fuel combustion -domestic aviation - liquid fuels	CO_2	0.4%	0.6%	85.8%
40	Energy	1.A.2.h-Fuel combustion - manufacturing of machinery - gaseous fuels	CO_2	0.4%	0.5%	86.3%
41	IPPU	2.C.3-Metal industry - aluminium production	CO_2	0.4%	0.5%	86.8%
42	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - solid fuels	N_2O	0.4%	0.5%	87.4%
43	Energy	1.A.4. a-Fuel combustion - commercial/institutional - liquid fuels	CO_2	0.4%	0.5%	87.8%
44	Energy	1.A.2.g-Fuel combustion -manufacturing of transport equipment - solid fuels	CO_2	0.3%	0.5%	88.3%
45	Energy	1.A.2.a-Fuel combustion - iron and steel - gaseous fuels	CO_2	0.3%	0.5%	88.8%
46	Energy	1.A.1.c-Fuel combustion -manufacture of solid fuels and other energy industries - liquid fuels	CO_2	0.3%	0.4%	89.2%
47	Energy	1.A.4.c -Fuel combustion - agriculture/forestry/fishing - solid fuels	CO_2	0.3%	0.4%	89.6%
48	Energy	1.A.4.b-Fuel combustion - residential - biomass	N_2O	0.3%	0.4%	90.0%
49	Energy	1.A.1.a -Fuel combustion - public electricity and heat production - municipal solid waste (MSW)	CO_2	0.3%	0.4%	90.4%
50	Energy	1.A.4.b-Fuel combustion - residential - solid fuels	CH_4	0.3%	0.4%	90.8%
51	Energy	1.B.1.a.ii-Solid fuels - surface mines	CH_4	0.3%	0.4%	91.2%
52	Energy	1.A.1.b-Fuel combustion - petroleum refining - gaseous fuels	CO_2	0.3%	0.4%	91.5%

No.	Category	Category	GHGs	Trend assessment	Contribution in trend assessment	Accumulative contribution in trend assessment
53	Energy	1.B.2.b-Fugitive emissions from oil and natural gas system - natural gas	CH_4	0.3%	0.4%	91.9%
54	Energy	1.A.3.c -Fuel combustion - railways - liquid fuels	CO_2	0.3%	0.4%	92.2%
55	IPPU	2.B.8.b-Chemical industry-ethylene production	CO_2	0.3%	0.3%	92.6%
56	IPPU	2.C.1-Metal industry - iron and steel production	CO_2	0.3%	0.3%	92.9%
57	Energy	1.A.2.i-Fuel combustion - mining (excluding fuels) and quarrying - solid fuels	CO_2	0.2%	0.3%	93.3%
58	Energy	1.A.2.j-Fuel combustion - wood and wood products - solid fuels	CO_2	0.2%	0.3%	93.6%
59	Waste	5.D-Wastewater treatment and discharge	CH_4	0.2%	0.3%	93.9%
60	Energy	1.A.4.b-Fuel combustion - residential - liquid fuels	CO_2	0.2%	0.3%	94.2%
61	Energy	1.A.2.l-Fuel combustion - textile and leather - gaseous fuels	CO_2	0.2%	0.3%	94.5%
62	Waste	5.D-Wastewater treatment and discharge	N_2O	0.2%	0.3%	94.7%
63	Energy	1.A.2.e-Fuel combustion - food processing, beverages and tobacco - gaseous fuels	CO_2	0.2%	0.3%	95.0%

The above key categories adopt higher tier[2] methods and country-specific emission factors in the inventory compilation whenever possible. The specific methods used for each category are shown in Table 1-3.

Table 1-3 Main Methods for Compilation of National Inventories

Source/Sink Categories	CO_2		CH_4		N_2O	
	Methods	Emission Factors	Methods	Emission Factors	Methods	Emission Factors
1.A.1 Energy	T1,T2	D,CS	T1,T2	D,CS	T1,T2	D,CS
1.A.2 Manufacturing industries and construction	T1,T2	D,CS	T1	D	T1	D
1.A.3 Transport	T1,T2,T3	D,CS	T1,T3	D,CS	T1,T3	D,CS
1.A.4 Other sectors	T1,T2	D,CS	T1	D	T1	D
1.B.1 Solid fuels			T1, T2, T3	D,CS		
1.B.2 Oil and natural gas system			T1,T3	D,CS		
2.A Mineral industry	T1,T2	D,CS				
2.B Chemical industry	T1,T2	D,CS			T1,T2	D,CS
2.C Metal industry	T1,T2	D,CS	T1	D	NO	NO
2.D Non-energy products from fuels and solvent use	T1	D				
3.A Enteric fermentation			T1,T2	D,CS		
3.B Manure management			T1,T2	D,CS	T1,T2	D,CS
3.C Rice cultivation			T2,T3	CS		
3.D Agricultural soils					T1,T2	D,CS
3.F Field burning of agricultural residues			T1	D	T1	D
4.A Forest land	T2	CS	T1	D	T1	D
4.B Cropland	T3	CS				
4.C Grassland	T2	CS	T1	D	T1	D
4.D Wetlands	T2	CS	T2	CS	NE	NE
4.E Settlements	T2	CS				
4.F Other land	T2	CS				
4.G Harvested wood products	T2	CS				
4.H Other biomass	T2	CS				
5.A Solid waste disposal			T2	D,CS		
5.B Biological treatment of solid waste			T1	D	T1	D
5.C Incineration of waste	T2	CS	T1,T2	D,CS	T1,T2	D,CS
5.D Wastewater treatment and discharge			T2	CS	T1	D
1.D.1.a International aviation	T3	CS	T3	CS	T3	CS
1.D.1.b International navigation	T1	D	T1	D	T1	D

[2] The emission amounts of each emission source listed are primarily based on calculation methodologies, which are further divided into Tier 1, Tier 2, and Tier 3 methods based on the origin and specificity of the emission factors. Tier 1 and Tier 2 methods have similar calculation principles, generally based on the product of activity levels and emission factors. The difference lies in that Tier 1 uses default emission factors provided by the IPCC, while Tier 2 employs country-specific emission factors. For the domestic aviation sector, Tier 2 distinguishes between cruise and landing/takeoff phases to calculate emissions. Tier 3 utilizes detailed emission calculation models or available facility-level emission or monitoring data.

Source/Sink Categories	CO_2		CH_4		N_2O	
	Methods	Emission Factors	Methods	Emission Factors	Methods	Emission Factors
1.D.3 CO_2 emissions from biomass	T1	D				

Table 1-3 continued

Source/Sink Categories	HFCs		PFCs		SF_6	
	Methods	Emission Factors	Methods	Emission Factors	Methods	Emission Factors
2.A Mineral industry						
2.B Chemical industry	T1,T2	D,CS	T1	D	T1	D
2.C Metal industry			T2	CS	NO	NO
2.D Non-energy products from fuels and solvent use						
2.E Electronics industry			T2	CS		
2.F Product uses as substitutes for ozone depleting substances	T1,T2	D,CS				
2.G Other product manufacture and use					T2	CS

Notes: 1). The methodological codes T1, T2 and T3 represent Tier 1, Tier 2 and Tier 3 methods respectively.

2). The emission factor code CS represents the country-specific emission factor in China, D represents the default emission factor from IPCC.

3). Shaded cells do not require entries.

4). “NE” (not estimated) indicates that a particular source or sink category has not been estimated.

5). “NO” (not occurring) indicates that a particular source or sink category do not occur.

II. Overview of the National Inventory

In 2021, China's total GHG emissions (with LULUCF) amounted to about 12,999 $MtCO_2eq$, an increase of 4.3% from 2020. In 2021, GHG removals from LULUCF amounted to 1,315 $MtCO_2eq$. In 2021, China's total GHG emissions (without LULUCF) amounted to about 14,314 $MtCO_2eq$, an increase of 4.0% from 2020, primarily due to increased GHG emissions from Energy and IPPU. Detailed information on China's GHG emissions and removals is detailed in Table 1-4, and the adopted GWPs are shown in Table 1-5.

Based on the propagation of error and Monte Carlo Simulation methods, the overall uncertainties of inventories for 2005, 2020, and 2021 were from -4.1% to 4.4%, -4.1% to 4.4%, and -4.2% to 4.5%, respectively.

Table 1-4a China's GHG Emissions and Removals (Mt)

GHG Source/Sink Categories	2005			2020			2021		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Total (without LULUCF)	6,533.452	46.831	1.440	11,201.668	59.028	1.979	11,628.009	59.535	2.102
Total (with LULUCF)	5,804.785	47.463	1.441	9,859.040	60.426	1.979	10,281.510	60.645	2.102
1. Energy	5,784.299	22.205	0.259	9,660.879	27.922	0.442	10,095.043	28.165	0.464
1.A Fuel combustion	5,784.299	3.397	0.259	9,660.879	1.429	0.442	10,095.043	1.380	0.464
1.A.1 Energy industries	2,443.727	0.035	0.130	4,780.030	0.129	0.326	5,258.621	0.147	0.346

GHG Source/Sink Categories	2005			2020			2021		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
1.A.2 Manufacturing industries and construction	2,368.374	0.382	0.043	3,322.931	0.298	0.080	3,238.808	0.290	0.081
1.A.3 Transport	461.021	0.083	0.018	910.499	0.140	0.022	991.293	0.156	0.023
1.A.4 Other sectors	511.177	2.897	0.068	647.419	0.861	0.014	606.321	0.787	0.014
1.B Fugitive emissions from fuels		18.808			26.493			26.785	
1.B.1 Solid fuels		18.046			24.863			25.030	
1.B.2 Oil and natural gas system		0.763			1.630			1.755	
2. IPPU	748.647	0.003	0.108	1,532.118	0.005	0.489	1,523.983	0.006	0.580
2.A Mineral industry	526.062			1,034.947			1,013.027		
2.B Chemical industry	156.081		0.108	315.761		0.489	328.775		0.580
2.C Metal industry	64.532	0.003	NO	178.933	0.005	NO	179.433	0.006	NO
2.D Non-energy products from fuels and solvent use	1.972			2.477			2.748		
2.E Electronics industry									
2.F Product uses as substitutes for ozone depleting substances									
2.G Other product manufacture and use									
3. Agriculture		21.365	0.983		23.720	0.946		24.279	0.949
3.A Enteric fermentation		11.204			11.242			11.518	
3.B Manure management		2.404	0.272		3.447	0.222		3.753	0.227
3.C Rice cultivation		7.550			8.849			8.851	
3.D Agricultural soils			0.706			0.719			0.718
3.F Field burning of agricultural residues		0.207	0.005		0.182	0.005		0.157	0.004
4. LULUCF	-728.667	0.632	0.000	-1,342.629	1.398	0.000	-1,346.499	1.110	0.000
4.A Forest land	-551.205	0.002	0.000	-895.592	0.000	0.000	-876.827	0.000	0.000
4.B Cropland	-41.077			-98.018			-106.162		
4.C Grassland	-47.769	0.001	0.000	-72.707	0.000	0.000	-64.082	0.000	0.000
4.D Wetlands	-13.730	0.629	NE	-29.788	1.398	NE	-24.599	1.110	NE
4.E Settlements	0.163			-2.396			-0.634		
4.F Other land	5.436			2.641			1.556		
4.G Harvested wood products	-61.215			-103.863			-103.820		
4.H Other biomass	-19.271			-142.906			-171.931		
5. Waste	0.507	3.257	0.090	8.671	7.380	0.103	8.983	7.085	0.109

GHG Source/Sink Categories	2005			2020			2021		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
5.A Solid waste disposal		1.494			5.055			4.721	
5.B Biological treatment of solid waste		0.014	0.001		0.043	0.003		0.064	0.005
5.C Incineration of waste	0.507	0.000	0.000	8.671	0.002	0.011	8.983	0.002	0.016
5.D Wastewater treatment and discharge		1.750	0.089		2.280	0.088		2.297	0.088
1.D Memo items									
1.D.1.a International aviation	13.300	0.000	0.000	22.069	0.000	0.001	20.322	0.000	0.001
1.D.1.b International navigation	15.386	0.001	0.000	35.868	0.003	0.001	39.933	0.004	0.001
1.D.3 CO_2 emissions from biomass	832.063			292.306			325.068		

Table 1-4b China's GHG Emissions and Removals

GHG Source/Sink Categories ($MtCO_2eq$)	2005			2020			2021		
	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6
IPPU	117.353	4.537	7.100	272.563	21.607	92.919	335.853	23.051	103.311
2.A Mineral industry									
2.B Chemical industry	112.896	0.004	0.403	14.215	0.127	2.363	27.255	0.151	1.904
2.C Metal industry		4.376	NO		20.830	NO		21.628	NO
2.D Non-energy products from fuels and solvent use									
2.E Electronics industry		0.157			0.650			1.273	
2.F Product uses as substitutes for ozone depleting substances	4.456			258.348			308.598		
2.G Other product manufacture and use			6.697			90.556			101.408

Notes: 1). Shaded cells do not require entries;

2). 0.000 indicates that the value is less than 0.0005.

3). "NE" (not estimated) indicates that a particular source or sink category has not been estimated; "NO" (not occurring) indicates that a particular source or sink category do not occur.

4). Due to rounding, the aggregation of various items may be slightly different from the total.

5). Memo items are not counted in the total emissions.

Table 1-5 GWP Values Used in the Inventory (100-Year Time Horizon)

Gas	GWPs	Gas	GWPs
CO_2	1	**HFC-152a**	138
CH_4	28	**HFC-227ea**	3350
N_2O	265	**HFC-236ea**	1330
HFC-23	12400	**HFC-236fa**	8060
HFC-32	677	**HFC-245fa**	858

Gas	GWPs	Gas	GWPs
HFC-41	116	**HFC-365mfc**	804
HFC-125	3170	**PFC-14(CF_4)**	6630
HFC-134a	1300	**PFC-116(C_2F_6)**	11100
HFC-143a	4800	**SF_6**	23500

Note: HFCs include HFC-23, HFC-32, HFC-41, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-236ea, HFC-236fa, HFC-245fa, HFC- 365mfc; PFCs includes CF_4 and C_2F_6.

III. Time-Series Analysis by Gas

In 2021, CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 (with LULUCF) accounted for 79.1%, 13.1%, 4.3%, 2.6%, 0.2%, and 0.8% respectively, increased by 4.3%, 0.4%, 6.2%, 23.2%, 6.7%, and 11.2% from 2020 levels. In 2021, CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 (without LULUCF) accounted for 81.2%, 11.6%, 3.9%, 2.3%, 0.2% and 0.7%, respectively, increased by 3.8%, 0.9%, 6.2%, 23.2%, 6.7% and 11.2% from 2020 levels. See Table 1-6.

Table 1-6 GHG Emissions by Gas

GHGs	2005				2020				2021			
	With LULUCF		Without LULUCF		With LULUCF		Without LULUCF		With LULUCF		Without LULUCF	
	Emissions ($MtCO_2eq$)	Proportion (%)	Emissions ($MtCO_2eq$)	Proportion (%)	Emissions ($MtCO_2eq$)	Proportion (%)	Emissions ($MtCO_2eq$)	Proportion (%)	Emissions ($MtCO_2eq$)	Proportion (%)	Emissions ($MtCO_2eq$)	Proportion (%)
CO_2	5,805	75.9	6,533	78.2	9,859	79.1	11,202	81.4	10,282	79.1	11,628	81.2
CH_4	1,329	17.4	1,311	15.7	1,692	13.6	1,653	12.0	1,698	13.1	1,667	11.6
N_2O	382	5.0	382	4.6	524	4.2	524	3.8	557	4.3	557	3.9
HFCs	117	1.5	117	1.4	273	2.2	273	2.0	336	2.6	336	2.3
PFCs	5	0.1	5	0.1	22	0.2	22	0.2	23	0.2	23	0.2
SF_6	7	0.1	7	0.1	93	0.7	93	0.7	103	0.8	103	0.7
Total	7,644	100.0	8,355	100.0	12,463	100.0	13,766	100.0	12,999	100.0	14,314	100.0

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

(i) Carbon Dioxide (CO_2)

In 2021, China's total CO_2 emissions (with LULUCF) amounted to about 10,282 $MtCO_2eq$, an increase of 4.3% from 2020. To be specific, CO_2 emissions from Energy and Waste were 10,095 Mt and 9 Mt, respectively, a 4.5% and 3.6% increase from 2020. CO_2 emissions from IPPU were 1,524 Mt, a 0.5% decrease from 2020. In 2021, LULUCF, as sinks, removed 1,346 Mt CO_2. In 2021, China's total CO_2 emissions (without LULUCF) amounted to about 11,628 $MtCO_2eq$, an increase of 3.8% from 2020. See Figure 1-3.

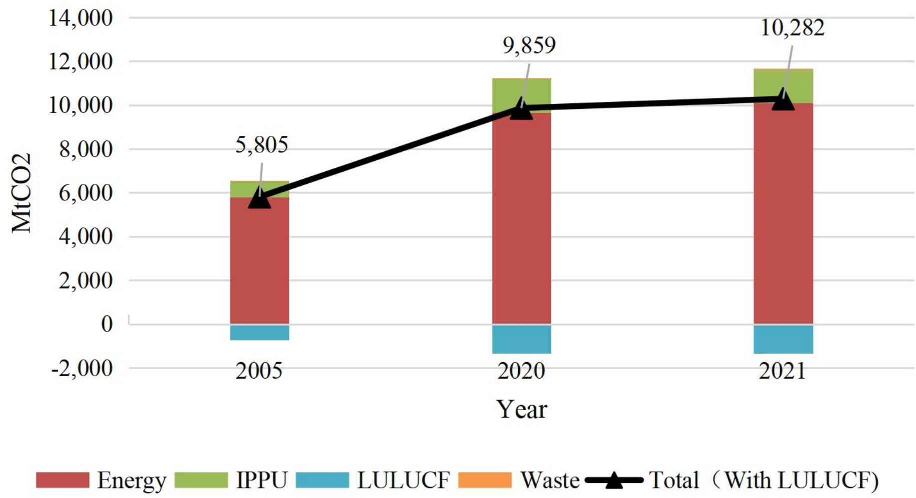


Figure 1-3 China's CO_2 Emissions and Removals by Category (Mt)

From 2020 to 2021, CO_2 emissions from international aviation decreased from 22.069 Mt to 20.322 Mt; CO_2 emissions from international navigation increased from 35.868 Mt to 39.933 Mt; and CO_2 emissions from biomass grew from 292.306 Mt to 325.068 Mt. These emissions were reported as memo items and not counted in the total emissions.

(ii) Methane (CH_4)

In 2021, China's total CH_4 emissions (with LULUCF) amounted to 60.645 Mt, a 0.4% increase from 2020. See Figure 1-4. To be specific, CH_4 emissions from Energy and Agriculture were 28.165 Mt and 24.279 Mt, respectively, a 0.9% and 2.4% increase from 2020. CH_4 emissions from IPPU were 5,714 t, essentially the same as in 2020. CH_4 emissions from Waste were 7.085 Mt, a 4.0% decrease from 2020. CH_4 emissions from LULUCF were 1.110 Mt.

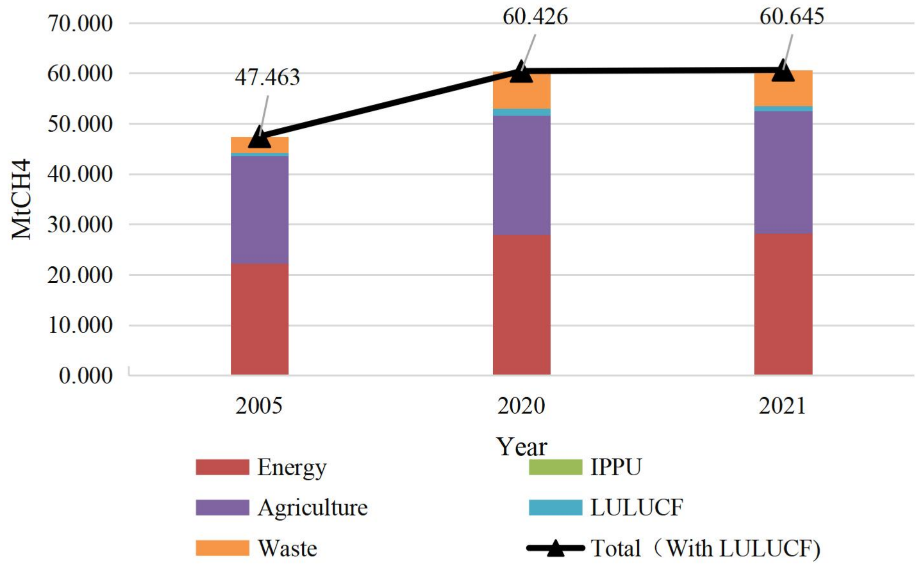


Figure 1-4 China's CH_4 Emissions by Category (Mt)

(iii) Nitrous Oxide (N_2O)

In 2021, China's total N_2O emissions (with LULUCF) amounted to 2.102 Mt, a 6.2% increase from 2020. See Figure 1-5. To be specific, N_2O emissions from Energy, IPPU and Waste were 0.464 Mt, 0.580 Mt and 0.109 Mt, respectively, a 5.1%, 18.6% and 6.6% increase from 2020. N_2O emissions from Agriculture were 0.949 Mt in 2021, a 0.3% increase from 2020. N_2O emissions from LULUCF were 19 t in 2021.

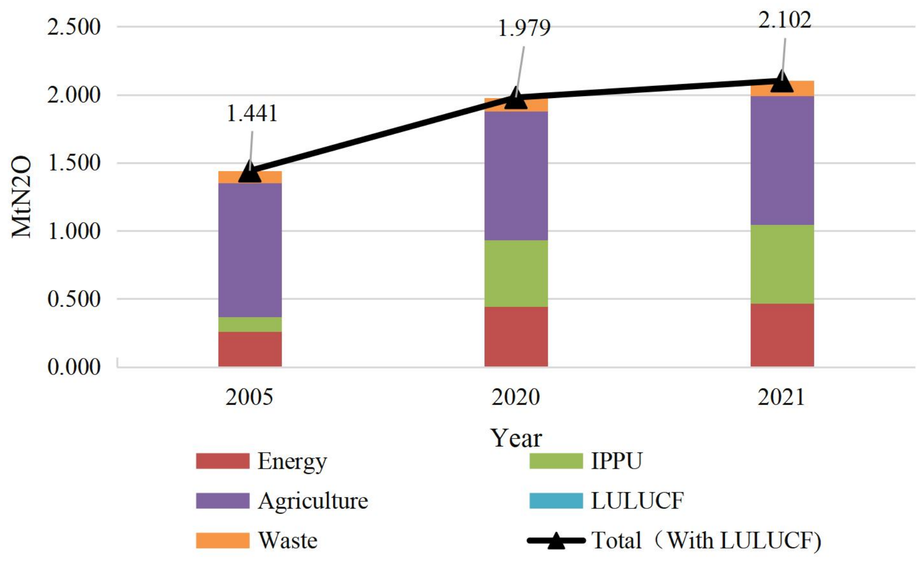


Figure 1-5 China's N_2O Emissions by Category (Mt)

(iv) F-gases

In 2021, China's F-gas emissions reached 462 $MtCO_2eq$, a 19.4% increase from 2020. These emissions were entirely sourced from IPPU, with details shown in Figure 1-6 and Table 1-15.

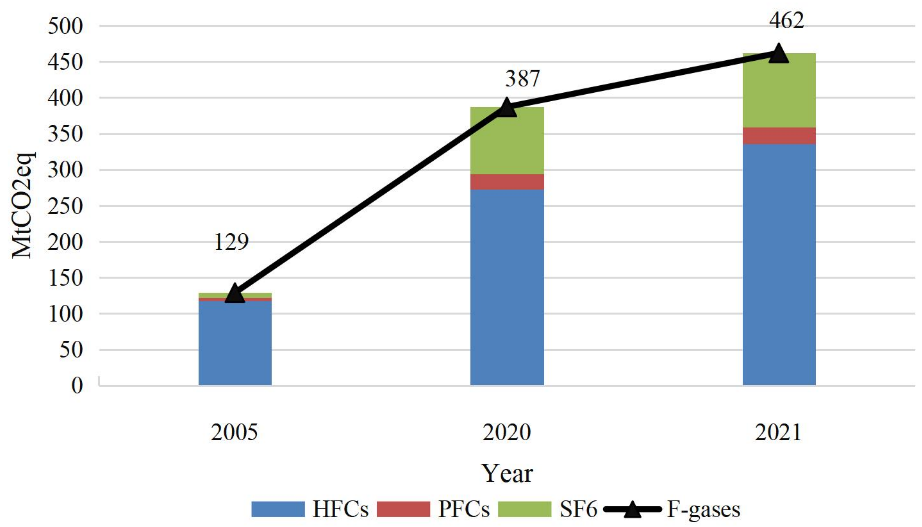


Figure 1-6 China's F-gas Emissions ($MtCO_2eq$)

IV. Time-Series Analysis by Category

In 2021, Energy, IPPU, Agriculture, and Waste accounted for 76.9%, 14.9%, 6.5%, and 1.7% of China's total GHG emissions (without LULUCF), respectively. Compared to 2020, the proportion of emissions from each category remained largely stable, as shown in Figure 1-7.

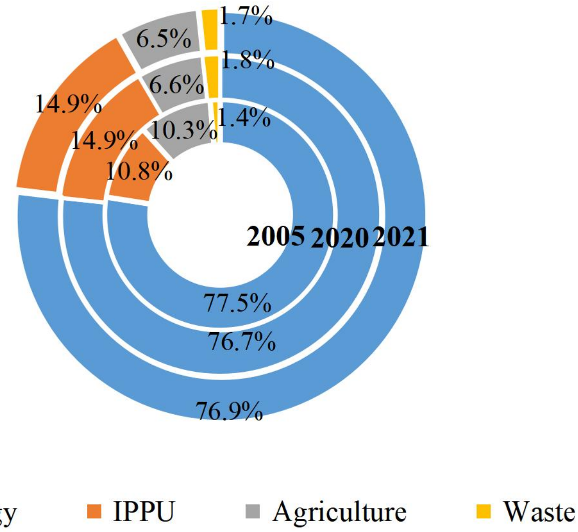


Figure 1-7 China's GHG Emissions by Category (without LULUCF)

(i) Energy

In 2021, China's GHG emissions from Energy reached 11,007 $MtCO_2eq$, a 4.2% increase from 2020. CO_2, CH_4 and N_2O emissions accounted for over 91%, 7%, and 1%. The proportions of emissions by gas remained basically unchanged from 2020 to 2021. To be specific, in 2021, GHG emissions from fuel combustion were 10,257 $MtCO_2eq$, accounting for more than 93% of those from Energy, a 4.5% increase from 2020. In 2021, fugitive emissions of CH_4 were 750 $MtCO_2eq$, a 1.1% increase from 2020, as shown in Figure 1-8.

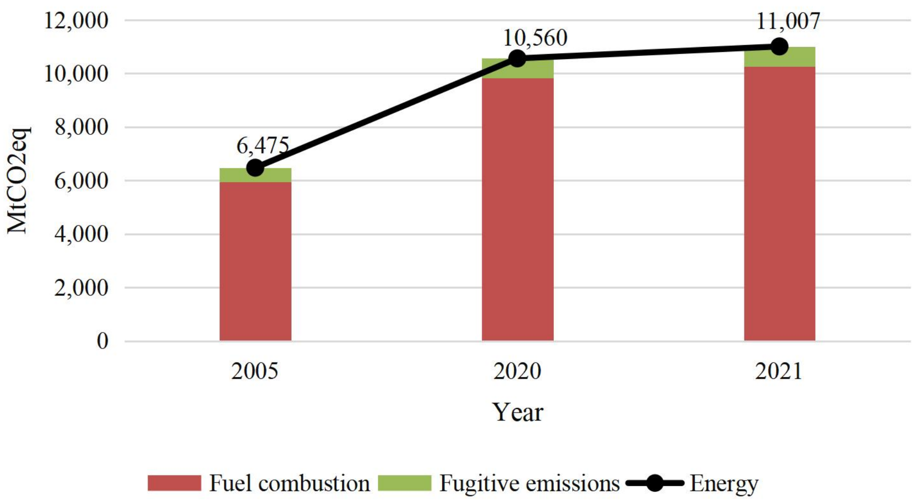


Figure 1-8 Emissions from Energy in China

(ii) IPPU

In 2021, China's GHG emissions from IPPU reached 2,140 $MtCO_2eq$, a 4.4% increase from 2020. CO_2, HFCs and N_2O emissions accounted for over 70%, 15%, and less than 8%. CH_4, PFCs and SF_6 combined, accounted for less than 6%. Compared to 2020, the proportion of CO_2 emissions from IPPU decreased in 2021, while the proportions of the other five types of GHG emissions slightly increased. To be specific, the mineral industry was the largest source under IPPU, accounting for more than 47%. In 2021, the mineral industry emitted 1,013 $MtCO_2eq$, a decrease of 2.1% from 2020. In 2021, GHG emissions from chemical industry, electronics industry, product uses as substitutes for ozone depleting substances (ODS), and other product manufacture and use were 512 $MtCO_2eq$, 1 $MtCO_2eq$, 309 $MtCO_2eq$, and 101 $MtCO_2eq$, respectively, increased by 10.8%, 95.9%, 19.5% and 12.0% from 2020. In 2021, GHG emissions from mineral industry, non-energy products from fuels and solvent use were 201 $MtCO_2eq$ and 3 $MtCO_2eq$, respectively, which remained essentially unchanged compared to 2020, as shown in Figure 1-9.

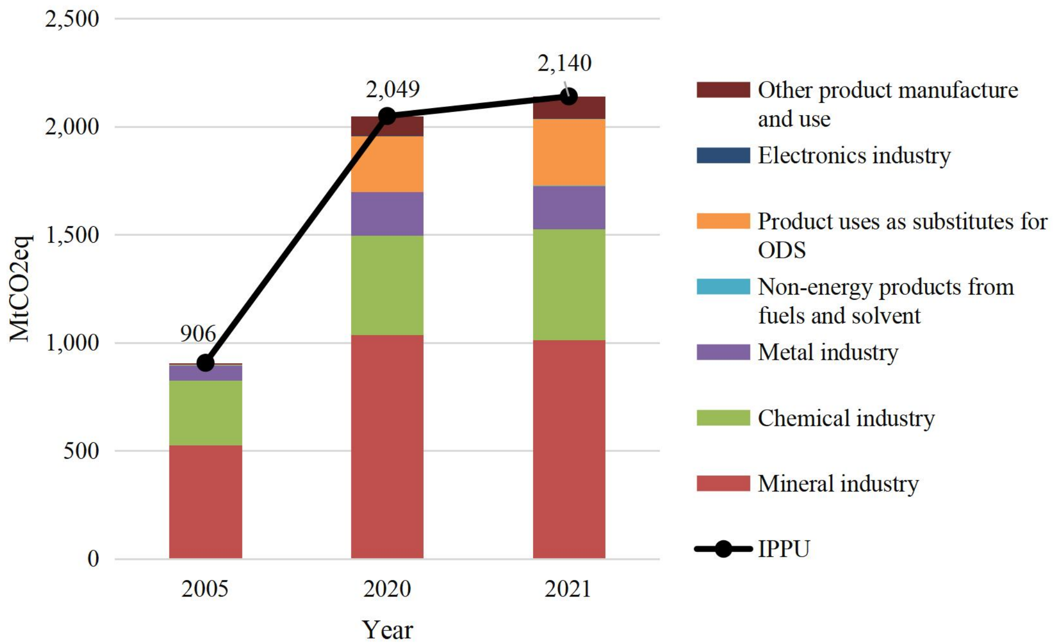


Figure 1-9 Emissions from IPPU in China

(iii) Agriculture

In 2021, China's GHG emissions from Agriculture reached 931 $MtCO_2eq$, a 1.8% increase from 2020. CH_4 emissions accounted for over 70%, with the remainder being N_2O. The proportion of GHG emissions from Agriculture by gas remained basically unchanged from 2020 to 2021. To be specific, in 2021, GHG emissions from enteric fermentation and manure management reached 322 $MtCO_2eq$ and 165 $MtCO_2eq$, respectively, increased by 2.4% and 6.3% from 2020. In 2021, GHG emissions from rice cultivation and agricultural soils amounted to 248 $MtCO_2eq$ and 190 $MtCO_2eq$, respectively, remaining largely unchanged from 2020. In 2021, GHG emissions from field burning of agricultural residues amounted to 5 $MtCO_2eq$, a decrease of 13.6% compared to 2020, as shown in Figure 1-10.

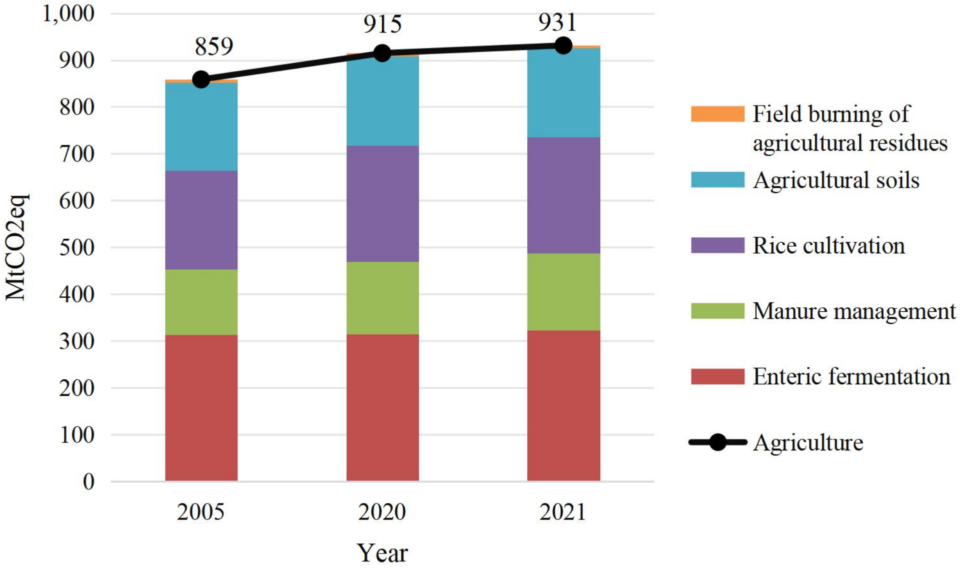


Figure 1-10 Emissions from Agriculture in China

(iv) LULUCF

In 2021, China's GHG removals from LULUCF, as sinks, reached 1,315 $MtCO_2eq$. In 2021, LULUCF, as sinks, removed 1,346 $MtCO_2$. In 2021, LULUCF, as sources, emitted 1.11 $MtCH_4$ and 19 tN_2O. In terms of sources and sinks, in 2021, GHGs removals from sinks such as forest land, cropland, grassland, settlements, harvested wood products, and other biomass were 877 $MtCO_2eq$, 106 $MtCO_2eq$, 64 $MtCO_2eq$, 1 $MtCO_2eq$, 104 $MtCO_2eq$, and 172 $MtCO_2eq$, respectively. GHG emissions from sources such as wetlands and other land were 6 $MtCO_2eq$ and 2 $MtCO_2eq$, respectively.

(v) Waste

In 2021, China's GHG emissions from Waste reached 236 $MtCO_2eq$, a 2.5% decrease from 2020. CH_4 emissions accounted for more than 80%, N_2O emissions about 12%, and CO_2 emissions less than 4%. Solid waste disposal was the largest source under Waste. In 2021, GHG emissions from landfills amounted to 132 $MtCO_2eq$, a 6.6% decrease from 2020, mainly due to the reduction in both the number of landfills and the amount of waste entering landfills. GHG emissions from biological treatment of solid waste, incineration of waste, and wastewater treatment were 3 $MtCO_2eq$, 13 $MtCO_2eq$, and 88 $MtCO_2eq$, respectively, increased by 50.1%, 14.4%, and 0.6% compared to 2020, as shown in Figure 1-11.

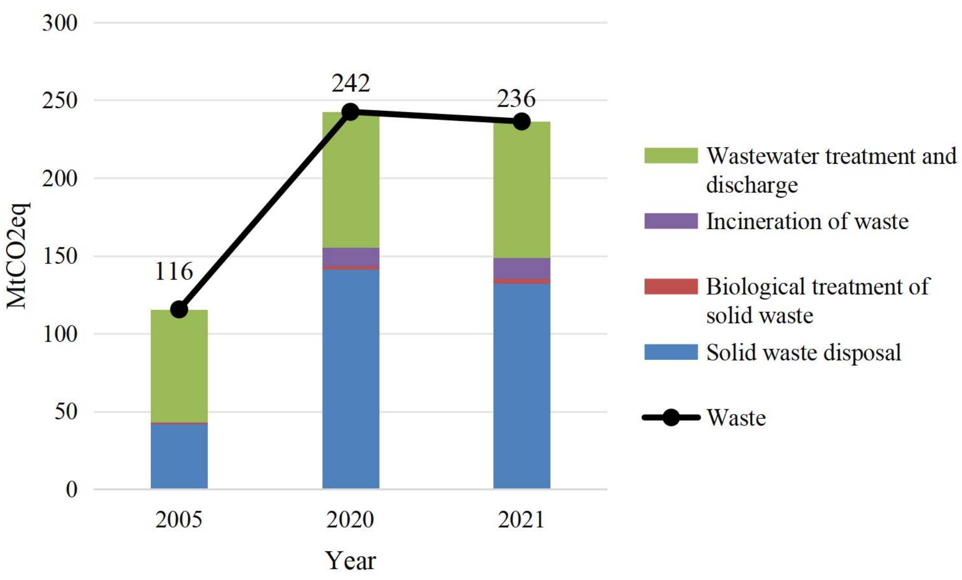


Figure 1-11 Emissions from Waste in China

Chapter 3 Energy

I. Overview

(i) Scope

The GHG Inventory on Energy covers fuel combustion and fugitive emissions. Fuel combustion sources include CO_2, CH_4, and N_2O emissions from energy industries, manufacturing industries and construction, transport, and other sectors. Other sectors can be further segmented into commercial/institutional, residential, and agriculture/forestry/fishing. Off-road transportation other than agricultural machinery and construction sites should have been reported under other sectors, but due to limitations in the underlying statistics, they were reported under road transportation. With regard to waste treatment, CH_4 and N_2O emissions from municipal solid waste (MSW) incineration and CO_2 emissions from fossil sources are reported under Energy. Fugitive emissions cover CH_4 emissions from solid fuels, and oil and natural gas system. Due to the limited data availability, the current inventory didn't report on CO_2 transport, injection, and geological storage. In addition, the inventory on Energy also reported CO_2, CH_4 and N_2O emissions from international bunkers and CO_2 emissions from biomass in memo items.

(ii) Methods

CO_2, CH_4 and N_2O emissions from fossil fuel combustion were calculated by the Sectoral Approach and verified with the Reference Approach. Tier 2 method was used for CO_2 emissions from stationary combustion. Tier 2 method was used for CH_4 and N_2O emissions from public electricity and heat production, and Tier 1 method was used for CH_4 and N_2O emissions from other stationary sources. With regard to mobile combustion, Tier 2 method was used for CO_2 emissions from road transportation, and COPERT model was used for CH_4 and N_2O emissions; Tier 3 method was used for GHG emissions from domestic navigation, and Tier 1 method was used for GHG emissions from railways, domestic navigation and pipeline transportation. With regard to other fuels, Tier 2 method was used for CH_4 emissions from residential biomass combustion, and fossil-derived GHG emissions from MSW incineration, while Tier 1 method was used for other components. Tier 2 and Tier 3 methods were used for CH_4 emissions from underground mines, and Tier 1 method was used for CH_4 emissions from surface mines. Tier 1 and Tier 3 methods were used for fugitive CH_4 emissions from oil and natural gas system, see Table 1-3.

(iii) General

In 2021, China's GHG emissions from Energy were 11,007 $MtCO_2eq$. To be specific, CO_2 emissions were 10,095 Mt, CH_4 emissions were 28.165 Mt, and N_2O emissions were 0.464 Mt, accounting for 91.7%, 7.2%, and 1.1%, and increased by 4.5%, 0.9%, and 5.1%, respectively, over the 2020 levels, as shown in Table 1-4.

(iv) Uncertainty Assessment

Based on the propagation of error and Monte Carlo Simulation methods, the uncertainties of the GHG Inventory on Energy in 2005, 2020, and 2021 were from -5.1% to 5.3%, -5.4% to 5.7%, and -5.6% to 5.8% respectively, as detailed in Table 1-7.

Table 1-7 Uncertainty Assessment for Energy (%)

Source Categories	2005	2020	2021
1.A Fuel combustion	-2.1~2.2	-2.5~2.9	-2.8~3.1
1.B Fugitive emissions	-26.4~26.4	-23.7~23.9	-24.0~24.1
Overall uncertainty	-5.1~5.3	-5.4~5.7	-5.6~5.8

II. Fuel combustion

In 2021, China's GHG emissions from fuel combustion were 10,257 $MtCO_2eq$, an increase of 4.5% compared to 2020. This was mainly due to the fact that China's total energy consumption reached 5,260 Mtce, an increase of 5.5% over the previous year. To be specific, in 2021, GHG emissions from the energy industries, manufacturing industries and construction, transport, and other sectors were 5,354 $MtCO_2eq$, 3,269 $MtCO_2eq$, 1,002 $MtCO_2eq$, and 632 $MtCO_2eq$, respectively. GHG emissions from energy industries grew by 9.9% compared to 2020, mainly due to the increase in the burning of fossil fuels. GHG emissions from manufacturing industries and construction decreased by 2.5% compared to 2020, primarily due to a slight decline in output in industries such as steel and non-metallic minerals. GHG emissions from transport grew by 8.9% compared to 2020, primarily due to the recovery from the COVID-19 pandemic and the rapid growth in road transportation. The specific details can be found in Table 1-4.

(i) Category Description

GHG emissions from fuel combustion refer to CO_2, CH_4 and N_2O emissions from combustion of different types of fuels in stationary or mobile combustion equipment. Fuel combustion sources include CO_2, CH_4, and N_2O emissions from energy industries, manufacturing industries and construction, transport, and other sectors. Energy industries can be further segmented into public electricity and heat production, petroleum refining, manufacture of solid fuels and other energy industries; manufacturing industries and construction can be further segmented into iron and steel, non-ferrous metals, chemicals, pulp, paper and print, food processing, beverages and tobacco, non-metallic minerals, manufacturing of transport equipment, manufacturing of machinery, mining (excluding fuels) and quarrying, wood and wood products, construction, textile and leather, and other industries; transport can be further segmented into domestic aviation, road transportation, railways, domestic navigation, and other transport; other sectors can be further segmented into commercial/institutional, residential, and agriculture/forestry/fishing. Of these, civil aviation and water-borne navigation also need to be split separately into international aviation and international navigation, which are reported as memo items. According to the 2006 IPCC Guidelines, non-energy products from fuels and solvent use was reported under IPPU, and the above emissions have excluded emissions from non-energy products from fuels and solvent use. CH_4 and N_2O emissions from biomass combustion were reported under public electricity and heat production, as well as residential; CO_2 emissions from biomass were reported as memo items. CH_4 and N_2O emissions, as well as fossil-derived CO_2 emissions from MSW incineration under Waste, were reported under public electricity and heat production. In addition, coal-to-oil and coal-to-gas were reported separately under petroleum refining, and manufacture of solid fuels and other energy industries.

The classification of fuel types for fuel combustion are detailed in Table 1-8.

Table 1-8 Fuel Type Classification for Inventory on Energy

Fuel type		Energy type
Fossil fuels	Solid fuel	Raw coal, cleaned coal, other washed coal, gangue, briquettes, coke, other coking products, coke oven gas, blast gas, converter gas, other gas
	Liquid fuels	Crude oil, gasoline, kerosene, diesel oil, fuel oil, liquefied petroleum gas, refinery gas, naphtha, lubricants, paraffin waxes, white spirit, petroleum asphalt, petroleum coke, and other petroleum products
	Gaseous fuels	Natural gas, liquefied natural gas
Biofuels		Straw, animal manure, biogas, MSW (biogenic), bioethanol, biodiesels
Other fossil fuels		MSW (fossil-derived)

(ii) Methods

According to the 2006 IPCC Guidelines, CO_2, CH_4, and N_2O emissions from fossil fuel combustion were calculated using the Sectoral Approach. Additionally, the Reference Approach was used to provide an overall estimate at the macro level to verify the results of CO_2 emissions calculated using the Sectoral Approach.

1. Fossil fuel combustion of stationary sources

GHG emissions from fossil fuel combustion were calculated by sector, by fuel type, and by equipment, using activity data such as fuel consumption, and corresponding emission factors through a layered aggregation process. For CO_2 emissions in key categories, Tier 2 method and country-specific emission factors were used as much as possible. For CH_4 and N_2O emissions in non-key categories, Tier 1 method was used for the majority of stationary combustion sources. To more accurately calculate CH_4 and N_2O emissions from coal-fired electricity generation, coal-fired electricity generation were further subdivided into circulating fluidized bed and other coal-fired power boilers, and the technology-specific emission factors from 2006 IPCC Guidelines for different boiler types were used.

The consumption of fossil fuels from stationary combustion is expressed in terms of calorific value, and obtained by multiplying the physical quantity data by the net calorific value. Activity data on stationary-source fossil fuel combustion were primarily sourced from the China Energy Statistical Yearbook, NBS, and relevant statistical materials from other government departments. Detailed major activity data on Energy can be found in Table 1-9. The carbon content per unit calorific value, carbon oxidation rate, and emission factor of catalyst coking were derived from data reported by companies in the national carbon market. The carbon content per unit calorific value of natural gas and liquefied natural gas (LNG) was based on measured data on major oil and gas fields and imported natural gas in China. Other emission factors were based on the 2018 inventory or adopted default values in the 2006 IPCC Guidelines. Blast gas and converter gas are byproduct gases in steel production, which are used as end-use energy in industries such as public electricity and heat production. Based on data availability, emissions of blast gas and converter gas were reported under iron and steel instead of public electricity and heat production. The emission factors for coal-to-oil and coal-to-gas were calculated based on the feedstock inputs and product outputs of different technological routes in China's coal chemical industry.

Table 1-9 Major Activity Data on Energy in China (Mtce)

Activity Data	2005	2020	2021
Coal consumption	1,892	2,835	2,940
Petroleum consumption	465	937	978
Natural gas consumption	63	419	463

2. Fossil fuel combustion of mobile sources

GHG emissions from jet kerosene and aviation gasoline in domestic aviation were calculated using Tier 3 and Tier 1 methods, respectively. The activity data includes the consumption of jet kerosene for each segment, primarily from the official statistics of CAAC. The aviation gasoline consumption data was estimated based on the recommended method in the 2006 IPCC Guidelines, and the emission factors were mainly referenced from the default emission factors in the 2006 IPCC Guidelines. Furthermore, the activity data of civil aviation emissions needs to be further differentiated between domestic and international.

CO_2 emissions from road transportation were calculated using Tier 2 method, while CH_4 and N_2O emissions were calculated using the COPERT model. With regard to the model method, the fuel balance module was used to verify the model results, ensuring that the deviation between the bottom-up model output fuel consumption and the top-down exogenous fuel consumption is less than 2%. The total amounts of gasoline, diesel, natural gas, and liquefied petroleum gas for road transportation were from NBS and adjusted results of Energy Balance of China, and were verified using information from the fuel supply and retail sides. The information required such as vehicle ownership by vehicle type and by emission standard, and average annual mileage, were referred to data sources like NBS, MEE, and industry associations.

GHG emissions from railways, domestic navigation, and pipeline transportation were calculated using Tier 1 method. Activity data were based on official statistics from NBS and data provided by China State Railway Group Co., Ltd., etc. The carbon content per unit calorific value, carbon oxidation rate, CH_4 and N_2O emission factors were based on the 2018 inventory or adopted default values in the 2006 IPCC Guidelines. Furthermore, the activity data of water-borne navigation emissions needs to be further differentiated between domestic and international.

3. Biomass combustion

Tier 2 method was used for CH_4 emissions from rural residential straw burning in biomass combustion, and Tier 1 method was used for the remaining biomass combustion sources. Activity data on biomass consumption for rural residents' domestic energy use, total annual gas production from rural household biogas digesters and biogas projects, electricity generation from biomass waste, and consumption of bio-alternative fuels for road transportation were obtained from the China Rural Energy Yearbook, the China Environment Statistical Yearbook, MARA, and research data from relevant organizations. Other emission factors were based on the 2018 inventory or adopted default values in the 2006 IPCC Guidelines.

4. Other fossil fuel combustion

Other fossil fuels are mainly MSW. Tier 2 method was used for fossil-derived MSW incineration emissions, and Tier 1 method was used for biogenic MSW incineration emissions. The details of activity data and emission factors can be found in the Waste section.

5. International bunkers

International aviation encompasses domestic airlines and foreign airlines operating flights departing from within the country and with destinations abroad. For domestic airlines, emissions were calculated using the fuel consumption per aircraft type and number of takeoff and landing operations provided by CAAC. For foreign airlines, emissions were calculated using the jet kerosene consumption data from NBS on "oversea airplanes refueling in China".

International navigation covers transportation by domestic and foreign water transport companies departing from within the country and with destinations abroad. For domestic navigation companies, emissions were calculated using the "domestic ships refueling in abroad" data provided by NBS. For foreign water transport companies, emissions were calculated using the "oversea ships refueling in China" data provided by NBS.

International aviation and international navigation were calculated in the same way as domestic aviation and domestic navigation.

(iii)Comparison of the sectoral approach with the reference approach

1. Reference approach

The reference approach is used to estimate the CO_2 emissions from domestic fuel combustion by calculating the total carbon content in fuels available for domestic consumption, and excluding the carbon sequestered in products for non-energy uses. The specific method is to calculate the apparent consumption (physical quantity) of various types of fuels based on the production, import and export quantities, stock changes, and international bunkers in Energy Balance of China; and estimate CO_2 emissions from fuel combustion by calculating the total carbon content in fuels available for domestic consumption based on their respective net calorific values and carbon content per unit calorific value, and excluding the carbon content in non-energy uses. Production, import and export quantities etc. in the reference approach were derived from official statistics such as the Energy Balance of China and net calorific values, carbon content per unit calorific value and carbon oxidation rate of each fuel were weighted according to the consumption data of the corresponding fuel types in the sectoral approach.

2. Comparison of emission results

The variance between the reference and sectoral approach in 2020 and 2021 was 2.5% and 1.2%, respectively, as detailed in Table 1-10. The variances exist for two reasons: first, energy transportation losses, coal washing and screening losses, "balance differences", and stock changes in end-use sectors lead to discrepancies between the apparent energy consumption in the reference approach and the terminal energy consumption in the sectoral approach; second, regarding emission factors, in case of oil products, the reference approach mainly calculates crude oil, while the sectoral approach mainly calculates refined oil products consumed by end-use sectors, and there are certain differences in carbon content per unit calorific value between crude oil and various refined oil products. Overall, the variance between the reference and sectoral approach was within 5%.

Table 1-10 Comparison of CO_2 Emission Results between the Reference and Sectoral Approach

Year	Reference Approach (Mt)	Sectoral Approach (Mt)	Variance (%)
2005	5,495	5,784	-5.0
2020	9,903	9,661	2.5
2021	10,220	10,095	1.2

(iv) Uncertainty Assessment

Based on the propagation of error and Monte Carlo Simulation methods, the uncertainties of the GHG inventory on fossil fuel combustion for 2005, 2020 and 2021 were from -2.1% to 2.2%, -2.5% to 2.9%, and -2.8% to 3.1%, respectively, as detailed in Table 1-11.

Table 1-11 Uncertainty Assessment for Fuel Combustion Emissions

Source Categories	2005	2020	2021
1.A.1 Energy industries	-3.9~4.2	-4.8~5.4	-5.1~5.7
1.A.2 Manufacturing industries and construction	-3.0~3.0	-2.7~2.7	-2.5~2.5
1.A.3 Transport	-0.4~0.4	-0.5~0.5	-0.6~0.6
1.A.4 Other sectors	-0.5~2.7	-0.1~0.4	-0.1~0.3
1.A Overall uncertainty	-2.1~2.2	-2.5~2.9	-2.8~3.1

III. Fugitive Emissions

In 2021, China's fugitive CH_4 emissions were 26.785 Mt, an increase of 1.1% from 2020. To be specific, in 2021, CH_4 emissions from solid fuel and oil and natural gas system were 25.030 Mt and 1.755 Mt, respectively, an increase of 0.7% and 7.7% compared to 2020, mainly due to the rise in fossil fuel production. The details can be found in Table 1-12.

Table 1-12 Fugitive CH_4 Emissions in China (Mt)

Source Categories	2005	2020	2021
1.B Fugitive emissions	18.808	26.493	26.785
1.B.1 Solid fuels	18.046	24.863	25.030
1.B.1.a.i Underground mines	17.793	23.837	23.788
1.B.1.a.ii Surface mines	0.252	1.027	1.242
1.B.2 Oil and natural gas system	0.763	1.630	1.755
1.B.2.a Oil	0.595	0.652	0.664
1.B.2.b Natural gas system	0.168	0.977	1.091
1.B.2.c Venting and flaring	NE, IE	0.001	0.000

Note: 1). 0.000 indicates that the value is less than 0.0005.

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

4). "IE" (included elsewhere) indicates that a particular source or sink category has been estimated and reported under other sub-sectors.

(i) Category Description

1. Solid fuel

The fugitive emissions from solid fuels include coal mining and handling, as well as uncontrolled combustion and burning coal dumps. Coal mining and handling includes underground mines and surface mines. The fugitive emissions from underground mines include CH_4 emissions from mining activities, post-mining activities, and abandoned underground mines. Fugitive emissions from surface mines include CH_4 emissions from mining activities and post-mining activities of surface mines. Due to limited data availability and lack of clear methodologies, the current inventory has not yet reported on emissions from uncontrolled combustion and burning coal dumps.

2. Oil and natural gas system

Fugitive emissions from oil and natural gas system include CH_4 leakage emissions from all segments of oil exploration, production and upgrading, transport, refining and storage, CH_4 leakage emissions from all segments of natural gas exploration, production and gathering, processing, transmission and storage, and distribution, as well as CH_4 emissions from venting and flaring.

(ii) Methods

1. Solid fuel

With regard to fugitive CH_4 emissions from solid fuels, Tier 2 method was used for CH_4 emissions from mining activities and post-mining activities in underground mines, Tier 1 method was used for fugitive emissions from surface mines, and Tier 3 method was used for CH_4 emissions from abandoned underground mines. The activity data includes the raw coal output of underground mining, the number of abandoned mines, and the raw coal output of surface mines. The main sources are the China Energy Statistical Yearbook and the Research on the Development of the World Coal Industry. Emission factors were based on the 2018 inventory.

2. Oil and natural gas system

For fugitive emissions from oil and natural gas system, Tier 3 method was used for transportation of crude oil tank, while Tier 1 method was used for the remaining sources. Activity data were mainly sourced from CNPC, Sinopec Group, CNOOC, YCPC and PipeChina, as well as data published by NBS on crude oil and natural gas production, crude oil consumed in refining, natural gas consumption, as well as the data published by GACC on LNG imports in the current year. Emission factors were based on the 2018 inventory. See Table 1-13 for major activity data.

Table 1-13 Major Activity Data on Fuel Fugitive Emissions

Activity Data	2005	2020	2021
Coal production (Mt)	2,365	3,902	4,126
Crude oil production (Mt)	181	195	199
Natural gas production (Bcm)	49.32	199.49	215.55

(iii) Uncertainty Assessment

Based on the propagation of error and Monte Carlo Simulation methods, the uncertainties of the fugitive emissions for 2005, 2020 and 2021 were from -26.4% to 26.4%, -23.7% to 23.9%, -24.0% to 24.1%, respectively, as detailed in Table 1-14.

Table 1-14 Uncertainty Assessment for Fuel Fugitive Emissions (%)

Source Categories	2005	2020	2021
1.B.1 Solid fuels	-27.5~27.5	-25.3~25.5	-25.6~25.7
1.B.2 Oil and natural gas system	-39.8~39.8	-25.2~25.2	-25.0~25.0
1.B Overall uncertainty	-26.4~26.4	-23.7~23.9	-24.0~24.1

Chapter 4 Industrial Processes and Product Use (IPPU)

I. Overview

(i) Scope

The GHG Inventory on IPPU covers mineral industry, chemical industry, metal industry, non-energy products from fuels and solvent use, electronics industry, product uses as substitutes for ODS, and other product manufacture and use. Inventory on mineral industry covers CO_2 emissions from cement, lime and glass production. Inventory on chemical industry covers CO_2, N_2O, HFCs, PFCs and SF_6 emissions from ammonia, nitric acid, adipic acid, caprolactam, calcium carbide, titanium dioxide, soda ash, petrochemical and carbon black and fluorochemical production. Inventory on metal industry covers CO_2, CH_4 and PFCs emissions from iron and steel, ferroalloys, aluminium, magnesium, lead and zinc production. Inventory on non-energy products from fuels and solvent use covers CO_2 emissions from the use of lubricants and paraffin waxes as non-energy products. Inventory on electronics industry covers emissions from use of PFCs. Inventory on product uses as substitutes for ODS covers HFCs emissions from use of refrigeration and air conditioning, foam bowing agents, fire protection, and aerosols. Inventory on other product manufacture and use covers emissions from use of SF_6 in the production, installation, operation and retirement of electricity. To avoid double-counting or omissions, short-term carbon sinks from downstream urea and soda ash production were not excluded from IPPU.

(ii) Methods

According to the 2006 IPCC Guidelines, the carbon mass balance method was used for petrochemical and carbon black and iron and steel production under IPPU, while the emission factor method was mainly used for other emission sources. Tier 2 method was used for emissions from cement, lime, ammonia, nitric acid, adipic acid, calcium carbide, petrochemical and carbon black, and HFCs use in fluorochemical production, as well as emissions from iron and steel production, aluminum, semiconductor manufacturing, refrigeration and air conditioning, and SF_6 use in electrical equipment. Tier 1 method was used for other emission sources, as detailed in Table 1-3.

(iii) General

In 2021, China's GHG emissions from IPPU amounted to 2,140 $MtCO_2eq$. Of these, CO_2 emissions were 1,524 Mt, CH_4 emissions were 5,714 t, N_2O emissions were 0.580 Mt, and fluorinated gas emissions were 462 $MtCO_2eq$, accounting for 71.2%, 0.0%, 7.2%, and 21.6%, respectively. CH_4, N_2O and fluorinated gas emissions increased by 6.7%, 18.6% and 19.4% respectively compared to 2020, while CO_2 emissions decreased by 0.5% compared to 2020, as shown in Table 1-4 and Table 1-15.

Table 1-15 Fluorinated Gas Emissions from IPPU (kt)

Fluorinated Gas Category	HFCs												PFCs		SF_6
	HFC-23	HFC-32	HFC-41	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236ea	HFC-236fa	HFC-245fa	HFC-365mfc	CF_4	C_2F_6	
IPPU in 2005	9.1	0.1	NO	0.1	3.3	0.0	0.00	0.0	NO	0.0	0.0	NO	0.6	0.1	0.3
2.A Mineral Industry															
2.B Chemical Industry	9.1	0.0	NO	0.0	0.1	0.0	NO	0.0	NO	0.0	NO	NO	0.0	0.0	0.0
2.C Metal Industry													0.5	0.1	NO
2.D Non-energy Products from Fuels and Solvent Use															
2.E Electronics Industry													0.0	0.0	
2.F Product Uses as Substitutes for ODS	NO	0.0	NO	0.0	3.2	0.0	0.0	0.0	NO	NO	0.0	NO			
2.G Other Product Manufacture and Use															0.3
IPPU in 2020	0.7	55.5	0.0	45.3	50.3	1.2	2.1	2.9	0.0	0.1	0.8	0.0	2.7	0.3	4.0
2.A Mineral Industry															
2.B Chemical Industry	0.7	1.1	0.0	0.7	1.0	0.2	0.2	0.2	0.0	0.0	0.1	NO	0.0	0.0	0.1
2.C Metal Industry													2.6	0.3	NO
2.D Non-energy Products from Fuels and Solvent Use															
2.E Electronics Industry													0.1	0.0	
2.F Product Uses as Substitutes for ODS	0.0	54.4	0.0	44.6	49.4	1.1	1.9	2.8	NO	0.1	0.7	0.0			
2.G Other Product Manufacture and Use															3.9
IPPU in 2021	1.7	67.3	0.0	53.1	59.0	2.2	2.3	3.5	0.0	0.1	1.4	0.0	2.9	0.3	4.4
2.A Mineral Industry															
2.B Chemical Industry	1.7	1.2	0.0	0.9	1.0	0.3	0.2	0.2	0.0	0.0	0.1	NO	0.0	0.0	0.1
2.C Metal Industry													2.7	0.3	NO

Fluorinated Gas Category	**HFCs**												**PFCs**		**SF_6**
	HFC-23	**HFC-32**	**HFC-41**	**HFC-125**	**HFC-134a**	**HFC-143a**	**HFC-152a**	**HFC-227ea**	**HFC-236ea**	**HFC-236fa**	**HFC-245fa**	**HFC-365mfc**	**CF_4**	**C_2F_6**	
2.D Non-energy Products from Fuels and Solvent Use															
2.E Electronics Industry													0.2	0.0	
2.F Product Uses as Substitutes for ODS	0.0	66.1	0.0	52.2	58.0	2.0	2.2	3.4	NO	0.1	1.4	0.0			
2.G Other Product Manufacture and Use															4.3

Notes: 1). Shaded cells do not require entries;

2). 0.0 indicates that the value is less than 0.05.

3). "NO" (not occurring) indicates that a particular source or sink category do not occur.

4). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

5). Due to rounding, the aggregation of various items may be slightly different from the total.

(iv) Uncertainty Assessment

Based on the propagation of error method, the uncertainties of the GHG inventories on IPPU for 2005, 2020 and 2021 were from -4.5% to 4.5%, -3.8% to 3.8% and -4.0% to 4.0%, respectively, as detailed in Table 1-16.

Table 1-16 Uncertainty Assessment for IPPU (%)

Source Categories	2005	2020	2021
2.A Mineral Industry	-4.4~4.4	-4.5~4.5	-4.4~4.4
2.B Chemical Industry	-11.0~11.0	-4.9~4.9	-5.1~5.1
2.C Metal Industry	-9.2~9.2	-8.3~8.3	-8.2~8.2
2.D Non-energy Products from Fuels and Solvent Use	-51.2~51.2	-51.2~51.2	-51.2~51.2
2.E Electronics Industry	-13.8~13.8	-13.8~13.8	-14.0~14.0
2.F Product Uses as Substitutes for ODS	-20.0~20.0	-20.0~20.0	-20.0~20.0
2.G Other Product Manufacture and Use	-22.4~22.4	-22.4~22.4	-22.4~22.4
Overall uncertainty	-4.5~4.5	-3.8~3.8	-4.0~4.0

II. Mineral Industry

In 2021, China's CO_2 emissions from mineral industry were 1,013 Mt, decreased by 2.1% from 2020. Of these, CO_2 emissions from the cement production were 802 Mt, decreased by 3.2% from 2020, mainly due to the impact of lower cement clinker outputs. CO_2 emissions from lime and glass production were 188 Mt and 22 Mt, respectively, an increase of 1.6% and 6.8% compared to 2020, mainly due to the impact of lime and flat glass outputs. See Table 1-17 for details.

Table 1-17 CO_2 Emissions from Mineral Industry (Mt)

Source Categories	2005	2020	2021
2.A Mineral Industry	526	1,035	1,013
2.A.1 Cement production	412	829	802
2.A.2 Lime production	106	186	188
2.A.3 Glass production	9	21	22

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

(i) Category Description

GHG emissions from mineral industry include CO_2 emissions from cement, lime and glass production. The carbon dioxide is released due to the decomposition of calcium carbonate and magnesium carbonate contained in the limestone and dolomite during the calcination process in the cement clinker and lime kilns, as well as the decomposition of carbonate minerals such as limestone, dolomite, and soda ash during the glass melting process.

(ii) Methods

Tier 2 method was used for GHG emissions from cement and lime production, and Tier 1 method was used for glass production. The activity data were mainly derived from NBS, the statistical reporting system for climate change, and CBMF, as shown in Table 1-18. Emission factors for cement production and lime production and glass production were derived from typical enterprise surveys.

Table 1-18 Major Activity Data on Mineral Industry (Mt)

Activity Data	2005	2020	2021
Cement clinker outputs	764.710	1,580.000	1,530.000
Lime outputs	154.300	269.000	273.000
Flat glass outputs	20.105	47.614	50.864

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainties of the GHG emissions from mineral industry for 2005, 2020 and 2021 were from -4.4% to 4.4%, -4.5% to 4.5%, and -4.4% to 4.4%, respectively, as detailed in Table 1-19.

Table 1-19 Uncertainty Assessment for Mineral Industry (%)

Source Categories	2005	2020	2021
2.A.1 Cement production	-5.5~5.5	-5.5~5.5	-5.5~5.5
2.A.2 Lime production	-5.0~5.0	-5.0~5.0	-5.0~5.0
2.A.3 Glass production	-3.5~3.5	-3.5~3.5	-3.5~3.5
2.A Overall uncertainty	-4.4~4.4	-4.5~4.5	-4.4~4.4

III. Chemical Industry

In 2021, China's GHG emissions from chemical industry reached 512 $MtCO_2eq$, a 10.8% increase from 2020. Of these, ammonia, adipic acid, and petrochemical and carbon black production were the largest emission sources. In 2021, GHG emissions from ammonia, adipic acid, and petrochemical and carbon black production were 143 $MtCO_2eq$, 121 $MtCO_2eq$, and 158 $MtCO_2eq$, respectively, an increase of 1.4%, 21.4%, and 7.2% compared to 2020. In 2021, GHG emissions from adipic acid production were 9.442 $MtCO_2eq$, an increase of 12.2% compared to 2020, mainly due to the increase in adipic acid outputs. In 2021, GHG emissions from fluorochemical production amounted to 29 $MtCO_2eq$, a 75.5% increase from 2020. This was primarily due to China's phase-down of HCFCs in accordance with the schedule for Article 5 countries under the Montreal Protocol, in order to achieve the 32.5% reduction target by the end of 2020. As a result, the production and use of HFCs, which are HCFCs substitutes, increased, as detailed in Table 1-15 and Table 1-20.

Table 1-20 GHG Emissions from Chemical Industry ($MtCO_2eq$)

Year	Source Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
2005	**2.B Chemical Industry**	**156.081**		**28.736**	**112.896**	**0.004**	**0.403**	**298.121**
	2.B.1Ammonia production	126.818						126.818
	2.B.2 Nitric acid production			12.463				12.463
	2.B.3 Adipic acid production			15.768				15.768
	2.B.4 Caprolactam production			0.506				0.506
	2.B.5 Calcium carbide production	8.418						8.418
	2.B.6 Titanium dioxide production	0.009						0.009
	2.B.7 Soda ash production	0.122						0.122

Year	Source Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	2.B.8 Petrochemical and carbon black production	20.714						20.714
	2.B.9 Fluorochemical production				112.896	0.004	0.403	113.304
2020	**2.B Chemical Industry**	**315.761**		**129.521**	**14.215**	**0.127**	**2.363**	**461.986**
	2.B.1Ammonia production	141.188						141.188
	2.B.2 Nitric acid production			21.331				21.331
	2.B.3 Adipic acid production			99.773				99.773
	2.B.4 Caprolactam production			8.417				8.417
	2.B.5 Calcium carbide production	26.272						26.272
	2.B.6 Titanium dioxide production	0.428						0.428
	2.B.7 Soda ash production	0.201						0.201
	2.B.8 Petrochemical and carbon black production	147.673						147.673
	2.B.9 Fluorochemical production				14.215	0.127	2.363	16.705
2021	**2.B Chemical Industry**	**328.775**		**153.595**	**27.255**	**0.151**	**1.904**	**511.679**
	2.B.1Ammonia production	143.181						143.181
	2.B.2 Nitric acid production			23.012				23.012
	2.B.3 Adipic acid production			121.142				121.142
	2.B.4 Caprolactam production			9.442				9.442
	2.B.5 Calcium carbide production	26.579						26.579
	2.B.6 Titanium dioxide production	0.504						0.504
	2.B.7 Soda ash production	0.212						0.212
	2.B.8 Petrochemical and carbon black production	158.299						158.299
	2.B.9 Fluorochemical production				27.255	0.151	1.904	29.309

Note: 1). 0.000 indicates that the value is less than 0.0005.
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). Shaded cells do not require entries.

(i) Category Description

GHG emissions from ammonia production include CO_2 emissions from feedstocks such as anthracite and natural gas during the gasification and reforming process. Emissions from nitric acid production include N_2O emissions from the ammonia catalytic oxidation process. Emissions from adipic acid production mainly include N_2O emissions from use of nitric acid oxidisers. Emissions from caprolactam production include N_2O emissions from the oxidation of ammonia. Emissions from calcium carbide production include CO_2 emissions from the production of calcium carbide using feedstocks such as lime and charcoal, and from the acetylene production using calcium carbide. The main source of CO_2 emissions in titanium dioxide production was the oxidation of petroleum coke during the chloride process used to make rutile-type titanium dioxide. The main source of emissions in soda ash production was the calcination of natural soda ash in the reverberatory furnace, which generates carbon dioxide as a by-product of producing soda ash. Petrochemical and carbon black production mainly emitted CO_2 during methanol and ethylene production processes. GHG emissions from fluorochemical production in China include HFC-23 emissions from HCFC-22 production and fugitive emissions from HFCs, PFCs and SF_6 production.

(ii) Methods

1. Ammonia production

GHG emissions from ammonia production were calculated using Tier 2 method. The activity data on ammonia was mainly derived from the China Industry Statistical Yearbook, where the proportion of ammonia based on coal, natural gas and coke oven gas as feedstock was referenced from the China Energy Statistical Yearbook and public research reports on the ammonia industry. Emission factors for ammonia production were calculated based on data reported by companies in the national carbon market.

2. Nitric acid production

GHG emissions from nitric acid production were calculated using Tier 2 method, with N_2O emissions calculated based on output data and emission factors by different production technology. Nitric acid production was derived from statistics of China Nitrogen Fertilizer Industry Association (CNFA). Emission factors were calculated based on typical survey data for the high-pressure method, double-pressurisation method and other technology types.

3. Adipic acid production

GHG emissions from adipic acid production were calculated using Tier 2 method. The adipic acid output was derived from the research reports on industry developments by relevant domestic think tanks and other public information, and the emission factors by technology type were calculated based on typical surveys.

4. Caprolactam production

GHG emissions from caprolactam production were calculated using Tier 1 method. The caprolactam output was derived from the CFCIF's research report on industry developments and other public information, and the emission factors were derived from the default emission factors of the 2006 IPCC Guidelines.

5. Calcium carbide production

GHG emissions from calcium carbide production were calculated using Tier 2 method, and the activity data on calcium carbide production were mainly derived from the China Industry Statistical Yearbook, and the emission factors calculated based on data reported by companies in the national carbon market.

6. Titanium dioxide production

GHG emissions from titanium dioxide production were calculated using Tier 1 method, with titanium dioxide output derived from relevant information from industry organizations and emission factors using default emission factors from the 2006 IPCC Guidelines.

7. Soda ash production

GHG emissions from soda ash production were calculated using Tier 1 method, with soda ash output sourced from corporate reports, and emission factors referenced to the purity of China's soda ash and default emission factors from the 2006 IPCC Guidelines.

8. Petrochemical and carbon black production

GHG emissions from methanol and ethylene production were calculated using Tier 2 method. Emissions were calculated for methanol production, which was divided into feedstock routes based on coal, coke oven gas and natural gas, and for ethylene production, which was divided into feedstock routes based on naphtha and ethane. The total output data of methanol and ethylene were from the statistics of CPCIF, the outputs of different feedstock routes referred to the data of industry reports, and the emission factors were derived from data reported by companies in the national carbon market.

9. Fluorochemical production

HFC-23 emissions from HCFC-22 production were calculated using Tier 2 method. Fugitive emissions from the production of HFC-23, HFC-32, HFC-41, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-236ea, HFC-236fa, and HFC-245fa, CF_4, C_2F_6, and SF_6 were calculated using Tier 1 method. The amount of HFC-23 produced as a by-product of HCFC-22 was calculated by enterprises using monitoring data or the mass balance method. Emission factors for the production of HFCs, PFCs and SF_6 used default emission factors from the 2006 IPCC Guidelines. The data on the output of HCFC-22 and HFCs were obtained from the Office of the National Leading Group for the Protection of the Ozone Layer, and the data on the production of PFCs and SF_6 were calculated through questionnaire surveys of the producers and consultation with industry experts.

Major activity data on chemical industry can be found in Table 1-21.

Table 1-21 Major Activity Data on Chemical Industry (Mt)

Activity Data	2005	2020	2021
Ammonia outputs	45.963	51.171	51.894
Nitric acid outputs	5.185	13.100	14.270
Adipic acid outputs	0.203	1.554	1.889
Caprolactam outputs	0.212	3.529	3.959
Calcium carbide outputs (discounted at 300 L/kg)	8.946	27.919	28.246
Titanium dioxide outputs	0.007	0.319	0.376
Soda ash outputs	0.890	1.466	1.545
Methanol outputs	5.362	55.000	56.000
Ethylene outputs	7.289	21.600	28.257
HCFC-22 outputs	0.312	0.689	0.767

Note: Ethylene outputs here refers to output data by steam cracking of petroleum-based feedstocks.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainties of the GHG emissions from chemical industry for 2005, 2020 and 2021 were from -11.0% to 11.0%, -4.9% to 4.9%, and -5.1% to 5.1%, respectively, as detailed in Table 1-22.

Table 1-22 Uncertainty Assessment for Chemical Industry (%)

Source Categories	2005	2020	2021
2.B.1Ammonia production	-8.9~8.9	-8.9~8.9	-8.9~8.9
2.B.2 Nitric acid production	-14.1~14.1	-14.1~14.1	-14.1~14.1
2.B.3 Adipic acid production	-14.1~14.1	-14.1~14.1	-14.1~14.1
2.B.4 Caprolactam production	-40.1~40.1	-40.1~40.1	-40.1~40.1
2.B.5 Calcium carbide production	-4.9~4.9	-4.9~4.9	-4.9~4.9
2.B.6 Titanium dioxide production	-10.1~10.1	-10.1~10.1	-10.1~10.1
2.B.7 Soda ash production	-2.2~2.2	-2.2~2.2	-2.2~2.2
2.B.8 Petrochemical and carbon black production	-6.7~6.7	-7.5~7.5	-7.3~7.3
2.B.9 Fluorochemical production	-27.0~27.0	-27.0~27.0	-27.0~27.0
2.B Overall uncertainty	-11.0~11.0	-4.9~4.9	-5.1~5.1

IV. Metal Industry

In 2021, China's GHG emissions from metal industry were 201.221 $MtCO_2eq$, an increase of 0.7% from 2020. Of these, emissions from ferroalloys production, aluminium production, lead production and zinc production were 51.100 $MtCO_2eq$, 75.913 $MtCO_2eq$, 1.279 $MtCO_2eq$ and 3.566 $MtCO_2eq$, respectively, increased by 1.7%, 2.8%, 5.0% and 12.3% from 2020, mainly due to the increase in the outputs of ferroalloys, aluminium, lead and zinc. In 2021, emissions from iron and steel production and magnesium production were 65.490 $MtCO_2eq$ and 3.873 $MtCO_2eq$, respectively, a decrease of 2.3% and 11.3% compared to 2020, mainly due to the decrease in the outputs of steel and magnesium, as detailed in Table 1-23.

Table 1-23 GHG Emissions from Metal Industry ($MtCO_2eq$)

Year	Source Categories	CO_2	CH_4	PFCs	Total
2005	**2.C Metal Industry**	**64.532**	**0.090**	**4.376**	**68.998**
	2.C.1 Iron and steel production	25.919			25.919
	2.C.2 Ferroalloys production	23.230	0.090		23.320
	2.C.3 Aluminium production	12.386		4.376	16.762
	2.C.4 Magnesium production	2.293			2.293
	2.C.5 Lead production	0.386			0.386
	2.C.6 Zinc production	0.318			0.318
2020	**2.C Metal Industry**	**178.933**	**0.150**	**20.830**	**199.913**
	2.C.1 Iron and steel production	67.029			67.029
	2.C.2 Ferroalloys production	50.120	0.150		50.270
	2.C.3 Aluminium production	53.024		20.830	73.855
	2.C.4 Magnesium production	4.365			4.365
	2.C.5 Lead production	1.218			1.218
	2.C.6 Zinc production	3.176			3.176
2021	**2.C Metal Industry**	**179.433**	**0.160**	**21.628**	**201.221**

Year	Source Categories	CO_2	CH_4	PFCs	Total
	2.C.1 Iron and steel production	65.490			65.490
	2.C.2 Ferroalloys production	50.940	0.160		51.100
	2.C.3 Aluminium production	54.285		21.628	75.913
	2.C.4 Magnesium production	3.873			3.873
	2.C.5 Lead production	1.279			1.279
	2.C.6 Zinc production	3.566			3.566

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). Shaded cells do not require entries.

(i) Category Description

GHG emissions from iron and steel production mainly include from CO_2 emissions from the decomposition and oxidation of fluxes during the preparation of feedstocks for ironmaking and the production of crude steel. According to the China's data statistics base, iron-making reductant emissions such as pulverised coal and coke and steel-making carbon reduction emissions were reported under Energy, and CO_2 emissions from the consumption of fluxes such as limestone, dolomite and magnesite by steel producers were reported for iron and steel production. Emissions from ferroalloys production were mainly from the combustion and conversion of reductants and feedstocks, and include CO_2 emissions from the consumption of graphite electrodes in electric arc furnaces, and the volatilisation of carbon-containing feedstocks in the form of CH_4. Emissions from aluminium production include CO_2 emissions from anode consumption during the conversion of alumina to primary aluminium, and CF_4 and C_2F_6 emissions from the anode effect during primary aluminium production. Emissions from magnesium production include CO_2 emissions from the calcination of carbonate ores, and magnesium production in China does not currently involve SF_6 emissions. Emissions from lead production were sourced from the use of coke, coal, etc. as a reducing agent and the production of recycled lead. Emissions from zinc production were sourced from the use of coke, coal, etc. as a reducing agent and the production of recycled zinc in the zinc production industry. As ferroalloys, lead and zinc emissions involve the use of energy as a feedstock, this part of the emissions needs to be excluded from Energy.

(ii) Methods

GHG emissions from iron and steel production were calculated using Tier 2 method. The iron output was from the China Steel Yearbook. Emission factors for the consumption of limestone, dolomite and magnesite as fluxes were obtained from special studies.

GHG emissions from ferroalloys production were calculated using Tier 1 method, with ferroalloys output sourced from the China Industry Yearbook and emission factors using default emission factors from the 2006 IPCC Guidelines.

GHG emissions from aluminium production were calculated using Tier 2 method, with aluminium output and emission factors sourced from CNIA.

GHG emissions from magnesium production were calculated using Tier 1 method. Raw magnesium output data was derived from the China Industry Yearbook and emission factors were based on the 2018 inventory.

GHG emissions from lead and zinc production were calculated using the Tier 1 emission factor method. Mineral lead, recycled lead, pyrozinc and recycled zinc outputs were derived from the statistical data of CNIA, and the emission factors adopted the default emission factors of the 2006 IPCC Guidelines, with specific activity data detailed in Table 1-24.

Table 1-24 Major Activity Data on Metal Industry (Mt)

Outputs of Metal Industry	2005	2020	2021
Iron	343.752	888.976	868.568
Ferroalloys	9.302	21.399	21.749
Aluminium	7.790	37.080	38.500
Magnesium	0.451	0.858	0.762
Lead	2.391	5.513	5.806
Zinc	0.618	1.402	1.529

Note: Ferroalloys activity data here cover ferrosilicon alloys, ferromanganese alloys, ferrochrome alloys, silicomanganese alloys and silicon metal.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainties of the GHG emissions from metal industry for 2005, 2020 and 2021 were from -9.2% to 9.2%, -8.3% to 8.3%, and -8.2% to 8.2%, respectively (Table 1-25).

Table 1-25 Uncertainty Assessment for Metal Industry (%)

Source Categories	2005	2020	2021
2.C.1 Iron and steel production	-20.6~20.6	-20.6~20.6	-20.6~20.6
2.C.2 Ferroalloys production	-13.3~13.3	-13.3~13.3	-13.3~13.3
2.C.3 Aluminium production	-8.5~8.5	-8.5~8.5	-8.5~8.5
2.C.4 Magnesium production	-2.4~2.4	-2.4~2.4	-2.4~2.4
2.C.5 Lead production	-22.4~22.4	-22.4~22.4	-22.4~22.4
2.C.6 Zinc production	-22.4~22.4	-22.4~22.4	-22.4~22.4
2.C Overall uncertainty	-9.2~9.2	-8.3~8.3	-8.2~8.2

V. Non-energy Products from Fuels and Solvent Use

In 2021, China's GHG emissions from non-energy products from fuels and solvent use were 2.748 Mt CO_2, an increase of 10.9% from 2020. Of these, emissions from lubricant use were 1.603 Mt CO_2, a decrease of 1.4% from 2020. Emissions from paraffin wax use were 1.145 Mt CO_2, an increase of 34.6% from 2020, mainly due to changes in lubricant and paraffin use (see Table 1-26).

Table 1-26 GHG Emissions from Non-energy Products from Fuels and Solvent Use ($MtCO_2$)

Source Categories	2005	2020	2021
2.D Non-energy Products from Fuels and Solvent Use	1.972	2.477	2.748
2.D.1 Lubricant use	1.368	1.626	1.603
2.D.2 Paraffin wax use	0.604	0.851	1.145

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

(i) Category Description

GHG emissions from non-energy products from fuels and solvent use include CO_2 emissions from lubricant and paraffin wax use.

(ii) Methods

CO_2 emissions from use of lubricants and paraffin waxes were calculated using Tier 1 method. The amount of lubricant and paraffin wax used was derived from the China Energy Statistical Yearbook, and emission factors used default emission factors from the 2006 IPCC Guidelines.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty in estimating GHG emissions from non-energy products from fuels and solvent use was from -51.2% to 51.2%.

VI. Electronics Industry

In 2021, China's GHG emissions from electronics industry were 1.273 $MtCO_2eq$, an increase of 95.9% from 2020 (Table 1-27). China's PFCs emissions from electronics industry cover both semiconductor manufacturing and liquid crystal display (LCD) manufacturing, and were reported in semiconductor manufacturing as the data statistics in the previous period did not distinguish between the above categories.

Table 1-27 GHG Emissions from Electronics Industry ($MtCO_2eq$)

Source Categories	2005	2020	2021
2.E Electronics Industry	0.157	0.650	1.273
2.E.1 Semiconductor manufacturing	0.157	0.650	1.273
2.E.2 LCD manufacturing	IE	IE	IE

Note: "IE" (included elsewhere) indicates that a particular source or sink category has been estimated and reported under other sub-sectors.

(i) Category Description

GHG emissions from electronics industry were sourced from the use of PFCs feedstock gases in processes such as etching and cleaning in the production of semiconductors and LCD panels, as well as from the generation of CF_4 as a by-product of the production process.

(ii) Methods

GHG emissions from electronics industry were calculated using Tier 2 method, where the amount of PFCs used was derived from enterprise surveys and expert judgement, as shown in Table 1-28, the emission factor for the use process was derived from expert judgement, and the other parameters were derived from default emission factors of the 2006 IPCC Guidelines.

Table 1-28 Major Activity Data on Electronics Industry (t)

Activity Data	2005	2020	2021
Amount of CF_4 used	51.7	189.1	405.3
Amount of C_2F_6 used	17.8	248.0	245.6

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty in estimating GHG emissions from electronics industry was from -14.0% to 14.0%.

VII. Product Uses as Substitutes for ODS

In 2021, China's GHG emissions from product uses as substitutes for ODS were 308.598 $MtCO_2eq$, an increase of 19.5% from 2020. Of these, the emissions of refrigeration and air conditioning, foam bowing agents, fire protection and aerosols were 290.380 $MtCO_2eq$, 1.387 $MtCO_2eq$, 10.975 $MtCO_2eq$ and 5.856 $MtCO_2eq$, respectively, an increase of 18.5%, 66.8%, 15.5% and 94.3% compared to 2020, mainly due to the increase in the use of HFCs, as shown in Table 1-29.

Table 1-29 HFCs Emissions from Product Uses as Substitutes for ODS ($MtCO_2eq$)

Source Categories	2005	2020	2021
2.F Product Uses as Substitutes for ODS	4.456	258.348	308.598
2.F.1 Refrigeration and air conditioning	4.275	244.999	290.380
2.F.2 Foam bowing agents	0.029	0.832	1.387
2.F.3 Fire protection	0.099	9.504	10.975
2.F.4 Aerosols	0.053	3.013	5.856

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

(i) Category Description

GHG emissions from product uses as substitutes for ODS mainly include HFCs emissions from the use of refrigeration and air conditioning, foam bowing agents, fire protection and aerosols. Among them, refrigeration and air conditioning are used in room air conditioners, automotive air conditioners and commercial and industrial refrigeration air conditioners, etc., and the types of HFCs involved include R-410A, R-407C, R-404A, HFC-134a and HFC-32, etc. Foam bowing agents include polyurethane foams and extruded polystyrene foams, and the types of HFCs involved include HFC-134a, HFC-152a, HFC-227ea, HFC-245fa, and HFC-365mfc. HFCs are used in fixed fire extinguishing systems and portable fire protection equipment, and the types of HFCs involved include HFC-227ea and HFC-236fa. Aerosols include both medical and non-medical aerosols, and the types of HFCs involved include HFC-134a, HFC-152a and HFC-227ea. Emissions from the use of HFCs in the electronics and cleaning sectors were not included due to small amount of HFCs used.

(ii) Methods

HFCs emissions from refrigeration and air conditioning were calculated using Tier 2 method. Activity data cover HFC emissions throughout the product life cycle of product/equipment processing, in-service (including operation and maintenance), and waste disposal. Emissions from foam bowing agent, fire extinguisher and aerosol use were calculated using Tier 1 method. Activity data were obtained from the Office of the National Leading Group for the Protection of the Ozone Layer and national fluorine statistics, and emission factors used default emission factors from the 2006 IPCC Guidelines. The details of the activity data can be found in Table 1-30.

Table 1-30 Major Activity Data Variables for HFCs Use for 2005 and 2020-2021 (kt)

Year	HFCs category	Refrigeration and air conditioning	Foam bowing agents	Fire protection	Aerosols
2005	HFC-23	NO			
	HFC-32	0.6			
	HFC-41	NO			
	HFC-125	0.6			
	HFC-134a	6.0	0.0		0.1
	HFC-143a	0.0			
	HFC-152a	NO	0.4		NO
	HFC-227ea		NO	0.7	NO
	HFC-236fa				NO
	HFC-236ea			NO	
	HFC-245fa	NO	0.6		
	HFC-365mfc		NO		
2020	HFC-23	0.0			
	HFC-32	115.1			
	HFC-41	0.0			
	HFC-125	37.9			
	HFC-134a	36.4	2.0		3.0
	HFC-143a	2.4			
	HFC-152a	NO	5.0		3.0
	HFC-227ea		0.0	29.2	0.3
	HFC-236fa				NO
	HFC-236ea			0.0	
	HFC-245fa	0.1	8.4		
	HFC-365mfc		0.2		
2021	HFC-23	0.0			
	HFC-32	126.7			
	HFC-41	0.0			
	HFC-125	44.7			
	HFC-134a	41.8	1.0		4.0
	HFC-143a	7.8			
	HFC-152a	NO	2.0		NO
	HFC-227ea		0.0	25.5	0.4
	HFC-236fa				NO
	HFC-236ea			NO	
	HFC-245fa	0.3	8.7		
	HFC-365mfc		0.4		

Note: 1). 0.0 indicates that the value is less than 0.05.

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). Shaded cells do not require entries.

4). "NO" (not occurring) indicates that a particular source or sink category do not occur.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty in estimating GHG emissions from product uses as substitutes for ODS was from -20.0% to 20.0%.

VIII. Other Product Manufacture and Use

Emissions from other product manufacture and use include those from SF_6 use in electrical equipment. In 2021, China's emissions from other product manufacture and use were 101 $MtCO_2eq$, an increase of 12.0% from 2020, mainly due to elevated demand for SF_6 as a result of growth in demand for electricity and upgrades to the power grid.

(i) Category Description

The sources of GHG emissions from SF_6 use in electrical equipment mainly include manufacture and installation, use and operation, and end-of-life disposal of electrical equipment in the power industry. Among them, the statistics on the use of electrical equipment currently only cover power generation companies and power transmission, and the statistics on end-use electricity consumption only cover the electrical equipment used in the railway sector.

(ii) Methods

GHG emissions from SF_6 use in electrical equipment were calculated using the Tier 2 emission factor method. The consumption and filling volume of SF_6 in new electrical equipment, as well as the increased use of SF_6 from retired electrical equipment by grid companies, were derived from the statistical reporting system on climate change. The data on recovered volume was obtained from surveys of grid companies, while emission factors were based on the 2018 inventory.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty in estimating emissions from SF_6 use in electrical equipment was from -22.4% to 22.4%.

Chapter 5 Agriculture

I. Overview

(i) Scope

The Inventory of Agriculture covers CH_4 emissions from enteric fermentation, CH_4 and N_2O emissions from manure management, CH_4 emissions from rice cultivation, N_2O emissions from agricultural soils, and CH_4 and N_2O emissions from field burning of agricultural residues. Enteric fermentation emissions include CH_4 emissions from 12 livestock species including beef cattle, dairy cattle, goats and sheep, etc. Manure management emissions include CH_4 emissions and direct and indirect N_2O emissions from 14 livestock species such as dairy cattle, beef cattle, goats, sheep, swine and poultry, etc. Rice cultivation emissions include CH_4 emissions from single cropping rice, early rice and late rice of double cropping rice in rice growing season, and from winter-flooding paddy fields in non-rice growing season. N_2O emissions from agricultural soils include the direct N_2O emissions of 11 different types of agricultural soils including dryland, rice paddies with different rotations, vegetable fields, orchards, tea plantations, and pasture from the application of chemical fertilizers, animal manure, and crop residues, and the indirect N_2O emissions due to N inputs causing volatile N deposition, N leaching and runoff, as well as the direct and indirect N_2O emissions from mineralization of agricultural soils. The inventory didn't subtract the carbon captured during urea production in IPPU, so it also didn't include CO_2 emissions from the application of urea to agricultural soils. Moreover, due to data unavailability, the current inventory didn't include CO_2 emissions from the application of lime and dolomite to agricultural soils. Additionally, since there is no organic soil cultivation in China, its emissions have not been reported.

(ii) Methods

CH_4 emissions from enteric fermentation were calculated using Tier 2 method of the 2006 IPCC Guidelines for major sources such as beef cattle, dairy cattle, buffalo, sheep and goats, and Tier 1 method for other sources. CH_4 and N_2O emissions from manure management were calculated using Tier 2 method of the 2006 IPCC Guidelines for major sources such as swine, beef cattle, dairy cattle, poultry, buffalo, sheep and goats, and Tier 1 method for other sources. Manure management emissions include both direct N_2O emissions, and indirect N_2O emissions caused by volatile N deposition and N leaching and runoff. With regard to CH_4 emissions from rice cultivation, the CH_4MOD[3] model (Tier 3) was used for single cropping rice, early rice and late rice of double cropping rice in rice growing season, and empirical models (Tier 2) [4]were used for winter-flooding paddy fields in non-rice growing season. As for the former, the CH_4MOD model calculated the CH_4 emission factors of different types of rice fields based on the CH_4 generation, transmission, and emission mechanisms in rice growing season, and then calculated and aggregated CH_4 emissions at the prefecture/city level based on statistical data on the area of different types of rice fields. As for the latter, the CH_4 emission from winter-flooding paddy fields in non-rice growing season was calculated using empirical models, equivalent to the Tier 2 method of the 2006 IPCC Guidelines. N_2O emissions from agricultural soils were calculated using the IAP-N model[5] based on the Chinese crop farming system to calculate the N inputs of direct and indirect N_2O emissions from different types of agricultural soils by region, and to obtain N_2O emissions derived by applying the relevant emission factors. Direct and indirect N_2O emissions from soils mineralization and grazing animals, and CH_4 and N_2O emissions from field burning of agricultural residues were calculated using Tier 1 method, as shown in Table 1-3.

(iii) General

In 2021, China's GHG emissions from Agriculture were 931 $MtCO_2$eq. Of which, CH_4 emissions were 24.279 Mt, and N_2O emissions were 0.949 Mt, accounting for 73.0% and 27.0%, and increased by 2.4% and 0.3% respectively compared to 2020, as shown in Table 1-4.

(iv) Uncertainty Assessment

Based on the error propagation method, the uncertainties of the GHG emissions from

[3] Huang, Y, Zhang, W., Zheng, X.H., Li, J. and Yu, Y.Q. (2004). Modeling methane emission from rice paddies with various agricultural practices. Journal of Geophysical Research-Atmospheres 109 (D8): Art. No. D08113 APR 29 2004.

[4] Xiumei Ma, Bo Zhu, Zelin Du, and Xunhua Zheng. Study on Greenhouse Gas Emission Fluxes during the Winter Fallow Period of Paddy Fields, Journal of Agro-Environmental Science, 2005, 24: 1199-1202.

[5] Zheng, X., C. Liu C, S. Han. Description and application of a model for simulating regional nitrogen cycling and calculating nitrogen flux Advances in Atmospheric Sciences 2008a, 25(2): 181-201.

Agriculture for 2005, 2020 and 2021 were from -13.7% to 20.4%, -13.6% to 20.2%, and -13.8% to 20.2%, respectively (see Table 1-31).

Table 1-31 Uncertainty Assessment for Agriculture (%)

Source Categories	2005	2020	2021
3.A Enteric fermentation	-21.0~21.0	-21.4~21.4	-21.8~21.8
3.B Manure management	-55.2~55.2	-44.2~44.2	-44.9~44.9
3.C Rice cultivation	-25.8~32.9	-29.7~37.8	-29.7~37.9
3.D Agricultural soils	-13.8~66.7	-14.1~66.6	-14.2~66.5
3.F Field burning of agricultural residues	-47.6~47.6	-48.2~48.2	-48.2~48.2
Overall uncertainty	-13.7~20.4	-13.6~20.2	-13.8~20.2

II. Enteric Fermentation

In 2021, China's GHG emissions from enteric fermentation were 322.493 $MtCO_2eq$, an increase of 2.4% compared to 2020. Among them, the emissions from cattle, sheep, and swine were 204.830 $MtCO_2eq$, 60.337 $MtCO_2eq$, and 18.867 $MtCO_2eq$, respectively, an increase of 1.7%, 6.4%, and 10.5% compared to 2020. This was mainly due to the increase in the population of major livestock such as cattle and swine by 2.7% and 10.5%, respectively, compared to 2020. Other livestock emissions were 38.458 $MtCO_2eq$, a decline of 2.9% from 2020, as detailed in Table 1-32 and Table 1-33.

Table 1-32 CH_4 Emissions from Enteric Fermentation ($MtCO_2eq$)

Source Categories	2005	2020	2021
3.A Enteric fermentation	313.705	314.784	322.493
3.A.1 Cattle	219.294	201.401	204.830
3.A.2 Sheep	36.442	56.683	60.337
3.A.3 Swines	12.129	17.074	18.867
3.A.4 Other livestock	45.840	39.626	38.458

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

(i) Category Description

Most CH_4 emissions from enteric fermentation were sourced from the microbes living in their digestive systems fermenting feed as part of normal digestion. This includes animals like dairy cattle, beef cattle, buffalo, yaks, other cattle, sheep, goats, swines, camels, horses, donkeys, and mules.

(ii) Methods

CH_4 emissions from enteric fermentation were calculated using Tier 2 method for major sources such as beef cattle, dairy cattle, buffalo, sheep and goats, and Tier 1 method for other sources. The numbers of cattle, sheep, swines and other animals were sourced from the China Statistical Yearbook, the China Animal Husbandry and Veterinary Science Yearbook, as well as the statistical data of the livestock industry in China (see Table 1-33). The emission factors for animals, specifically for key sources, were mainly calculated based on survey data, and determined based on parameters such as animal growth characteristics, feed types, feed intake, feed quality, and digestibility. At the same time, according to the characteristics of livestock and poultry farming in China, intensive, household, and grazing farming methods were distinguished, and the CH_4 emission factors from enteric fermentation for different livestock types, farming methods, and life stages were calculated by region.

Table 1-33 Major Activity Data on Enteric Fermentation

Activity Data	2005	2020	2021
Cattle in stock (M)	109.908	95.621	98.172
Sheep in stock (M)	151.337	173.095	186.377
Swines in stock (M)	433.191	406.504	449.924
Other livestock in stock (M)	165.630	140.482	140.012

Note: According to Chinese statistical standards, "cattle" includes beef cattle, dairy cattle, yaks, buffalo, and other cattle.

(iii) Uncertainty Assessment

Based on the error propagation method, the uncertainties of the CH_4 emissions from enteric fermentation for 2005, 2020 and 2021 were from -21.0% to 21.0%, -21.4% to 21.4%, and -21.8% to 21.8%, respectively.

III. Manure Management

In 2021, China's GHG emissions from manure management were 165.115 $MtCO_2eq$, an increase of 6.3% compared to 2020. Of these, the emissions from cattle, sheep, and swines were 34.327 $MtCO_2eq$, 4.572 $MtCO_2eq$, and 91.856 $MtCO_2eq$, respectively, increased by 2.8%, 9.4%, and 11.1% compared to 2020. This was mainly due to the increase in the population of major livestock such as cattle and swines. The emissions from other livestock were 34 $MtCO_2eq$, a decrease of 2.3% from 2020, as shown in Table 1-34.

Table 1-34 Emissions from Manure Management ($MtCO_2eq$)

Source Categories		2005	2020	2021
3.B Manure management		139.278	155.387	165.115
3.B.1 Cattle	CH_4	11.047	16.724	17.548
	N_2O	23.577	16.657	16.779
3.B.2 Sheep	CH_4	1.059	2.321	2.506
	N_2O	2.654	1.859	2.066
3.B.3 Swines	CH_4	52.277	70.708	78.786
	N_2O	23.533	11.936	13.070
3.B.4 Other livestock	CH_4	2.925	6.773	6.252
	N_2O	22.204	28.408	28.107

Note: 1). According to Chinese statistical standards, "cattle" includes beef cattle, dairy cattle, yaks, buffalo, and other cattle.
2). Due to rounding, the aggregation of various items may be slightly different from the total.

(i) Category Description

GHG emissions from manure management include direct CH_4 and N_2O emissions from the storage and handling of animal manure prior to its application to the soil, as well as indirect N_2O emissions due to volatilisation of ammonia and NOx with N loss in leaching and runoff processes. Animal categories include dairy cattle, beef cattle, buffalo, yaks, other cattle, sheep, swines, camels, goats, horses, donkeys, mules, poultry and rabbits.

(ii) Methods

CH_4 and N_2O emissions from manure management were calculated using Tier 2 method of the 2006 IPCC Guidelines for major sources such as swine, beef cattle, dairy cattle, poultry, buffalo and goats, and Tier 1 method for other sources. The activity data of various animals were sourced from the China Statistical Yearbook and the China Animal Husbandry and Veterinary Science Yearbook. The emission factors were primarily based on periodic surveys of animal growth parameters, including daily volatile solid excretion, methane generation potential of manure, methane conversion factors, N excreted in animal manure, and manure management practices. At the same time, according to the characteristics of livestock and poultry farming in China, intensive, household, and grazing farming methods were distinguished, and the CH_4 emission factors and direct N_2O emission factors from main manure management practices under these different farming methods were calculated by region.

(iii) Uncertainty Assessment

Based on the error propagation method, the uncertainties of the GHG emissions from manure management for 2005, 2020 and 2021 were from -55.2% to 55.2%, -44.2% to 44.2%, and -44.9% to 44.9%, respectively.

IV. Rice Cultivation

In 2021, CH_4 emissions from rice cultivation were 248 $MtCO_2eq$, basically flat with 2020, as shown in Table 1-4.

(i) Category Description

CH_4 emissions from rice cultivation include those from single cropping rice, early rice and late rice of double cropping rice in rice growing season, and from winter-flooding paddy fields in non-rice growing season. Water management methods were divided into continuous flooding and multiple drainage modes.

(ii) Methods

With regard to CH_4 emissions from rice cultivation, the CH_4MOD model was used for single cropping rice, early rice and late rice of double cropping rice in rice growing season, and empirical models were used for winter-flooding paddy fields in non-rice growing season. As for the former, the CH_4MOD model calculates the CH_4 emission factors of different types of rice fields in rice growing season based on the CH_4 generation, transmission, and emission mechanisms from rice cultivation, and then calculates and aggregates CH_4 emissions at the prefecture/city level based on statistical data on the area of different types of rice fields. The data for the area of mid-season rice, single-cropping late rice, early rice, and double-cropping late rice were sourced from the China Agriculture Statistical Yearbook and the China Rural Statistical Yearbook, while the area of winter-flooding paddy fields was from survey data, as detailed in Table 1-35.

Table 1-35 Major Activity Data on CH_4 Emissions from Rice Cultivation (Mha)

Activity Data	2005	2020	2021
Harvest area with mid-season rice and single-cropping late rice	16.272	20.147	20.097
Harvest area with early rice	6.028	4.751	4.734
Harvest area with double cropping late rice	6.547	5.177	5.090
Winter-flooding paddy fields in non-rice growing season	2.173	1.576	1.523

(iii) Uncertainty Assessment

Based on the error propagation and Monte Carlo Simulation methods, the uncertainties of the CH_4 emissions from rice cultivation for 2005, 2020 and 2021 were from -25.8% to 32.9%, -29.7% to 37.8%, and -29.7% to 37.9%, respectively.

V. Agricultural Soils

In 2021, China's N_2O emissions from agricultural soils were 190 $MtCO_2eq$, essentially unchanged from 2020, as shown in Table 1-4.

(i) Category Description

N_2O emissions from agricultural soils include direct and indirect emissions. Direct N_2O emissions from agricultural soils include those caused by N inputs (synthetic fertilizer N, animal manure N, N excreted by grazing animals, N from returned crop residues and soil mineralization, etc.) in the current season, while indirect N_2O emissions from agricultural soils include those caused by atmospheric N deposition and N loss in leaching and runoff processes.

(ii) Methods

Direct N_2O emissions from agricultural soils were calculated using Tier 2 method, and indirect emissions were calculated using a combination of Tier 1 and Tier 2 methods. Activity data on synthetic fertilizer N, animal manure N, N excreted by grazing animals and N from returned crop residues were calculated based on statistical data and parameters, where statistical data were mainly sourced from China Statistical Yearbook, China Rural Statistical Yearbook, China Animal Husbandry and Veterinary Science Yearbook, China Environment Statistical Yearbook, provincial statistical yearbooks, and special study data of the Agricultural Information Institute of CAAS (CASS-AII); and crop residues returning rates, crop parameters, N volatility coefficients of fertilizer application and N loss coefficients in leaching and runoff processes were obtained from thematic studies and literature. Direct N_2O emission factors from agricultural soils were derived from field observation data and data sets generated by national key research projects. Indirect N_2O emission factors from agricultural soils were partially based on the recommended values from the 2006 IPCC Guidelines. Direct and indirect N_2O emissions from the soil mineralization and grazing animals, and CH_4 and N_2O emissions from field burning of agricultural residues were calculated using Tier 1 method, as detailed in Table 1-36.

Table 1-36 Major Activity Data on Agricultural Soils (Mt N)

Activity Data	2005	2020	2021
Synthetic fertilizer N	26.854	26.112	25.482
Animal manure N	9.249	7.659	8.046
N from crop residues returning	3.703	6.666	6.655
Total N excreted by grazing animals	1.400	1.465	1.552
Mineralization N of agricultural soils	0.658	0.444	0.417
N loss from ammonia and NOx volatilization	4.492	4.463	4.427
N loss in leaching and runoff processes	6.223	6.363	6.341

(iii) Uncertainty Assessment

Based on the error propagation method, the uncertainties of the N_2O emissions from agricultural soils for 2005, 2020 and 2021 were from -13.8% to 66.7%, -14.1% to 66.6%, and -14.2% to 66.5%, respectively.

VI. Field Burning of Agricultural Residues

In 2021, China's GHG emissions from field burning of agricultural residues were 5.477 $MtCO_2eq$, a 13.6% decrease compared to 2020, as shown in Table 1-4.

(i) Category Description

GHG emissions from field burning of agricultural residues include CH_4 and N_2O emissions resulting from the in situ combustion of agricultural residues in or around agricultural fields.

(ii) Methods

GHG emissions from field burning of agricultural residues were calculated using Tier 1 method. The dry weight of field burning of agricultural residues was calculated based on crop yield and parameters such as field burning rate of agricultural residues, etc. The field burning area of agricultural residues was determined based on data on the dry weight of crop residues burned and the dry weight produced by crop residues per unit area in China; the field burning rate of crop residues was determined based on satellite monitoring data, data from the First National Pollution Source Census, and MARA data on the comprehensive utilization of crop residues; and the default values of the 2006 IPCC Guidelines were used for CH_4 and N_2O emission factors (See Table 1-37). .

Table 1-37 Major Activity Data on Field Burning of Agricultural Residues (Mt)

Activity Data	2005	2020	2021
Crop residues burned in the field (dry weight)	85.323	74.845	64.633

(iii) Uncertainty Assessment

Based on the error propagation method, the uncertainties of the GHG emissions from field burning of agricultural residues for 2005, 2020 and 2021 were from -47.6% to 47.6%, -48.2% to 48.2%, and -48.2% to 48.2%, respectively.

Chapter 6 Land Use, Land-Use Change and Forestry (LULUCF)

I. Overview

(i) Scope

China's GHG Inventory on LULUCF covers six land-use categories, including forest land, cropland, grassland, wetlands, settlements and other land, as well as emissions and removals of CO_2, CH_4 and N_2O. According to the 2006 IPCC Guidelines, using a default 20-year time interval, the aforementioned land-use categories were further divided into land remaining a particular land, and land converted to another land from 2000-2020 and 2001-2021.

On this basis, carbon stock changes in six types of carbon pools, including above-ground biomass, below-ground biomass, litter, dead wood, soil organic matter and harvested wood products, as well as changes in carbon stocks in other biomass, and GHG emissions and removals due to fires, were assessed on a case-by-case basis. In this case, a default value of 30 cm was taken for soil depth in calculating soil organic carbon stocks. In addition, CH_4 emissions from wetlands were reported. Changes in biomass carbon stocks in trees other than forests were reported separately as other biomass.

(ii) Methods

National GHG Inventory on LULUCF was prepared mainly using the 2006 IPCC Guidelines, with reference to the 2013 IPCC Wetlands Supplement.

To be specific, non-CO_2 emissions from forest and grassland fires were calculated using Tier 1 method; changes in organic carbon stocks in agricultural soils were calculated using Tier 3 method with the Agro-C model; changes in ecosystem carbon stocks for all other land-use categories were calculated using Tier 2 Stock Change Approach; wetlands CH_4 emissions were calculated using Tier 2 method; changes in carbon stocks in harvested wood products were calculated using Tier 2 Production Accounting Approach; and CH_4 and N_2O emissions were calculated using the emission factor method (see Table 1-3 for details).

(iii) General

China's LULUCF generally acts as carbon sinks. In 2020 and 2021, net GHG removals from LULUCF amounted to 1,303 $MtCO_2eq$ and 1,315 $MtCO_2eq$, respectively. Of these, in 2020 and 2021, LULUCF removed 1,343 $MtCO_2$ and 1,346 $MtCO_2$; and emitted 1.398 $MtCH_4$ and 1.110 $MtCH_4$, and 31 tN_2O and 19 tN_2O, respectively.

(iv) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from LULUCF for 2005, 2020 and 2021 were from -14.7% to 14.7%, -12.5% to 12.5%, and -12.6% to 12.6%, respectively. See Table 1-38 for details.

Table 1-38 Uncertainty Assessment for LULUCF (%)

Source/Sink Categories	2005	2020	2021
4.A Forest land	-20.0~20.0	-18.9~18.9	-19.2~19.2
4.B Cropland	-17.4~17.4	-15.3~15.3	-16.0~16.0

Source/Sink Categories	2005	2020	2021
4.C Grassland	-5.4~5.4	-5.1~5.1	-4.4~4.4
4.D Wetlands	-14.9~14.9	-12.1~12.1	-12.7~12.7
4.E Settlements	-37.9~37.9	-38.7~38.7	-38.8~38.8
4.F Other land	-35.4~35.4	-31.2~31.2	-28.1~28.1
4.G Harvested wood products	-26.0~26.0	-26.0~26.0	-26.0~26.0
4.H Other biomass	-15.0~15.0	-15.8~15.8	-17.0~17.0
Overall uncertainty	-14.7~14.7	-12.5~12.5	-12.6~12.6

II. Forest Land

In 2021, China's total GHG removals from forest land, as a sink, were 876.815 $MtCO_2eq$. In 2021, total GHG removals from forest land remaining forest land were 552.626 $MtCO_2eq$, making it the largest sink in forest land (Table 1-39).

Table 1-39 GHG Emissions/Removals from Forest Land ($MtCO_2eq$)

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2005	4.A Forest land	-551.205	0.066	0.034	-551.104
	4.A.1 Forest land remaining forest land	-322.731			-322.731
	4.A.2 Land converted to forest land	-228.474			-228.474
	4(IV).A Forest fires	IE	0.066	0.034	0.100
2020	4.A Forest land	-895.592	0.011	0.006	-895.575
	4.A.1 Forest land remaining forest land	-566.421			-566.421
	4.A.2 Land converted to forest land	-329.170			-329.170
	4(IV).A Forest fires	IE	0.011	0.006	0.017
2021	4.A Forest land	-876.827	0.008	0.004	-876.815
	4.A.1 Forest land remaining forest land	-552.626			-552.626
	4.A.2 Land converted to forest land	-324.201			-324.201
	4(IV).A Forest fires	IE	0.008	0.004	0.011

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.

2). “IE” (included elsewhere) indicates that a particular source or sink category has been estimated and reported under other sub-sectors.

3). Shaded cells do not require entries.

(i) Category description

Sources/sinks of GHG emissions from forest land include CO_2 removals/emissions from forest land remaining forest land, CO_2 removals/emissions from land converted to forest land, and CH_4 and N_2O emissions from forest fires.

According to the 2006 IPCC Guidelines and in conjunction with Technical Regulation of the third nationwide land survey (TD/T 1055-2019), China's forest land types were further subdivided into arboreal woodland, bamboo woodland, shrubland, other woodland, and perennial woody fruit orchards, tea gardens, rubber gardens and other gardens, in accordance with GPG. On this basis, the land use type in forest land was further divided into two categories: forest land remaining in the same subcategory, and forest land converted to a different subcategory.

(ii) Methods

For forest land remaining forest land, Tier 2 method provided in the 2006 IPCC Guidelines and country-specific parameters were used to estimate changes in carbon stocks in biomass, dead organic matter, and soil organic matter.

For land converted to forest land, Tier 2 method provided in the 2006 IPCC Guidelines and country-specific parameters were used to estimate changes in carbon stocks in biomass, dead organic matter, and soil organic matter, based on the land type before the conversion and the forest land subcategory after the conversion.

For forest fires, Tier 1 method and default values provided in the 2006 IPCC Guidelines were used to estimate CH_4 and N_2O emissions from forest fires, based on area burned by forest fires and fuel quality in China in the inventory year. In this case, fuel quality includes above-ground biomass, litter and dead wood.

Activity data required for estimating GHG emissions/removals from forest land mainly include the area of forest land and the volume of forest stock by category, which were mainly derived from previous continuous forest resources inventories, the 2021 nationwide comprehensive ecology monitoring of forest and grassland， and first, second and third national territorial spatial surveys. Among them, the area of arboreal forests, bamboo forests and forest stock in 2021 mainly referred to the results of the 2021 nationwide comprehensive ecology monitoring of forest and grassland. The area of arboreal forests, bamboo forests and forest stock in 2020 were obtained by interpolating the data in actual survey years of each province (autonomous region and municipality) of the 9th Forest Resources Inventory (2014-2018) with the data from the 2021 nationwide comprehensive ecology monitoring of forest and grassland. The area of all other types of land was primarily based on data from the first, second and third national territorial spatial surveys, with the figures obtained through interpolation. The area of other land is equal to the total national land area minus the areas of forests, cropland, grassland, wetlands, and settlements, as detailed in Table 1-40.

Table 1-40 Area of Land Use in China (Mha)

Type of land use area	2005	2020	2021
Forest Land	243.3407	303.5287	306.4650
Cropland	122.0827	127.1189	127.5164
Grassland	300.5031	263.1230	264.4511
Wetlands	54.2382	54.0261	54.1273
Settlements	32.4386	43.7785	43.1902

Note: Original data for land use was sourced from the MNR, and reclassified according to the IPCC land use categories.

The parameters required for the calculation of GHG emissions/removals from forest land were mainly derived from national/industry standards, published literature, measured data, and the results of statistical analyses of the relevant measured data, and some of the parameters adopted the default values provided by IPCC.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from forest land for 2005, 2020 and 2021 were from -20.0% to 20.0%, -18.9% to 18.9%, and -19.2% to 19.2%, respectively. See Table 1-41 for details.

Table 1-41 Uncertainty Assessment for GHG Emissions/Removals from Forest Land (%)

Source/Sink Categories	2005	2020	2021
4.A.1 Forest land remaining forest land	-28.6~28.6	-26.0~26.0	-26.4~26.4
4.A.2 Land converted to forest land	-26.5~26.5	-25.5~25.5	-26.1~26.1
4(IV).A Forest fires	-38.8~38.8	-38.8~38.8	-38.8~38.8
4.A Overall uncertainty	-20.0~20.0	-18.9~18.9	-19.2~19.2

III. Cropland

In 2021, China's total GHG removals from cropland, as a sink, were 106.162 $MtCO_2eq$. Among them, GHG removals from cropland remaining cropland, generally as a carbon sink, has shown an increasing trend. GHG removals from land converted to cropland were negative, indicating that the land converted to cropland in China generally acts as a source (Table 1-42).

Table 1-42 GHG Emissions/Removals from Cropland ($MtCO_2eq$)

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2005	4.B Cropland	-41.077			-41.077
	4.B.1 Cropland remaining cropland	-47.981			-47.981
	4.B.2 Land converted to cropland	6.903			6.903
2020	4.B Cropland	-98.018			-98.018
	4.B.1 Cropland remaining cropland	-106.557			-106.557
	4.B.2 Land converted to cropland	8.538			8.538
2021	4.B Cropland	-106.162			-106.162
	4.B.1 Cropland remaining cropland	-111.253			-111.253
	4.B.2 Land converted to cropland	5.090			5.090

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). Shaded cells do not require entries.

(i) Category description

Sources/sinks of GHG emissions from cropland in China include cropland remaining cropland and land converted to cropland. According to the 2006 IPCC Guidelines, and in conjunction with the division of cropland types in the Technical Regulation of the third nationwide land survey, cropland was categorized into paddy fields, irrigated land, and dry land.

GHG emissions or removals from cropland depend mainly on changes in carbon stocks in soil organic matter. According to the 2006 IPCC Guidelines, agricultural soils can be categorized into mineral and organic soils. Given the small proportion of organic soil in Chinese cropland, and based on the principle of determining key categories, the inventory of organic carbon stocks in agricultural soils ignored organic soils, and all agricultural soils were assumed to be mineral soils.

(ii) Methods

GHG emissions/removals from cropland in China were calculated using the Tier 3 Agro-C modeling method, which calculates the impacts of China's major cropping systems and cropland management practices on carbon stocks in agricultural soils by simulating the increase in soil organic carbon stocks caused by the entry of straw, roots and organic fertilizers into the soil, and the process of soil carbon emissions through decomposition.

Activity data required for estimating GHG emissions/removals from cropland include land use, crop phenology, organic carbon inputs and tillage management data. Land use data includes the cropping system zoning, the spatial distribution of arable land, and the sown area of crops. Crop phenology data includes sowing, heading, and harvest dates. Organic carbon data includes crop yields, proportion of straw returned to fields, and amount of farmyard manure applied. Tillage management data includes mechanized no-tillage sowing. Among them, the data on cropping system zoning was from China Agroclimatic Resources and Cropping System Zoning; the data on the spatial distribution of arable land was from CAS; the crop phenology data was from the China Agricultural Phenology Atlas; the data on crop yields was from the CASS-AII; the data on the proportion of straw returned to fields was from the China Rural Energy Yearbook issued by MARA; the data on the amount of farmyard manure applied was from the outputs of the Inventory on Agriculture; and mechanised no-till sowing data was from the China Agricultural Machinery Industry Yearbook published by China Association of Agricultural Machinery Manufacturers (CAAMM).

The environmental data required for estimating GHG emissions/removals from cropland include national-level climate data and soil data. Climate data, including temperature and precipitation, were mainly from the China Meteorological Administration (CMA). Soil data mainly include soil attribute parameters such as organic carbon, bulk weight, clay particles, total N, acidity and alkalinity, as well as soil type distribution data. Among them, the soil attribute parameter dataset was obtained from the Institute of Soil Science, CAS, and the soil profile data were obtained from the Second National Soil Census.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from cropland for 2005, 2020 and 2021 were from -17.4% to 17.4%, -15.3% to 15.3%, and -16.0% to 16.0%, respectively. See Table 1-43 for details.

Table 1-43 Uncertainty Assessment for GHG Emissions/Removals from Cropland (%)

Source/Sink Categories	2005	2020	2021
4.B.1 Cropland remaining cropland	-19.9~19.9	-16.5~16.5	-16.7~16.7
4.B.2 Land converted to cropland	-4.3~4.3	-15.5~15.5	-15.2~15.2
4.B Overall uncertainty	-17.4~17.4	-15.3~15.3	-16.0~16.0

IV. Grassland

In 2021, China's total GHG removals from grassland, as a sink, were 64.080 $MtCO_2eq$. Among them, CO_2 removals from grassland remaining grassland, generally as a sink, was

64.441 $MtCO_2eq$, and land converted to grassland and the grassland fires mainly act as sources (Table 1-44).

Table 1-44 GHG Emissions/Removals from Grassland ($MtCO_2eq$)

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2005	4.C Grassland	-47.769	0.016	0.014	-47.739
	4.C.1 Grassland remaining grassland	-47.800			-47.800
	4.C.2 Land converted to grassland	0.031			0.031
	4(IV).C Grassland fires	IE	0.016	0.014	0.030
2020	4.C Grassland	-72.707	0.003	0.003	-72.701
	4.C.1 Grassland remaining grassland	-73.122			-73.122
	4.C.2 Land converted to grassland	0.415			0.415
	4(IV).C Grassland fires	IE	0.003	0.003	0.006
2021	4.C Grassland	-64.082	0.001	0.001	-64.080
	4.C.1 Grassland remaining grassland	-64.441			-64.441
	4.C.2 Land converted to grassland	0.359			0.359
	4(IV).C Grassland fires	IE	0.001	0.001	0.002

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). "IE" (included elsewhere) indicates that a particular source or sink category has been estimated and reported under other sub-sectors.
3). Shaded cells do not require entries.

(i) Category description

GHG emissions and removals from grassland refers to the changes in carbon stocks in the ecosystem from grassland remaining grassland and land converted to grassland, under the influence of grassland management practices, as well as non-CO_2 GHG emissions caused by grassland fires. Among them, grassland management practices can be categorized as grazing bans, grazing rests, rotational grazing, artificial grass planting, as well as fencing and improved grasslands. Based on the classification of grasslands in China, the grassland types can be further divided into 7 main types: alpine meadows, alpine grasslands, alpine deserts (including alpine desertified grasslands), temperate grasslands, temperate meadow grasslands (including mountain meadows), temperate desert grasslands (including temperate deserts), and warm shrub grasslands.

(ii) Methods

For grassland remaining grassland, Tier 2 method provided in the 2006 IPCC Guidelines and country-specific parameters were used to estimate changes in carbon stocks in soil organic matter.

Since the area of management activities cannot be split between grassland remaining grassland and land converted to grassland, it is assumed here that soil organic carbon density is the same for grassland remaining grassland and land converted to grassland in the inventory year and 20 years prior to the inventory year, and that the change in soil organic carbon stocks is mainly related to the area of management activities.

For land converted to grassland, Tier 2 method provided in the 2006 IPCC Guidelines and country-specific parameters were used to estimate changes in carbon stocks in biomass, dead organic matter, and soil organic matter in grassland converted from forest land, cropland, wetlands, settlements and other land.

For grassland fires, Tier 1 method for non-CO_2 GHG emissions from biomass combustion, and default values provided in the 2006 IPCC Guidelines were used to estimate non-CO_2 GHG emissions from fires on grassland remaining grassland.

To calculate the biomass depletion during grassland fires, the biomass depletion value during fires was based on the recommended values of the 2006 IPCC Guidelines, the biomass depletion value of savanna (burned in the mid/late dry season) was adopted for grasslands in China, and the biomass depletion value of tropical/subtropical grasslands was adopted for warm scrub grasslands in China.

Activity data required for estimating GHG emissions/removals from grassland mainly include grassland area, area of managed grasslands, area of different grassland types and grassland fire area. The data on grassland area were mainly the national and provincial (autonomous region and municipal) grassland area data based on the first, second, and third national territorial spatial surveys conducted by MNR. The data on area of managed grasslands were mainly based on the original data on the area of grassland management practices provided in the "China Grassland Statistics" by the National Animal Husbandry Services and the "China Forestry and Grassland Statistical Yearbook" by NFGA, and were obtained through proportional conversion. The data on the area of different grassland types were mainly based on the proportion of each type of grassland in each province (autonomous region and municipality) provided in the "China Grassland Resources" by MARA, and were obtained by decomposing the area of managed grasslands. The data on the area of grassland fires were from NBS on the affected area of grassland fires.

The soil organic carbon density for each management activity on the grassland was calculated based on the soil organic matter content, soil bulk density, and the emission/removal parameters of each activity, according to different grassland types. Among them, the soil organic matter content and soil bulk density data for each grassland type were extracted using a multi-data source fusion method, and based on the soil map (1:4 million) provided by the Institute of Soil Science, CAS, the soil organic carbon distribution map (spatial resolution of 1km×1km) provided by the Institute of Geographic Sciences and Natural Resources Research, CAS, the soil (0-30cm layer) organic carbon content and bulk density data provided by the United States National Geospatial Data Center, and the soil organic matter content and soil bulk density data from FAO, and overlaid with the vegetation type map.

Soil carbon change factors (dimensionless) were calculated for grassland management practices. Firstly, data on the impacts of grassland management and inputs on soil organic carbon were obtained through surveys and collection (including literature data, statistical data, etc.); then the collected and surveyed data were integrated using the Meta-analysis methodology, and the default values of emission/removal parameters of the IPCC GPG were revised. The proportion of degraded grassland in China was obtained by integrating data such as the area of degraded grassland in the China Environment Status Bulletin.

Non-CO_2 GHG emissions from grassland biomass combustion were calculated using the recommended values for savannas and grasslands from the 2006 IPCC Guidelines.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from grassland for 2005, 2020 and 2021 were from -5.4% to 5.4%, -5.1% to 5.1%, and -4.4% to 4.4%, respectively. See Table 1-45 for details.

Table 1-45 Uncertainty Assessment for GHG Emissions/Removals from Grassland (%)

Source/Sink Categories	2005	2020	2021
4.C.1 Grassland remaining grassland	-5.4~5.4	-5.1~5.1	-4.5~4.5
4.C.2 Land converted to grassland	-18.4~18.4	-10.8~10.8	-10.3~10.3
4(IV).C Grassland fires	-36.9~36.9	-49.5~49.5	-48.5~48.5
4.C Overall uncertainty	-5.4~5.4	-5.1~5.1	-4.4~4.4

V. Wetlands

In 2021, China's GHG emissions from wetlands were 6.472 $MtCO_2eq$. Wetlands, generally as a source, removed 24.599 Mt CO_2 and emitted CH_4 of 31.071 $MtCO_2eq$. Of these, CO_2 removals from land converted to wetlands were 24.109 Mt, which is the most significant sink in wetlands (Table 1-46).

Table 1-46 GHG Emissions/Removals from Wetlands ($MtCO_2eq$)

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2005	4.D Wetlands	-13.730	17.610	NE	3.880
	4.D.1 Wetlands remaining wetlands	-0.009	0.015	NE	0.006
	4.D.2 Land converted to wetlands	-13.721	17.595	NE	3.874
2020	4.D Wetlands	-29.788	39.135	NE	9.347
	4.D.1 Wetlands remaining wetlands	-0.587	0.862	NE	0.274
	4.D.2 Land converted to wetlands	-29.201	38.274	NE	9.073
2021	4.D Wetlands	-24.599	31.071	NE	6.472
	4.D.1 Wetlands remaining wetlands	-0.489	0.721	NE	0.232
	4.D.2 Land converted to wetlands	-24.109	30.350	NE	6.241

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). “NE” (not estimated) indicates that a particular source or sink category has not been estimated.

(i) Category description

GHG emissions and removals from wetlands were mainly from changes in carbon stocks in ecosystems of wetlands remaining wetlands and land converted to wetlands.

According to the 2006 IPCC Guidelines and the 2013 IPCC Wetlands Supplement, wetlands remaining wetlands can be further classified into wetlands with no change in wetland type and wetlands with a change in wetland type, based on land-use change characteristics. According to the classification of land use types, China's wetland types can be divided into inland wetlands, coastal wetlands, and flooded lands. Inland wetlands can be further divided into forested swamps, shrub swamps, marsh meadows, inland mudflats, and marshes. Coastal wetlands can be further divided into mangrove forests and coastal mudflats. Flooded lands can be further divided into river surfaces, lake surfaces, reservoir surfaces, pond surfaces, and ditches.

The 2006 IPCC Guidelines categorizes peatlands as a distinct type of wetland. However, since China lacks statistical data on the activity of peatland resources, and based on the findings of the National Peatland Survey (1983-1985) which indicate that peatlands account for only 1% of China's total wetland area, peatlands were included in inland wetlands.

(ii) Methods

The estimation of CO_2 emissions and removals from wetlands remaining wetlands incorporates the methodologies provided in the 2006 IPCC Guidelines and the 2013 IPCC Wetlands Supplement. The Tier 2 Gain/Loss approach and country-specific parameters were used to estimate changes in carbon stocks in biomass, dead organic matter, and soil organic matter.

The estimation of CO_2 emissions and removals from land converted to wetlands includes wetlands converted from other land and wetlands with a change in wetland type, and incorporates the methodologies provided in the 2006 IPCC Guidelines and the 2013 IPCC Wetlands Supplement. The Tier 2 method and country-specific parameters were used to estimate changes in carbon stocks in biomass and soil organic matter.

CH_4 emissions from wetlands remaining wetlands and land converted to wetlands were calculated using Tier 2 method and country-specific parameters.

Activity data required for estimating GHG emissions/removals from wetlands mainly include area of different wetland types, and area of different wetland types in different climate zones. The underlying data on the area of different wetland types were mainly derived from the data of the first, second and third national territorial spatial surveys issued by MNR, and the activity data on wetlands remaining wetlands and land converted to wetlands were obtained by constructing the area transfer matrix of wetland subtypes.

Based on elements such as temperature, precipitation and monsoon characteristics, China's typical climate zones can be divided into temperate humid and semi-humid zones, temperate arid and semi-arid zones, the Tibetan Plateau zone, and tropical-subtropical humid zones. The climate zones of each of China's provincial administrations were identified, and for administrations whose boundaries include two or more climate zones, the type of climate zone that is most widely distributed in the province shall prevail. On this basis, the climatic zones to which the wetlands of each province (autonomous region and municipality) belong were clarified, from which the data of different wetland types in different climatic zones were obtained.

Parameters for wetland GHG emissions/removals were mainly obtained from the research literature, and the corresponding wetland emission/removal parameters were determined in accordance with the four climate zones and different climate types mentioned above.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from wetlands for 2005, 2020 and 2021 were from -14.9% to 14.9%, -12.1% to 12.1%, and -12.7% to 12.7%, respectively. See Table 1-47 for details.

Table 1-47 Uncertainty Assessment for GHG Emissions/Removals from Wetlands (%)

Source/Sink Categories	2005	2020	2021
4.D.1 Wetlands remaining wetlands	-19.5~19.5	-14.4~14.4	-15.9~15.9
4.D.2 Land converted to wetlands	-14.9~14.9	-12.4~12.4	-13.0~13.0
4.D Overall uncertainty	-14.9~14.9	-12.1~12.1	-12.7~12.7

VI. Settlements

In 2021, China's GHG removals from settlements, generally as a sink, were 0.634 $MtCO_2eq$, all of which were from land converted to settlements (Table 1-48).

Table 1-48 GHG Emissions/Removals from Settlements ($MtCO_2eq$)

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2005	4.E Settlements	0.163			0.163
	4.E.1 Settlements remaining settlements	0			0
	4.E.2 Land converted to settlements	0.163			0.163
2020	4.E Settlements	-2.396			-2.396
	4.E.1 Settlements remaining settlements	0			0
	4.E.2 Land converted to settlements	-2.396			-2.396
2021	4.E Settlements	-0.634			-0.634
	4.E.1 Settlements remaining settlements	0			0
	4.E.2 Land converted to settlements	-0.634			-0.634

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). Shaded cells do not require entries.

(i) Category description

According to the 2006 IPCC Guidelines, the GHG emissions/removals of settlements, which was classified by land-use change characteristics as settlements remaining settlements and land converted to settlements, depend on changes in carbon stocks in ecosystems. Changes in biomass carbon stocks from settlements have been taken into account in the other biomass section, and changes in dead and soil organic matter from settlements are small, so GHG emissions/removals from settlements remaining settlements are negligible.

Changes in biomass carbon stocks from settlements converted from cropland, grassland, and other land are negligible, so these sources/sinks were not included.

Land converted to settlements involves only CO_2 emissions and removals.

(ii) Methods

For land converted to settlements, Tier 2 method provided in the 2006 IPCC Guidelines and country-specific parameters were used to estimate changes in carbon stocks in biomass, dead organic matter, and soil organic matter, based on the land use type before conversion.

For changes in biomass carbon stocks, only changes in biomass carbon stocks from land that was forest land and wetland (forested swamps and scrub swamps only) before conversion were considered. Negligible changes in biomass carbon stocks from settlements converted from cropland, grassland, and other land were assumed to be zero.

For changes in carbon stocks in dead organic matter (litter and dead wood), the methodology was the same as that for changes in biomass carbon stocks, and only settlements converted from forest land were considered, while negligible changes in carbon stocks in dead organic matter from settlements converted from other land type were assumed to be zero.

For changes in carbon stocks in soil organic matter, changes in carbon stocks in soil organic matter from land that was forest land, cropland, grassland, and wetland before conversion were considered. For settlements converted from other land, it was assumed that there was no change in carbon stocks in soil organic matter.

Activity data required for estimating GHG emissions/removals from settlements includes settlement area, which were mainly derived from the data of the first, second and third national territorial spatial surveys, with the interpolation method used for some years. The activity data on settlements remaining settlements and land converted to settlements were obtained by constructing the area transfer matrix of settlements.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from settlements for 2005, 2020 and 2021 were from -37.9% to 37.9%, -38.7% to 38.7%, and -38.8% to 38.8%, respectively.

VII. Other Land

In 2021, China's GHG emissions from other land, as a source, were 1.556 $MtCO_2eq$, all of which were from land converted to other land (Table 1-49).

Table 1-49 GHG Emissions/Removals from Other Land ($MtCO_2eq$)

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2005	4.F Other land	5.436			5.436
	4.F.1 Other land remaining other land	NE			NE
	4.F.2 Land converted to other land	5.436			5.436
2020	4.F Other land	2.641			2.641
	4.F.1 Other land remaining other land	NE			NE
	4.F.2 Land converted to other land	2.641			2.641

Year	Source/Sink Categories	CO_2	CH_4	N_2O	Total
2021	4.F Other land	1.556			1.556
	4.F.1 Other land remaining other land	NE			NE
	4.F.2 Land converted to other land	1.556			1.556

Note: 1). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.
2). Shaded cells do not require entries.

(i) Category description

According to the 2006 IPCC Guidelines, the GHG emissions/removals from other land, which was classified by land-use change characteristics as other land remaining other land and land converted to other land, depend on changes in carbon stocks in ecosystems. Changes in biomass carbon stocks from other land (or settlements) converted from cropland and grassland are negligible, so these sources/sinks were not included. Land converted to other land involves only CO_2 emissions and removals.

(ii) Methods

For land converted to other land, changes in carbon stocks in biomass, dead organic matter and soil organic matter were estimated according to the land use types (including forest land, cropland, grassland, wetlands, settlements, etc.) prior to the conversion, and the methods were the same as those for land converted to settlements.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from other land for 2005, 2020 and 2021 were from -35.4% to 35.4%, -31.2% to 31.2%, and -28.1% to 28.1%, respectively.

VIII. Harvested Wood Products

In 2021, China's changes in carbon stocks in harvested wood products were 103.820 Mt CO_2, as detailed in Table 1-4.

(i) Category description

Changes in carbon stocks in harvested wood products only covered harvested wood products, and changes in carbon stocks in bamboo and shrub wood products were not estimated due to the lack of corresponding statistical information.

Based on the above scope, and in accordance with the 2006 IPCC Guidelines and the FAO's definition and classification of wood products, and taking into account China's national conditions, harvested wood products were classified into primary products such as logs for industrial use and wood fuels. In particular, changes in carbon stocks of wood fuels (including charcoal and fuelwood) and products from landfill were estimated under Energy and Waste, respectively.

According to the FAO classification, logs for industrial use can be further subdivided into intermediate products such as sawn timber, wood-based panels, paper and paperboard, and other industrial log products. Due to the fact that China's current statistical data on other industrial log products are incomplete, and that carbon from these harvested wood products will not be immediately released to the atmosphere, changes in carbon stocks in other industrial log products were not taken into account in line with the principle of conservatism.

(ii) Methods

For changes in carbon stocks in harvested wood products, changes in carbon stocks in harvested wood products domestically produced and in use in China were estimated using Tier 2 method (first-order decomposition method) provided in the GPG, and country-specific parameters.

Data on China's production, imports and exports of harvested wood products were obtained from the FAO database. Of these, data on wood products such as industrial logs, sawn timber, wood-based panels, paper and paperboard have been statistically calculated since 1961.

The basic density and moisture content of harvested wood products such as sawn timber and wood-based panels were determined in accordance with the national standards Method for determination of the density of wood (GB/T1933-2009) and Method for determination of the moisture content of wood (GB/T1931-2009) respectively. The service life of harvested wood products were based on surveys on the production and processing enterprises and users using semi-structured interviews, and were determined by consulting expert opinions. In this report, the half-life data of wood products in 2005 was obtained through data survey, while the data for 2020 and 2021 were adjusted by using expert judgment method to obtain better data, taking into account China's current economic development and consumption habits. Since data on the fate and service life of exported products are not available, it was assumed that the service life of exported wood products was the same as that for domestic use in China.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainty related to harvested wood products for 2005, 2020 and 2021 was from -26.0% to 26.0%.

IX. Other Biomass

In 2021, China's total CO_2 removals from other biomass, generally a sink, were 171.931 Mt CO_2, as detailed in Table 1-4.

(i) Category description

GHG emissions/removals from other biomass were mainly from changes in biomass carbon stocks in trees other than forests, such as free-ranging trees (bamboo) and four-side trees.

(ii) Methods

GHG emissions from other biomass were calculated using the same Tier 2 method as for biomass from forest land, and changes in carbon stocks in above-ground and below-ground biomass were estimated.

Activity data required for estimating GHG emissions/removals from other biomass were mainly derived from the results of previous continuous forest resources inventories, and the 2021 nationwide comprehensive ecology monitoring of forest and grassland. For free-ranging trees and four-side trees, the parameters required for estimating GHG emissions/removals include above-ground biomass conversion and expansion factors, below-ground biomass/above-ground biomass ratios, and carbon content rates of above-ground and below-ground biomass. The above-ground biomass conversion and expansion factors and the below-ground biomass/above-ground biomass ratios adopted the same values as those used in the forest land biomass estimation process, and default values were used for carbon content rates of above-ground and below-ground biomass. For free-ranging bamboos, default values were used for the parameters required for estimating GHG emissions/removals, including above-ground and below-ground biomass of free-ranging bamboos per plant, and carbon content rates of above-ground and below-ground biomass.

(iii) Uncertainty Assessment

Based on the propagation of error, the uncertainties of the GHG emissions/removals from other biomass for 2005, 2020 and 2021 were from -15.0% to 15.0%, -15.8% to 15.8%, and -17.0% to 17.0%, respectively.

Chapter 7 Waste

I. Overview

(i) Scope

The GHG Inventory on Waste covers CH_4 emissions from solid waste disposal, CH_4 and N_2O emissions from biological treatment of solid waste, CO_2, CH_4 and N_2O emissions from incineration of waste, and CH_4 and N_2O emissions from wastewater treatment and discharge. Of these, incineration of waste was reported only for CO_2, CH_4 and N_2O emissions from the incineration of hazardous and medical wastes, as well as CH_4 and N_2O emissions from the incineration of sludge; CH_4 and N_2O emissions from MSW incineration, and fossil CO_2 emissions were reported under Energy, and the CO_2 emissions of biogenic origin were reported as memo items.

(ii) Methods

CH_4 emissions from landfill were calculated using the First Order Decay (FOD) method (Tier 2), while other sources were calculated using the emission factor method, as detailed in Table 1-3.

(iii) General

In 2021, China's GHG emissions from waste amounted to 236.330 $MtCO_2eq$. To be specific, CO_2 emissions were 8.983 Mt, CH_4 emissions were 7.085 Mt, and N_2O emissions were 0.109 Mt, accounting for 3.8%, 83.9%, and 12.3% respectively. Compared to 2020, CO_2 and N_2O emissions increased by 3.6% and 6.6%, while CH_4 emissions decreased by 4.0%. See Table 1-4 for details.

(iv) Uncertainty Assessment

Based on the propagation of error method, the uncertainties of the GHG Inventory on Waste for 2005, 2020 and 2021 were from -25.8% to 25.8%, -28.2% to 28.2%, and -27.4% to 27.4%, respectively (See Table 1-50).

Table 1-50 Uncertainty Assessment for Waste (%)

Source Categories	2005	2020	2021
5.A Solid waste disposal	-43.9~43.9	-43.9~43.9	-43.9~43.9
5.B Biological treatment of solid waste	-28.5~28.5	-28.5~28.5	-28.5~28.5
5.C Incineration of waste	-36.4~36.4	-36.4~36.4	-36.4~36.4
5.D Wastewater treatment and discharge	-32.4~32.4	-32.4~32.4	-32.2~32.2
Overall uncertainty	-25.8~25.8	-28.2~28.2	-27.4~27.4

II. Solid Waste Disposal

In 2021, China's GHG emissions from landfill were 132.182 $MtCO_2eq$, a decrease of 6.6% from 2020, mainly due to a reduction in the volume of waste entering landfills.

(i) Category Description

The main source of GHG emissions from landfill was the decomposition of organic matter in the waste (MSW) under anaerobic conditions, which produces CH_4.

(ii) Methods

CH_4 emissions from landfill were calculated using the FOD method (Tier 2). Activity data required for estimating CH_4 emissions from landfill covers the information on the total volume of MSW produced and landfilled from 1966 to 2021, which was sourced from the China Urban Construction Statistical Yearbook, China Population & Employment Statistics Yearbook, and China Statistical Yearbook, as shown in Table 1-51. The degradable organic carbon content in MSW was calculated based on the component data of MSW provided by RCEES-CAS for different years. The CH_4 correction factor (MCF) was obtained based on actual survey data and regional information. The CH_4 recovery and utilization volume was calculated based on the installed capacity of landfill gas power generation. Parameters such as CH_4 generation rate and the proportion of CH_4 in landfill gas were derived from actual surveys and expert judgments.

Table 1-51 Major Activity Data on Waste (Mt)

Activity Data	2005	2020	2021
MSW landfill	68.571	77.715	52.085
MSW biological treatment	3.454	10.732	16.111
Hazardous waste incineration	0.317	4.834	4.770
Medical waste incineration	-	1.061	1.533
Sludge incineration	-	11.870	17.567
Chemical oxygen demand (COD) discharge of domestic wastewater	8.594	9.189	8.118
COD discharge of industrial wastewater	5.547	0.497	0.423

Note: - indicates that no data is available.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty related to solid waste disposal for 2005, 2020 and 2021 was from -43.9% to 43.9%.

III. Biological Treatment of Solid Waste

In 2021, China's GHG emissions from biological treatment of solid waste were 3.085 $MtCO_2eq$, increasing by 50.1% from 2020. This was mainly due to China's implementation of waste sorting policies, leading to an increase in the biological treatment amount.

(i) Category Description

GHG emissions from biological treatment of solid waste include CH_4 and N_2O emissions from the microbial decomposition of organic matter in the biological treatment process.

(ii) Methods

GHG emissions from biotreatment were calculated using Tier 1 method. The treatment volume was derived from the China Urban Construction Statistical Yearbook, and the emissions factors were determined by expert judgment based on the type of waste, the amount and type of auxiliary materials used, temperature, moisture content, and air exchange during the process, combined with default emission factors in the 2006 IPCC Guidelines.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty related to biological treatment of solid waste for 2005, 2020 and 2021 was from -28.5% to 28.5%.

IV. Incineration of Waste

In 2021, GHG emissions from incineration of waste were 13.397 $MtCO_2eq$, an increase of 14.4% from 2020, mainly due to an increase in incineration amount.

(i) Category Description

GHG emissions from incineration include CO_2, CH_4 and N_2O emissions from the combustion of waste in incineration facilities. Since MSW incineration can be used as an energy source, CH_4 and N_2O emissions from MSW incineration, and fossil CO_2 emissions were reported under Energy, and biogenic CO_2 emissions were reported as memo items. The incineration of waste part only reports CO_2, CH_4 and N_2O emissions from hazardous and medical waste incineration, and CH_4 and N_2O emissions from sludge incineration.

(ii) Methods

GHG emissions from incineration were calculated using Tier 1 and Tier 2 the emission factor. Activity data on the incineration of MSW, hazardous waste, medical waste and sludge were obtained from the China Urban Construction Statistical Yearbook, the China Environment Statistical Yearbook, and the Annual Statistic Report on Environment in China. GHG emissions from MSW incineration were categorized into fossil and biogenic GHG emissions, with fossil emissions calculated using Tier 2 method and biogenic emissions calculated using

Tier 1 method. The proportion of carbon content in the waste and the proportion of mineral carbon content in the waste were obtained based on the waste composition, and the incinerator combustion efficiency was obtained using the average combustion efficiency of a typical surveyed incinerator. CH_4 and N_2O emission factors were determined by combining default emission factors in the 2006 IPCC Guidelines and expert judgment.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty related to incineration of waste for 2005, 2020 and 2021 was from -36.4% to 36.4%.

V. Wastewater Treatment and Discharge

In 2021, GHG emissions from wastewater treatment and discharge were 87.666 $MtCO_2eq$, an increase of 0.6% compared to 2020, mainly due to the increasing amount in wastewater treatment.

(i) Category Description

GHG emissions from wastewater treatment include CH_4 emissions from domestic wastewater treatment and industrial wastewater treatment, as well as N_2O emissions from wastewater treatment. The N_2O emissions from treatment plants or from direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes, or the sea.

(ii) Methods

1. CH_4 emissions from domestic wastewater treatment

CH_4 emissions from domestic wastewater treatment were calculated using Tier 2 method. Activity data on domestic wastewater treatment were obtained from the Annual Statistic Report on Environment in China for each year (see Table 1-51). The emission factor-related parameters such as maximum CH_4 producing capacity (Bo) and MCF were obtained based on statistical data and expert judgment.

2. CH_4 emissions from industrial wastewater treatment

CH_4 emissions from industrial wastewater treatment were calculated using Tier 2 method. Activity data on industrial wastewater treatment were obtained from the Annual Statistic Report on Environment in China for each year (see Table 1-51). Based on expert adjudgment, the CH_4 MCF was calculated by considering the proportions of three treatment methods: anaerobic treatment, well-managed aerobic treatment, and poorly-managed aerobic treatment, combined with the default emission factors for different treatment technologies as specified in the 2006 IPCC Guidelines.

3. N_2O emissions from wastewater treatment

N_2O emissions from wastewater treatment were calculated using Tier 1 method. Activity data required includes the population size, the average per capita annual protein consumption, and the N content in protein, which were obtained from the China Statistical Yearbook and specialized surveys conducted by relevant departments. The emission factor-related parameters include the emission factors for non-consumed proteins in wastewater, industrial and commercial co-discharged protein into the sewer system, etc., which were determined by expert adjudgment based on the treatment technology and management level, combined with the default emission factors in the 2006 IPCC Guidelines.

(iii) Uncertainty Assessment

Based on the propagation of error method, the uncertainty related to wastewater treatment and discharge for 2005, 2020 and 2021 were from -32.4% to 32.4%, -32.4% to 32.4%, and -32.2% to 32.2%, respectively.

Chapter 8 Cross-Cutting Issues

During the inventory compilation process, to ensure the clear boundaries of each source and sink, and to avoid double counting or omission, it is necessary to distinguish the inventory boundaries and the underlying data used between the cross-cutting categories.

In the cross-cutting categories of Energy and IPPU, emissions from non-energy use were reported under IPPU according to the 2006 IPCC Guidelines. Therefore, emissions from the use of energy as raw materials or materials during the production processes of products such as calcium carbide, ethylene, methanol, ferroalloys, lead and zinc production, as well as emissions from non-energy products from fuels and solvent use such as lubricants and paraffin waxes, were reported under IPPU. At the same time, to avoid double counting of converter gas emissions, only emissions from the use of carbonate fluxes were reported for iron and steel production under IPPU, and CO_2 emissions from converter steelmaking were not reported.

In the cross-cutting categories of Energy and Agriculture, to ensure the consistency of data on number of animals, grazing animals, and N_2O emissions from manure management, animal manure data has already deducted the amount of animal manure from pasture within farming regions, actual grazing animals in pastoral areas and grazing cattle manure as fuel to avoid double counting of manure entering the agricultural soils.

In the cross-cutting categories of Energy and Waste, emissions from incineration of waste as energy recovery should be reported under Energy. Therefore, CH_4 and N_2O emissions from incineration of MSW, and fossil CO_2 emissions were reported under Energy, while biogenic CO_2 emissions were reported as memo items. The emissions from incineration under Waste only covered CO_2, CH_4 and N_2O emissions from hazardous and medical waste incineration, and CH_4 and N_2O emissions from sludge incineration.

In the cross-cutting categories of IPPU, Energy, and Agriculture, short-term carbon sinks from downstream urea production and joint soda production were not excluded from emissions from ammonia production under IPPU. Correspondingly, CO_2 emissions from the use of urea as a catalyst in road transportation under Energy and the application of urea under Agriculture were not reported.

In the cross-cutting categories of Agriculture and LULUCF, the main sources of underlying data such as major crop statistics, agricultural residues returning rates, and the amount of manure applied to field crops are consistent.

In the cross-cutting categories of Waste and LULUCF, CH_4 emissions from harvested wood products (waste wood, paper, etc.) entering the MSW system were reported under Waste, while changes in carbon stocks of harvested wood products were reported under LULUCF.

In addition to emissions from biomass fuel combustion reported under Energy, CH_4 and N_2O emissions from field burning of agricultural residues were reported under Agriculture; CH_4 and N_2O emissions from the burning of biomass in forest land and grassland were reported under LULUCF; and emissions from the burning of biomass were not reported under Waste.

Chapter 9 Time-Series Consistency Analysis

As the consumption of firewood has decreased significantly and is not included in official statistics, emissions from consumption of firewood are not reported under Energy since 2015. Due to the lack of data on household biogas consumption, biogas plant gas production, and the number of energy-saving stoves in provinces, the calculation is based on related indicators such as the number of households using biogas and the utilization rate since 2019.

For solid fuels, starting from 2015, China no longer releases data on coal production of underground mines and surface mines at the provincial level. As a result, it is no longer possible to obtain the national CH_4 emissions from mining activities by summing up the emissions of different regions. For the 2020-2021 inventory, the emissions were calculated by multiplying the underground mines coal production with the national weighted CH_4 emission factor of mining activities in 2014. The proportion of raw coal production from coal production of surface mines to all coal production in 2020 was obtained by interpolating the proportions for 2019 and 2021. For the oil and natural gas system, the 2005 data was split based on the output in the current year and corresponding activity data in 2015. Additionally, due to a lack of statistics, emissions from well completions, abandoned wells, flaring, and LNG imports were not reported in the updated 2005 inventory.

For IPPU, due to the fact that the China Steel Statistics Yearbook no longer published the category-specific product data of the China Iron and Steel Association (CISA) after 2016, the ferroalloys output in 2020-2021 was split based on the proportion of category-specific product outputs in 2016. For electronics industry, to strengthen the inventory statistics, starting from 2014, NBS and NDRC issued the *Notice on Carrying Out Statistical Work for Climate Change* (GTZ[2013] No. 80), developed the *Statistical Reporting System for Climate Change by Sectors (Trial)*, and conducted national-level statistical work on the production and usage of HFCs, PFCs, SF_6 and fluorinated gases, and new addition data for automotive and room air conditioning equipment was sourced from the China Statistical Yearbook. The production data for 2005 was derived from industry association research and linear calculations, while the production and usage for fluorinated gases in 2020-2021 was sourced from data of the Statistical Reporting System for Climate Change.

For LULUCF, from 2021 onwards, the activity data on arboreal forests and bamboo forests were based on the results of the integrated forest and grassland ecological monitoring, and the area of each of the other land types was determined on the basis of the results of the Third Nationwide Land Survey in 2019 and its annual updated data. All activity data for 2005 and 2020 were re-integrated and adjusted to be consistent with the 2021 land use categories.

Chapter 10 Quality Assurance, Quality Control and Verification

I. Data Quality Control

(i) Data Collection and Verification

The collection of different categories of data including statistical data, key parameters, and emission factors was carried out in accordance with data collection priorities provided by the 2006 IPCC Guidelines, as detailed in Table 1-52.

Table 1-52 Data Collection Priorities and Overview of Sector-Specific Data Collection

Data types	Data collection priorities	Overview of sector-specific data collection
Activity data	The order of authoritativeness is the data from the national statistics authority, data from departments or industry associations, research data, and judgment by experts, with their uncertainties increasing from ±5% to ±30%.	♦ Most of the statistical data for the Energy, IPPU, Agriculture, LULUCF, and Waste were sourced from NBS and relevant departments (such as MARA, MNR, NFGA, and MEE). ♦ Some of the data that cannot be provided by the statistical agencies (such as the number of grazing animals in the pastoral area and manure used as fuels, soil data, and vegetation data, etc.) was obtained from the industry associations.
Key Parameters/ Emission Factors	The data of large sample testing/industry survey data adopting national/industry standard methods (such as national/industry census data) has the highest authority, followed by monitoring data published by research institutions, and finally expert judgment and IPCC default values, with uncertainties within the range of IPCC default values.	♦ The carbon content per unit calorific value and carbon oxidation rate of solid fuels were mainly sourced from measured data reported by enterprises in the national carbon market, and data collected from industry boiler surveys and tests. The data on carbon content per unit calorific value of gaseous fuels was mainly sourced from measured data on major oil and gas fields in China and natural gas importers. ♦ Data such as annual nitrogen excretion of major livestock were from monitoring data obtained from the National Pollution Source Census, and the proportions of manure management methods in different regions were derived from regular surveys in typical counties.

The following three data verification activities were carried out to ensure the quality of the inventory:

First, the activity data, emission factors and key parameters used in each category were verified against the original data.

Second, the model parameters were verified with other relevant modules. For example, for the COPERT model for road transportation, the fuel balance module was used to verify the total fuel consumption, ensuring the accuracy of CO_2 emissions.

Third, the consistency of the data from different categories were verified. For example, the data such as the number of grazing animals, the amount of animal manure used as fuels in pastoral areas and in farming areas were verified across agricultural sub-sectors. Another example is data verification of biomass fuel in the inventories on LULUCF and Energy.

(ii) Documentation Management

Following the 2006 IPCC Guidelines, the database system of national GHG inventories for activity data, emission factors, and related parameters were established, and the relevant inventory materials were archived and preserved.

II. Data Quality Assurance

The inventory has sought the comments and suggestions from the member units of the National Leading Group on Climate Change, Energy Conservation and Emissions Reduction, as well as relevant industry associations. The inventory results were compared with the relevant calculation results published by domestic and international peer institutions.

Chapter 11 Updates on Specific Source and Sink Categories

According to the implementation rules of the Paris Agreement, from 2024 onwards, the inventory reports submitted by the Parties shall refer to the 2006 IPCC Guidelines. With the comprehensive transformation of the 2020-2021 inventory methodology and the necessary adjustments of the underlying data, the current inventory for the base year (2005) of NDC was updated, with the specific results and difference analysis detailed in Table 1-53.

Newly added sources include CH_4 emissions from post-mining activities of surface mines, direct and indirect N_2O emissions from soils mineralization, and indirect N_2O emissions from N volatilization and re-deposition from animal manure.

In terms of calculation methods, the methodology for aviation was upgraded to Tier 3, and the methodology for the exploration was updated to further refine the distinction between oil and gas wells.

Activity data on production processes such as lime, ammonia, methanol, ethylene, titanium dioxide, aluminium, lead and zinc smelting were refined according to the availability of activity data sources. Data on animal feeding was adjusted based on revised data from the Third Agricultural Census. Activity data on area of managed grasslands, COD and BOD of domestic sewage and industrial wastewater were updated.

In terms of emission factors, the N content of the crop residues and the straw/grain ratios were updated with the data from the A Chronicle of Organic Fertilizer Nutrients in China and the national survey of crop residues conducted by the MARA. The crop residues returning rates were also updated. For Waste, the degradable organic carbon content of wastes was updated through machine learning analysis and literature review, which improved the accuracy of solid waste disposal data.

As for the reporting format, in accordance with the implementing rules of the Paris Agreement, Parties should use the 100-year time-horizon GWP values from IPCC AR5. Consequently, the GWPs of the various GHGs were updated from those in IPCC AR2 to those in IPCC AR5.

Table 1-53 Comparative Analysis of the Differences between Original and Updated Inventories 2005

Source/Sink Categories	Before	After	After-Before	Variance Analysis
	(MtCO₂eq)			
Energy	6,252	6,475	223	Based on the data adjustments for non-energy use under IPPU, emission subtractions in the cross-cutting sectors between energy and IPPU were updated. The methodology for aviation was upgraded to Tier 3. The emissions from other petroleum products were corrected. The data were updated based on the data on coal mine gas drainage provided by NEA for the years 2005-2021; emissions from post-mining activities of surface mines were newly added; and the methodology for the exploration was updated.
IPPU	865	906	42	Activity data for lime, ammonia, methanol, ethylene, titanium dioxide, aluminium, lead and zinc smelting were updated based on new data sources; GHG emissions from product uses as substitutes for ODS were corrected.
Agriculture	755	859	104	Indirect N_2O emission sources in the livestock industry were newly added, and cattle data were updated; Indirect N_2O emissions from grazing animals, direct and indirect N_2O emissions from the soils mineralization were newly added; the N content of the crop residues and the straw/grain ratios were updated; and indirect N_2O emissions from N volatilization and re-deposition from animal manure were reported under manure management.
LULUCF	-770	-711	59	Data on straw/grain ratios and activity data on area of managed grasslands were updated.
Waste	110	116	5	The value of the proportion of degradable organic carbon was refined through the study on changes in waste composition.

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). In accordance with the implementing rules of the Paris Agreement, Parties should use the 100-year time-horizon GWP values from IPCC AR5. Consequently, the GWPs of the various GHGs were updated from those in IPCC AR2 to those in IPCC AR5, and the details in each sector were not described here.

Chapter 12 Flexibility

Based on data availability, China prepared only the 2020-2021 inventory and updated the inventory for the base year (2005) of NDC. In terms of completeness, the key categories are covered without any omissions. The flexibility used is detailed in Table 1-54.

Table 1-54 Inventory Flexibility

Flexibility	Used or not	Reasons (difficulties and challenges)	Anticipated time frames for improvements
1. Identify key categories for the starting year and the latest reporting year, including and excluding LULUCF categories, using approach 1, for both level and trend assessment, using a threshold no lower than 85 per cent defined in the IPCC guidelines, allowing a focus on improving fewer categories and prioritizing resources.	Not used	Not involved	Not involved
2. Qualitatively and quantitatively discuss the uncertainty for key categories for at least the starting year and the latest reporting year of the inventory time series, and encourage to provide a quantitative estimate of uncertainty for all source and sink categories of the GHG inventory.	No quantitative trend uncertainty assessment was carried out for key categories.	No underlying data is available to support the assessment on trend uncertainty.	Plan to upgrade underlying data collection and conduct trend uncertainty assessments as appropriate.
3. Each Party may use the notation key "NE" when the estimates would be insignificant in terms of level according to the following considerations: emissions from a category should only be considered insignificant if the likely level of emissions is below 0.1 per cent of the national total GHG emissions, excluding LULUCF, or 1,000 kt CO_2 eq, whichever is lower. The total national aggregate of estimated emissions for all gases from categories considered insignificant, in this case, shall	The key categories are covered without any omissions. Due to a lack of statistical data and literature on other SF_6 and PFCs uses in other product manufacture and use, and the emissions are less than 1,000 ktCO_2eq as estimated by experts, these emissions were not reported. In the wetland, N_2O emissions are negligible because there is a lack of sufficient data to support draining and rewetting of organic-soil wetlands, and all inland wetlands are mineral-soil wetlands with no N application. For coastal wetlands, as the land use types include only coastal mudflats and mangroves, N_2O	No basic statistics or literature are available.	Plan to conduct statistical surveys and case analysis, and determine whether to report them in subsequent annual inventories depending on the results.

Flexibility	Used or not	Reasons (difficulties and challenges)	Anticipated time frames for improvements
remain below 0.2 per cent of the national total GHG emissions, excluding LULUCF.	emissions from coastal fishponds for aquaculture were not reported. Flooded land was not assessed as no methodology was available.		
4. Each Party shall elaborate an inventory quality assurance/quality control (QA/QC) plan, including information on the inventory agency responsible for implementing QA/QC; those developing country Parties that need flexibility in the light of their capacities with respect to this provision are instead encouraged to elaborate an inventory QA/QC plan, including information on the inventory agency responsible for implementing QA/QC.	QA/QC was implemented, but a QA/QC plan has not been in place.	Not involved	Plan to develop a QA/QC plan and provide information on the inventory agency responsible for implementing QA/QC, and conduct QA/QC procedures in accordance with the plan.
5. Each Party shall implement and provide information on general inventory QC procedures in accordance with its QA/QC plan and the IPCC guidelines; developing country Parties that need flexibility in the light of their capacities with respect to this provision are instead encouraged to implement and provide information on general inventory QC procedures in accordance with its QA/QC plan and the IPCC guidelines.		Not involved	
6. Each Party shall report seven gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3); those developing country Parties that need flexibility in the light of their capacities with respect to	CO_2, CH_4 and N_2O, HFCs, PFCs and SF_6, were reported, while NF_3 was not reported.	No basic statistics are available.	Plan to consolidate the basic capacity for verification of monitoring reports in the relevant industries and to

Flexibility	Used or not	Reasons (difficulties and challenges)	Anticipated time frames for improvements
this provision have the flexibility to instead report at least three gases (CO_2, CH_4 and N_2O) as well as any of the additional four gases (HFCs, PFCs, SF_6 and NF_3).			enhance the capacity for underlying data collection, and determine whether to report in subsequent annual inventories depending on the results.
7. Each Party shall report a consistent annual time series starting from 1990; those developing country Parties that need flexibility in the light of their capacities have the flexibility to instead report data covering a consistent annual time series from at least 2020 onwards.	The reporting year covered time series from 2020 onwards.	Due to the limited availability of basic statistics, it is not possible to obtain underlying data from 1990 onwards to support the compilation of a time-series inventory from 1990 onwards.	Plan to upgrade the capacity for underlying data collection and determine, as appropriate, whether to report in subsequent annual inventories.
8. For each Party, the latest reporting year shall be no more than two years prior to the submission of its national inventory report; those developing country Parties that need flexibility in the light of their capacities with respect to this provision have the flexibility to instead have their latest reporting year as three years prior to the submission of their national inventory report.	The latest reporting year was three years prior to the submission.	Due to the timeliness of reporting of basic statistics, it is not possible to obtain underlying data two years prior to the submission cannot be provided at this time due to limitations on the timeliness of reporting of basic statistics.	

Chapter 13 Inventory Improvement Plan

Based on the experience of the current inventory compilation and the results of the key category analysis, in order to further improve the quality of future inventories and reduce the uncertainty, an inventory improvement plan is elaborated in the following three aspects:

For activity data, based on the data foundation and needs of the current inventory, we will further revise the statistical reporting system for climate change, and add a special statistical survey on fuel consumption for each segment of navigation; increase the collection of uncertainty of basic statistics to support the trend uncertainty assessment; continuously verify the activity data against national carbon market facility-level data; conduct statistical surveys on the production of quicklime products by type; conduct regular rice irrigation surveys and surveys on area of winter-flooding paddy fields; plan to report CH_4 emissions data from coal and oil and natural gas production enterprises; conduct surveys on consumption of urea, soil conditioners (lime, dolomite); establish national official time-series consistent spatial data on land-use changes, and improve the data update frequency, taking into account the quantitative accounting of GHGs from natural emission sources such as forest fires.

For emission factors, we will carry out typical sampling surveys of the aluminum smelting industry, and update the anode effect emission factors, etc.; In the long term, it is planned to carry out special surveys, measurement and analysis of carbon content per unit calorific value and carbon oxidation rate and update the country-specific emission factors of steel, non-metallic minerals and non-ferrous metals and other high-energy-consuming industries. For major oil products such as gasoline, diesel fuel, aviation kerosene, aviation gasoline, fuel oil and natural gas, we will carry out measurement and analysis of carbon content per unit calorific value. It is planned to carry out regional monitoring of GHG emissions from typical farmland, typical surveys of parameters for livestock and poultry production and management under different feeding practices, and regular updating of key category emission factors for inventories on Agriculture. We will regularly conduct surveys on soil organic carbon data for each land use type, construct high-precision soil organic carbon density maps, and carry out studies on localization of domestic sewage discharge factors.

For the working mechanism of inventory compilation, we will foster regular inventory compilation, carry out a study on the work plan for regular inventory compilation, formulate a QA/QC plan, and further clarify the division of responsibilities of various departments in inventory compilation. Furthermore, we will strengthen exchanges with the international community on inventory compilation, and enhance capacity building of inventory compilation personnel. The capacity-building needs in this regard are set out in Chapter 5 of Part IV.

Part II Progress in Nationally Determined Contributions

On September 22, 2020, Chinese President Xi Jinping solemnly declared at the General Debate of the 75th Session of the United Nations General Assembly: China would scale up its Nationally Determined Contributions (NDC) by adopting more vigorous policies and measures. We aim to have carbon dioxide emissions peak before 2030 and strive to achieve carbon neutrality before 2060. In 2021, China proposed an updated 2030 NDC, which includes both carbon peaking and carbon neutrality goals, and mitigation goals of lower carbon dioxide emissions per unit of GDP by over 65% from the 2005 levels, to increase the share of non-fossil fuels in primary energy consumption to around 25%, to increase the forest stock volume by 6 billion cubic meters from the 2005 levels, and to bring China’s total installed capacity of wind and solar power to over 1,200 GW, as well as policies and actions for climate change adaptation.

To meet these NDC targets, China has issued several top-level Design Documents, such as the *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives Through the Year 2035 of the People's Republic of China*, *Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy*, and *Action Plan for Carbon Dioxide Peaking Before 2030* which promote a comprehensive green transformation of economic and social development. China has implemented a series of mitigation policies and actions across Energy, Industry, Construction, Transportation, Carbon Sinks, and Synergies Actions for Pollution-Carbon Reduction. Relevant departments have developed sector-specific implementation plans and supporting policies, while provinces (autonomous regions and municipalities directly under the central government) have formulated regional carbon peaking implementation plans. This section, according to MPGs, reports on China’s national circumstances and institutional arrangements related to the NDC, descriptions and tracking progress of NDCs target, and effects of mitigation policies and measures since 2020. Progress on adaptation actions of NDC will be reported in Part III.

Chapter 1 National Circumstances and Institutional Arrangements

I. Overview of National Circumstances Related to Climate Change Mitigation

(i) Government Structure

The socialist system is the fundamental system of the People’s Republic of China. The leadership of the Communist Party of China is the defining feature of socialism with Chinese characteristics. All power in the People’s Republic of China belongs to the people. The National People’s Congress (NPC) and local people’s congresses at various levels are the organs through which the people exercise state power. The NPC is the highest organ of state power, and its standing committee, the Standing Committee of the National People’s

Congress (NPCSC), NPC and NPCSC exercise the state legislative power. The NPC comprises representatives elected from provinces, autonomous regions, municipalities directly under the central government, special administrative regions, and the armed forces, serving five-year terms. Proper representation is allocated to ethnic minorities. The NPC meets annually, convened by the NPCSC, and is responsible for amending the Constitution, overseeing its implementation, and enacting or amending basic laws on criminal, civil, state institutional, and other matters. During NPC recesses, the NPCSC examines and approves any necessary adjustments to the national economic and social development plans and state budget, decides on appointments for ministers, heads of commissions, the auditor general, and the secretary-general as proposed by the Premier, and supervises the work of the State Council. NPC representatives and NPCSC members are entitled, during NPC and NPCSC sessions respectively, to question the State Council or its ministries and commissions in accordance with legal procedures. The questioned authorities must provide responses. The NPCSC decides on the ratification or abrogation of treaties and important agreements with foreign countries. The NPC has specialized committees that research, review, and draft relevant proposals under the leadership of the NPC and NPCSC.

The State Council, or Central People's Government, is the executive organ of the highest organ of state power and the highest state administrative organ. It operates under the responsibility of the Premier. Ministries and commissions operate under ministerial or directorial responsibility. The State Council enacts administrative measures, formulates administrative regulations, and issues decisions and orders based on the Constitution and laws; proposes bills to the NPC or NPCSC; defines the tasks and responsibilities of each ministry and commission; oversees the work of ministries, commissions, and national-level administrative tasks that are not covered by ministries and commissions; oversees the administrative work of local governments at all levels nationwide not belong to ministries and commissions; provides unified leadership in the work of state administrative organs at all levels throughout the country, delineates specific powers between central and provincial (autonomous region or municipal) state administrative organs; prepares and implements national economic and social development plans and budgets; directs and manages economic work, urban and rural development, and ecological civilization construction; leads education, science, culture, health, sports, and family planning efforts; and oversees civil, public security, and judicial administration, as well as foreign affairs and treaty agreements with other countries. The State Council is accountable to and reports on its work to the NPC, and during NPC recesses, to the NPCSC.

People's congresses and people's governments are established at the provincial, autonomous region, municipal, county, city, district, township (ethnic township), and town levels. Local people's congresses are local state organs of power. They ensure the adherence to and enforcement of the Constitution, laws, and administrative regulations within their administrative regions; adopt and issue resolutions; and review and determine plans for local economic, cultural, and public service construction according to legally defined powers. Local people's governments are the administrative organs at various local levels and exercise administrative authority to manage local economic, educational, scientific, cultural, health, sports, urban and rural development, finance, civil affairs, public security, ethnic affairs, judicial administration, and family planning affairs within their regions according to legally defined powers. Local people's governments are accountable to and report on their work to the higher-level state administrative organs. All local people's governments in China are under the unified leadership of the State Council and comply with its directives.

(ii) Population

China is a populous country, with a total population of [3]1.412 billion at the end of 2022, including an urban permanent population of 921 million (accounts for 65.2% of the total population) and a rural population of 491 million. To prevent and address the challenges of an aging population, China implemented a policy allowing couples with one child to have a second child in 2013, followed by a universal two-child policy in 2016. The natural population growth rate was -0.6‰ in 2022 (Figure 2-1)[4].

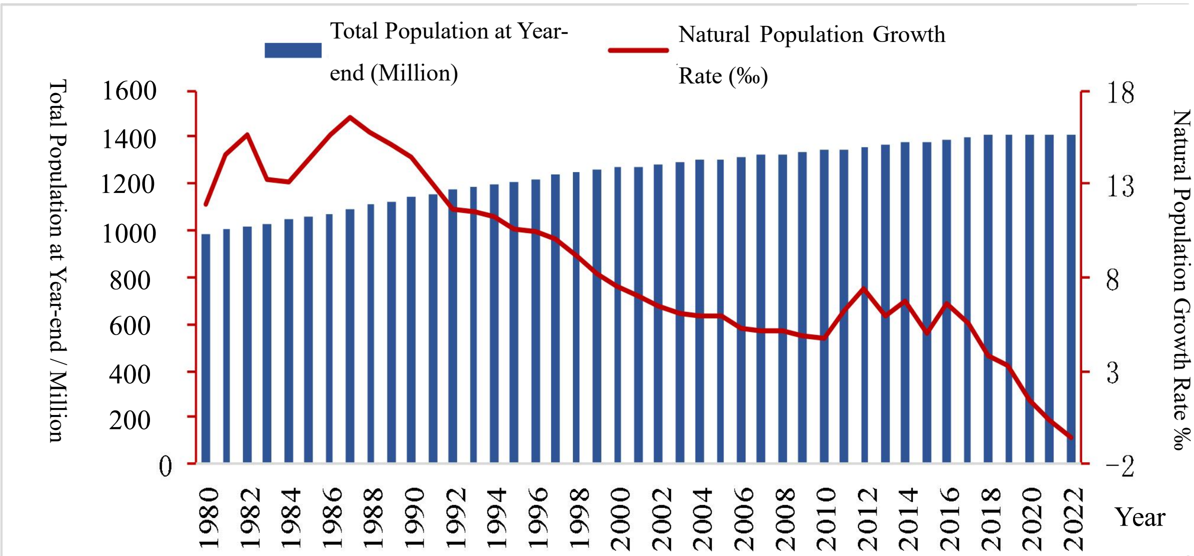


Figure 2-1 Changes in China's Total Population and Natural Growth Rate from 1980 to 2022

With improvements in living standards, health, and public health conditions, average life expectancy in China rose from 77.9 years in 2020 to 78.2 years in 2021[5]. In terms of age distribution, 68.2% of the population (962.89 million) were between 15 and 64 years old in 2022. The proportion of the elderly population has steadily increased, with individuals aged 65 and above numbering 209.78 million, accounting for 14.9% of the total population[6].

(iii) Geography

1. Energy Resources

China's energy resources are characterized by being "rich in coal, deficient in oil, and limited

[3] National population refers to the population of the 31 provinces (regions, municipalities) and active-duty military personnel, excluding residents of Hong Kong, Macao, and Taiwan and foreign nationals residing in the 31 provinces (regions, municipalities).
[4] Source: National Bureau of Statistics (NBS).
[5] Source: Statistical Communiqué on the Development of China's Health Sector 2021, issued by the National Health Commission of the People's Republic of China.
[6] Source: China Statistical Yearbook 2023

in natural gas". As shown in Table 2-1, the main energy mineral reserves for 2022. China has some of the largest hydropower resources globally, with 70% located in the southwestern provinces and the Tibet Autonomous Region, predominantly in the Yangtze River system, followed by the Yarlung Zangbo River. The Yellow and Pearl River systems also hold substantial hydropower potential[7]. China's wind energy resources are abundant, with the southeastern coast and its islands from the Yangtze River to Nan'ao Island, Northeast China, Inner Mongolia, and eastern Xinjiang as resource-rich regions. The southeastern coast is China's largest wind energy resource area. China is relatively rich in total abundant solar radiation resources, with a pattern of "higher in plateaus than plains, and more in dry western than humid eastern regions." The most solar-rich areas include most of Tibet, central Qinghai, and parts of northern Qinghai.

Table 2-1 Reserves of Major Energy Minerals in China 2022[8]

No.	Energy Mineral	Unit	Reserves
1	Coal	billion tons	207.012
2	Oil	billion tons	3.806
3	Natural gas	billion cubic meters	6,569.012
4	Coalbed Methane	billion cubic meters	365.969
5	Shale Gas	billion cubic meters	560.559

2. Agriculture

China's climate is diverse, fostering a rich variety of crops and flora and fauna. The country's high summer temperatures offer favorable heat conditions, allowing certain heat-intensive crops to grow at latitudes higher than in other countries worldwide. Wheat production is concentrated in the North China Plain and Northeast Plain; rice is predominantly grown south of the Qinling Mountains-Huaihe River line; and corn is widely distributed, primarily in the northeast, north, and southwest, forming an extended cultivation belt from northeast to southwest, with the largest areas in Shandong, Jilin, Hebei, Heilongjiang, Liaoning, Henan, and Sichuan. Rapeseed is mainly in the Yangtze River Basin, though recently shifting north; peanuts are mostly in the sandy and hilly areas of eastern China in warm-temperate, subtropical, and tropical zones; and soybeans have two main cultivation areas with high output—the spring-sown soybean in the Northeast and the summer-sown soybean in the Huang-Huai-Hai region. China's prominent monsoon climate provides favorable conditions for agriculture while also presenting challenges. Concentrated rainfall brought by monsoons from May to September often causes floods, which can adversely impact agriculture.

3. Forestry

China's vegetation types are diverse and distributed in a complex pattern. In the eastern monsoon region, vegetation includes tropical rainforest, tropical monsoon forest, evergreen broad-leaved forest of the South and Central subtropics, mixed deciduous and evergreen broad-leaved forests of the North subtropics, deciduous broad-leaved forest of the temperate

[7] Source: The people's Republic of China Yearbook

[8] Source: China Mineral Resources 2023, where oil, natural gas, coalbed methane, and shale gas reserves represent remaining proven technically recoverable reserves, while coal reserves include confirmed and credible reserves.

zone, temperate coniferous forest, subalpine coniferous forest, and temperate forest-steppe. In the northwestern and Qinghai-Tibet Plateau regions, vegetation includes dry grasslands, semi-desert shrub grasslands, dry desert grasslands, alpine desert, and alpine meadow shrub grasslands[9]. The Greater and Lesser Khingan Mountains and the Changbai Mountain area in Northeast China are the country's largest natural forest areas. The Hengduan Mountains in the Southwest form China's second largest natural forest region. The mountains in the southeastern provinces, such as Fujian and Jiangxi, are mainly covered by artificial and secondary forests.

(iv) Macroeconomy

In 2022, China's GDP reached RMB 121 trillion, with an optimized industrial structure shifting from 11.6:47.0:41.3 in 2005 to 7.3:39.3:53.4 in 2022 (Table 2-2). Per capita GDP was RMB 85,698 and per capita disposable income reached RMB 36,883. The Engel coefficient of household consumption fell from 37.3% in 2005 to 30.5% in 2022, and the quality of life in urban and rural areas has steadily improved. Efforts across all regions and departments have consolidated poverty alleviation achievements, raised rural construction standards, lifted 98.99 million rural people from poverty, delisted 832 poor counties, and completed 128 thousand poverty-stricken villages, achieving the major task of eradicating absolute poverty.

Table 2-2 Gross Domestic Product (GDP) and Industrial Structure in China, 2005, 2020, 2021, 2022

		2005	2020	2021	2022
Gross Domestic Product (RMB billion)		18,731.9	101,356.7	114,923.7	120,472.4
Primary Industry (RMB billion)		2,180.7	7,803.1	8,321.7	8,820.7
Secondary Industry (RMB billion)		8,808.2	38,356.2	45,154.4	47,379.0
Tertiary Industry (RMB billion)		7,743.0	55,197.4	61,447.6	64,272.7
Industrial Structure	Share of Primary Industry (%)	11.6	7.7	7.2	7.3
	Share of Secondary Industry (%)	47.0	37.8	39.3	39.3
	Share of Tertiary Industry (%)	41.3	54.5	53.5	53.4
Per Capita GDP (yuan)		14,368	71,776	81,356	85,310

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

For climate conditions, see Part III, Chapter 1.

(v) Key Sector Overview

1. Agriculture

In 2022, China's grain output was 687 million tons, feeding nearly 18% of the global population with only 9% of the world's arable land. Pork, beef, lamb, and poultry production totaled 92.27 million tons, increasing by 3.39 million tons (3.8% growth); total fruit production reached 312.96 million tons; and vegetable production was approximately 791 million tons. By the end of 2022, crop seed improvement coverage surpassed 96%, with a comprehensive mechanization rate for tillage, planting, and harvesting exceeding 73%. Total agricultural machinery power in 2022 reached 1,105.972 million kW, with 5.254 million large and medium-sized farm tractors and 16.187 million small farm tractors.

[9] Source: The People's Republic of China Yearbook

2. Energy Industry

China's energy consumption in 2022 was 5.41 billion tons of standard coal. Compared to 2005, the share of coal consumption in total energy consumption decreased by 16.4 percentage points. China has consistently ranked first in the world for both the annual newly added and cumulative installed capacity of hydropower, wind power, and solar power generation for many years. Renewable energy is playing an increasingly significant role in ensuring energy supply. China's wind and solar equipment manufacturing has established a complete industrial chain, with technologies and manufacturing scales leading globally. Chinese-manufactured photovoltaic components, wind turbines, gearboxes, and other key parts account for 70% of the global market, contributing significantly to global carbon reduction efforts.

3. Manufacturing and Construction

The added industrial value of the Chinese manufacturing sector accounts for about 30% of the global total, with complete industrial categories covering 41 major, 207 medium, and 666 minor industries, China boasts all industrial sectors categorized by the United Nations, having over 70,000 Specialized and Sophisticated SMEs (Small- and medium-sized enterprises).

The value added by the construction industry has consistently accounted for around 7% of GDP. Green buildings have rapidly developed, and building energy efficiency improvements are progressing steadily. China continues to advance major infrastructure projects, enhancing essential infrastructure for public welfare, and has made new breakthroughs in building new infrastructure. The capacity for housing construction has improved significantly, with a steady increase in per capita residential space.

4. Transportation

China has established a comprehensive transport network dominated by highways, railways, air, and water transport. By 2022, the total mileage of China's transport network exceeded 6 million km, with railway mileage of 155,000 km, highway mileage of 5.35 million km, and total commercial passenger transport and commercial freight transport of 5.59 billion passenger trips and 50.66 billion tons. Port throughput reached 15.68 billion metric tons, and container throughput was 296 million TEUs (twenty-foot equivalent units). Additionally, the daily average order volumes for ride-hailing services and shared bicycles were over 20 million and 33 million, respectively.

5. Services Sector

In 2022, the added value of tertiary industries (including transportation, warehousing, and postal services) reached RMB 64.2727 trillion, with the contribution rate to GDP rising from 44.3% in 2005 to 55.3% in 2022. The share of the financial sector in the tertiary industry has notably increased (Table 2-3).

Table 2-3 Composition of Tertiary Industry in China in 2005, 2010, 2015 and 2022 (unit:%)

Industrial sector	2005	2010	2015	2022
Wholesale and retail trade	18.0	19.7	19.4	18.1
Transportation, warehousing and postal services	13.8	10.3	8.7	7.9
Accommodation and catering industry	5.4	4.2	3.5	2.8
Financial industry	9.7	14.1	16.1	14.5
Real Estate business	11.0	12.8	12.2	11.5
Other sectors	41.0	37.7	39.1	44.2

Note: Due to rounding, the aggregation of various items may be slightly different from the total.

(vi) Impact on greenhouse gas emissions

China, as a developing country with a population of over 1.4 billion, faces a series of challenging tasks, including economic development, improving people's livelihoods, pollution control, and ecological protection. In terms of energy structure, fossil fuels still account for a relatively high proportion, around the global average. An energy structure dominated by coal is difficult to fundamentally change in the short term. From the perspective of industrial structure, China's industrial composition remains energy-intensive and carbon-intensive, and such industries still occupy a certain proportion in the national economy. The transformation of the industrial structure has reached a critical stage, making further upgrades increasingly challenging. These factors contribute to China's high total greenhouse gas emissions, and it's carbon intensity above the global average.

China overcame its own economic and social challenges and, with the greatest determination, intensified its efforts to address climate change. It has overachieved the target set for 2020 to reduce carbon dioxide emissions per unit of GDP by 40%–45% compared to 2005 levels, as pledged to the international community. China has promoted a comprehensive green transformation of economic and social development, implementing various policies and actions to mitigate climate change across energy, industry, construction, transportation, carbon sinks, and synergies of pollution-carbon reduction. Exports of the "New Three" (electric vehicles, lithium-ion batteries, and solar cells) have exceeded one trillion RMB, providing high-quality clean energy products and services, thus contributing "China's power" to global climate change mitigation and low-carbon transformation. China's climate action commitment is steadfast and impactful. China's government structure and institutional mechanisms enable efficient mobilization across departments, regions, and society through top-level planning. Currently, China's per capita energy consumption and per capita household electricity consumption remain below the overall level of OECD countries (in 2022, these figures were approximately 25% lower than the OECD average). Over the coming period, energy demand will continue to grow, and carbon emissions may also increase for a certain period. However, the Chinese government will implement a series of policy actions and measures to ensure the achievement of its carbon peaking and carbon neutrality targets.

II. Institutional Arrangements for Tracking Progress in Nationally Determined Contributions

In 2007, the State Council of China established the National Leading Group on Climate

Change, Energy Conservation and Emission Reduction as the central coordinating body for addressing climate change. Its main responsibilities include formulating major national strategies, policies, and countermeasures for addressing climate change, organizing climate response efforts, reviewing international cooperation and negotiation plans, and coordinating key climate response issues. The National Development and Reform Commission (NDRC) was responsible for the specific climate response work.

In 2008, to strengthen climate response organizational structure, the NDRC established a Department of Climate Change. In 2012, the National Center for Climate Change Strategy and International Cooperation (NCSC) was established. In 2018, following the *Plan on Deepening Reform of Party and State Institutions*, the responsibilities for climate change response were transferred from the NDRC to the newly formed Ministry of Ecology and Environment (MEE), and the Department of Climate Change and NCSC were transferred to the MEE. In 2019, the member units and personnel of the National Leading Group on Climate Change, Energy Conservation and Emission Reduction were adjusted. The MEE and NDRC took the lead on relevant responsibilities. (Figure 2-2) The MEE leads climate change response and emission reduction efforts, while the NDRC is responsible for coordinating carbon peaking and carbon neutrality, and overseeing energy conservation.

The MEE leads the formulation of the NDC, which is submitted to the National Leading Group on Climate Change, Energy Conservation and Emission Reduction for approval, based on extensive studies and public consultations. Each department implements responsibilities according to its respective mandates. The NDRC, the National Energy Administration, and others are responsible for promoting low-carbon energy transformation, enhancing clean and efficient coal utilization, and developing non-fossil fuels. The NDRC, Ministry of Industry and Information Technology, and other relevant agencies lead efforts to reduce energy consumption and carbon emissions in industries such as steel, non-ferrous metals, petrochemicals, chemicals, and non-metallic mineral products. The Ministry of Transport (MOT), Ministry of Housing and Urban-Rural Development (MOHURD), and other relevant agencies lead energy conservation in transportation and construction. The Ministry of Science and Technology (MOST) spearheads green and low-carbon technology research, development, and application. The Ministry of Natural Resources (MNR), the MEE, and other relevant agencies lead efforts to enhance carbon sink capacity in ecosystems. The People's Bank of China (PBC) leads efforts for establishing a green finance system, promoting the adoption of green and low-carbon lifestyles and production models.

China's NDC targets are mainly calculated and monitored through its National Inventory and relevant statistical data. Since the initial National Communication on Climate Change, the Chinese government has built a preliminary transparency framework, forming a relatively stable reporting team and a regular system for preparing the National Inventory. According to the division of responsibilities for climate change response, MEE leads the compliance of National Reports and relevant government departments provide fundamental data and information. MEE also coordinates with related industry associations and representative enterprises to gather relevant information, establishes a National Inventory database to support inventory compilation and data management, continuously tracks the progress of

China's NDC targets.

In 2022, China formulated the *Implementation Plan for Accelerating the Establishment of a Unified and Standardized Carbon Emission Statistical Accounting System*, outlining major tasks such as establishing national and regional carbon emission statistics and accounting systems, improving carbon emission accounting mechanisms for industries and enterprises, enhancing accounting methods for key products, and improving mechanisms for compiling the National Inventory. This provides solid support for improving transparency and compliance capacity.

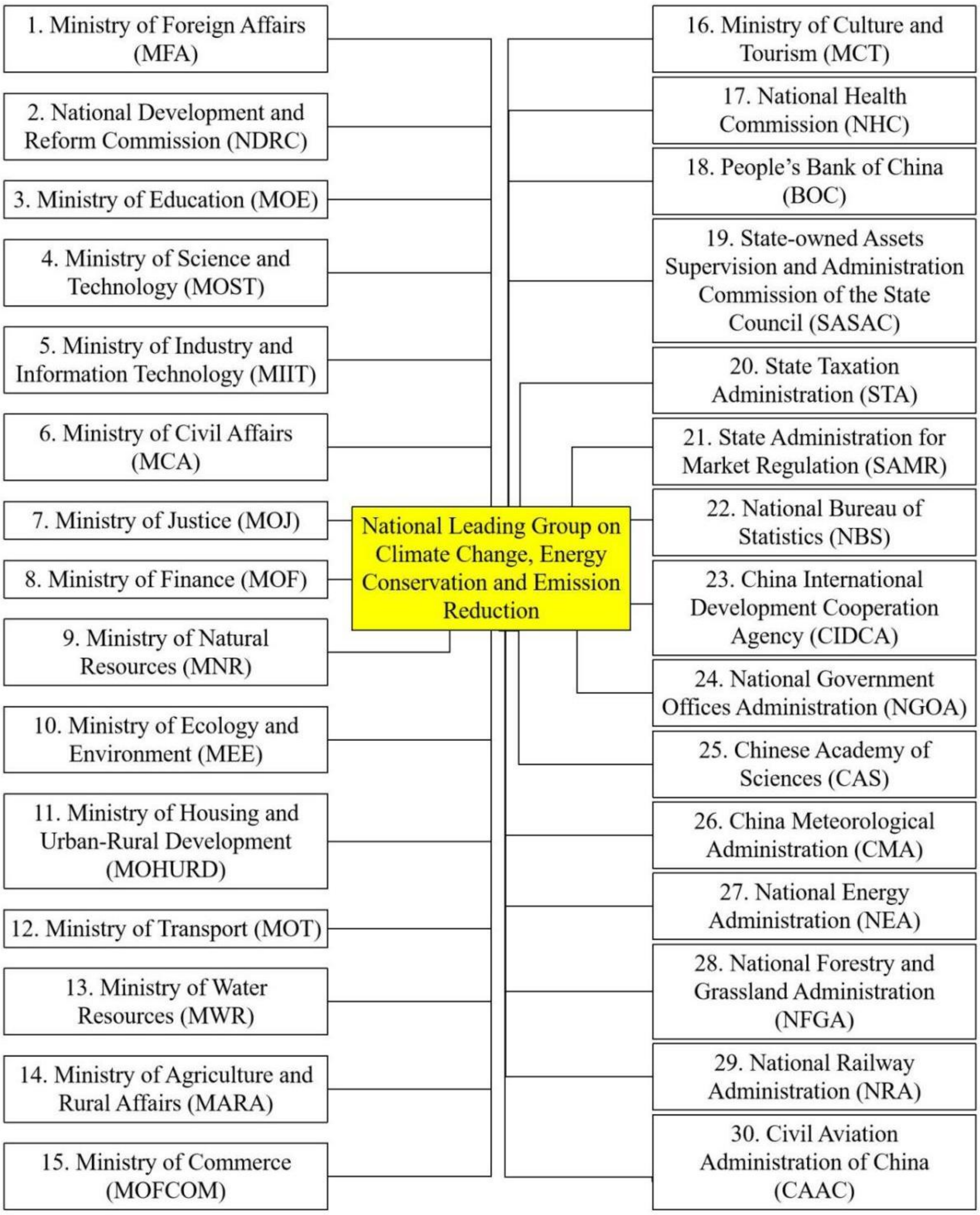


Figure 2-2 Member Departments of National Leading Group on Climate Change, Energy Conservation and Emission Reduction

Chapter 2 Description of NDC Targets

I. Overview

In June 2015, China submitted its *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions* which set forth its NDC targets for 2030. These include to achieve the peaking of carbon dioxide emission around 2030 and making best efforts to peak early; to lower carbon dioxide emissions per unit of GDP by 60%–65% from the 2005 levels; to increase the share of non-fossil fuels in primary energy consumption to around 20%; to increase the forest stock volume by around 4.5 billion cubic meters on the 2005 levels; and establishing mechanisms and capacities to effectively cope with climate change risks as part of adaptation goals. Fifteen policies and measures were also outlined to enhance climate action. Since proposing the NDC in 2015, China has actively and pragmatically fulfilled its commitments, achieving significant progress. On September 22, 2020, Chinese President Xi Jinping announced to the international community on the General Debate of the 75th Session of the United Nations General Assembly that, "China will scale up its intended Nationally Determined Contributions by adopting more vigorous policies and measures. We aim to have carbon dioxide emissions peak before 2030 and achieve carbon neutrality before 2060."

In October 2021, China officially submitted *China's Achievements, New Goals and New Measures for Nationally Determined Contributions* to the UNFCCC Secretariat, updating China's NDC targets. The updated NDC targets include: aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060; by 2030, to lower CO_2 emissions per unit of GDP by over 65% from the 2005 levels; to increase the share of non-fossil fuels in primary energy consumption to around 25%; to increase the forest stock volume by 6 billion cubic meters from 2005 levels; and to bring its total installed capacity of wind and solar power to over 1.2 billion kilowatts by 2030.

II. Descriptions of the Targets

(i) Carbon Peaking

Target Type and Description. In China's updated NDC in 2021, it is stated that "China aim to have CO_2 emissions peak before 2030," (hereinafter refered to as Carbon Peaking) meaning efforts will be made to achieve a stable platform phase in CO_2 emissions or for emissions to begin declining after reaching a peak before 2030.

Target Year and Base Year. This target does not involve a base year, with the target year is before 2030 and is a single-year target.

Scope and Sector. The scope of Carbon Peaking is emissions from Fuel Combustion and Industrial Processes and Product Use, which refers to all CO_2 emissions from Fuel Combustion (1A) in the Energy sector and IPPU in the National Inventory. It covers the sectors of Energy and IPPU, and the greenhouse gas involved is carbon dioxide.

(ii) Carbon Intensity Reduction

Target Type and Description. As part of its Nationally Appropriate Mitigation Actions

(NAMAs), China proposed in 2009 to lower CO_2 emissions per unit of GDP by 40%–45% by 2020 compared to 2005 levels. Based on that, in China further proposed in its updated Nationally Determined Contribution (NDC) of 2021 that "by 2030, to lower CO_2 emissions per unit of GDP by over 65% from the 2005 levels" (hereinafter referred to as Carbon Intensity Reduction). This means that by 2030, the carbon dioxide emissions related to energy per unit of GDP at constant price (i.e., Carbon Intensity) will have declined by at least 65% compared to the 2005 level.

Target Year and Base Year. The base year for this target is 2005, with a baseline value of 100%. The target year is 2030, representing a single-year target over a 25-year period.

Scope and Sectors. The scope of Carbon Intensity Reduction refers to the decline rate of energy-related carbon dioxide emissions per unit of GDP at constant price by 2030 when compared to that in 2005. It is related to the sectors of Energy and Industrial Processes and Product Use, and the greenhouse gas involved is carbon dioxide. According to the National Inventory, it covers the carbon dioxide emissions from the sectors of Fuel Combustion[10] and Non-Energy use[11]; the constant prices refer to prices adjusted for price changes to allow comparison across different time periods; and GDP refers to the final output of production activities by all resident units in a country over a certain period. It is a widely accepted macroeconomic indicator used internationally to measure the scale of economic activity of a country (or region).

(iii) Share of Non-Fossil Fuels

Target Type and Description. The target of "to increase the share of non-fossil fuels in primary energy consumption to around 25%" refers to increasing the proportion of non-fossil fuel energy consumption in the total primary energy consumption to around 25% by 2030. The proportion of non-fossil fuels refers to the percentage of energy consumption from hydropower, nuclear power, wind power, solar power, biomass energy, and geothermal energy out of total primary energy consumption. Primary electricity is standardized using the coal equivalent calculation for power generation.

Target Year and Baseline Year. No base year is involved, and the target year is 2030, with the goal being a single-year target.

Scope and Sector. This target does not involve greenhouse gas emission-related sectors or gases.

(iv) Forest Stock Volume

Target Type and Description. The target "to increase the forest stock volume by 6 billion cubic meters from 2005 levels" means that by 2030, forest stock volume will increase by 6

[10] Fuel Combustion in the Energy Sector (1A).

[11] Refers to the CO_2 emissions from the consumption of raw materials in Ammonia production (2B1), use of carbon materials and electrode paste in Calcium carbide production (2B5), fossil energy consumption in methanol (2B8a) and ethylene (2B8b) production, reductants and raw material consumption in Ferroalloys production (2C2), coal and coke consumption in Lead and Zinc production (2C5, 2C6), as well as coal and coke consumption in Lubricant use (2D1) and Paraffin wax use (2D2) under the Industrial Processes and Product Use Sector.

billion cubic meters compared to 2005 levels. Forest stock volume refers to the total trunk volume of all trees in the forest, an important indicator reflecting the quantity and quality of forest resources.

Target Year and Base Year. The base year for this target is 2005, with a baseline forest stock volume of approximately 13 billion cubic meters. The target year is 2030, representing a single-year target over a 25-year period.

Scope and Sector. This target does not involve greenhouse gas emission-related sectors or gases.

(v) Total Installed Capacity of Wind and Solar Power

Target Type and Description. The target "to bring its total installed capacity of wind and solar power to over 1.2 billion kilowatts" refers to achieving a total installed capacity of at least 1,200 GW for wind and solar power installations by 2030. Installed capacity of wind and solar power refers to the total output power of all wind and solar power generation units at rated conditions.

Target Year and Base Year. No base year is involved, and the target year is 2030, with the goal being a single-year target.

Scope and Sector. This target does not involve greenhouse gas emission-related sectors or gases.

Chapter 3 Progress on Implementation of NDC

I. Tracking Indicators for tracking progress

(i) Indicator for Carbon Peaking

The indicator for Carbon Peaking is CO_2 emissions from Fuel Combustion, Industrial Processes and Product Use. The scope and definitions are aligned with those used in the NDC target for Carbon Peaking and are directly related to the NDC target. Data is sourced from the National Inventory for the relevant years.

(ii) Indicator for Carbon Intensity Reduction

The indicator for Carbon Intensity Reduction is the energy-related CO_2 emissions per unit of GDP at constant price, which is the ratio of energy-related CO_2 emissions to the GDP at constant price for current year, and is directly related to the NDC target. The decline rate of carbon intensity is calculated by taking the carbon intensity in the base year, subtracting the carbon intensity in the target year, and then dividing by the base year's carbon intensity. The scope and definitions of energy-related CO_2 emissions, GDP at constant price are aligned with those used in the NDC target for Carbon Intensity Reduction. Data is derived from the National Inventory and official data published by the NBS for corresponding years.

(iii) Indicator for the Share of Non-Fossil Fuels

The scope and definition of the indicator for the Share of Non-Fossil Fuels are align with those used in the NDC targets for the Share of Non-Fossil Fuels, and is directly related to the NDC target. The share of non-fossil fuels is calculated as the total energy consumption minus the shares of coal, oil, and natural gas in total energy consumption. Data is sourced from official data published by the NBS for the relevant years.

(iv) Indicator for Forest Stock Volume

The indicator for forest stock volume is China's forest stock volume, and its scope and definition are consistent with the NDC target for forest stock volume, directly related to the NDC target. This indicator is derived through sampling, taking provinces as the survey unit, using fixed plots systematically set up for sampling, and measuring trees in plots with a diameter at breast height (DBH) of ≥5 cm. DBH and average tree height are recorded, and one-variable or two-variable tree volume tables for different tree species are used to calculate the timber volume for each tree. Provincial sample forest stock volumes are then aggregated to determine the total forest stock volume for China. Data is sourced from the National Forestry Inventory and the National Integrated Monitoring of Forest, Grassland and the Ecological Conditions.

(v) Indicator for Total Installed Capacity of Wind and Solar Power

The indicator for total installed capacity of wind and solar power is the full scope of installed capacity of installed capacity of wind power units and the installed capacity of solar power units, directly related to the NDC target. Data is sourced from official data published by the National Energy Administration for the relevant years.

II. Tracking Progress in NDC implementation

(i) Progress on Carbon Peaking

According to China's latest National Inventory, CO_2 emissions from Fuel Combustion, Industrial Processes and Product Use reached 11.62 billion tonnes in 2021.

(ii) Progress on Carbon Intensity Reduction

According to China's latest National Inventory, carbon intensity in 2021 decreased by 50.9% from 2005 levels.

(iii) Progress on the Share of Non-Fossil Fuels

According to data published on the NBS website, in 2023, the shares of coal, oil, and natural gas in China's total energy consumption were 55.3%, 18%, and 8.5%, respectively, with non-fossil fuels accounting for 17.9%.

(iv) Progress on Forest Stock Volume

According to the 2021 results of the National Integrated Monitoring of Forest, Grassland and the Ecological Conditions, the national forest stock volume was 19.493 billion cubic meters, an increase of 6.493 billion cubic meters from 2005 levels, thereby achieving the NDC target ahead of schedule.

(v) Progress on Total Installed Capacity of Wind and Solar Power

According to data from the National Energy Administration, by the end of 2023, China's grid-connected wind power installed capacity was 440 GW, and grid-connected solar power installed capacity was 610 GW, with a combined total installed capacity of wind and solar power reaching approximately 1050 GW. By October 2024, China's grid-connected wind power installed capacity was approximately 490 GW, and grid-connected solar power installed capacity was approximately 790 GW, with a combined total installed capacity of wind and solar power generation was about 1280 GW.

A summary table with information related to tracking progress on NDC targets is available in the common reporting tables (CTF).

China has not yet developed an official emissions projection model with associated scenarios and parameter assumptions. Therefore, this report does not include projections of greenhouse gas emissions and removals, in accordance with the flexibility requirements provided by the MPGs. China plans to continue using international financial support and its own resources to support domestic agencies, research institutions, and experts in developing emissions projection models and scenarios tailored to China. This aims to strengthen relevant capacity over the medium to long term, with subsequent BTRs including projections as appropriate.

Chapter 4 Mitigation Policies, Actions and Effects

I. Mitigation Policies and Actions

(i) Strengthening Guidance by National Strategies and Plans

To achieve its NDC goals, China released the *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives through the Year 2035 of the People's Republic of China* in March 2021, and the *Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy* and the *Action Plan for Carbon Dioxide Peaking Before 2030* in October 2021. China also formally submitted *China's Mid-Century Long-Term Low Greenhouse Gas Emission Development Strategy* to the UNFCCC Secretariat.

The *China's Mid-Century Long-Term Low Greenhouse Gas Emission Development Strategy* outlines China's basic policy and strategic vision for long-term low GHG emissions development in the mid-21st century. It also sets out strategic priorities and actions, and provides policy guidance with regard to establishing a green, low-carbon, and circular economic system, building a clean, low-carbon, safe, and efficient energy system, establishing an industrial system characterized by low emissions, fostering green and low-carbon urban-rural development, building a low-carbon integrated transport system, strengthening the control of non-CO_2 GHG emissions, promoting nature-based solutions, driving low-emission technology innovations, mobilizing community-wide participation, and modernizing the climate governance system and governance capabilities.

China has established a "1+N" policy framework for achieving carbon peaking and carbon neutrality. The *Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full* *and Faithful Implementation of the New Development Philosophy* serves as the "1" in the policy framework, clarifying the overall work requirements for carbon peaking and carbon neutrality, setting out the main objectives, and deploying major actions. The *Action Plan for Carbon Dioxide Peaking Before 2030* lays out 10 key actions: The action for green and low-Carbon energy transition; Energy Saving, Carbon emission mitigation and efficiency improvement; Peaking carbon dioxide emissions in industrial Sector; Peaking carbon dioxide emissions in urban-rural development area; Promoting green and low-carbon transportation; Promoting circular economy in carbon mitigation purpose; Advancing green and low-carbon technology innovation; Consolidating and enhancing carbon sink; Green and low-Carbon society; Promoting all regions to peak carbon dioxide emissions hierarchically and orderly. These actions, together with implementation plans and supporting measures for key sectors like energy, industry, transport, and urban-rural development, form the "N" in the policy framework. In addition, multiple provinces (autonomous regions and municipalities) have successively issued implementation plans and guiding opinions for carbon peaking and carbon neutrality.

The *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives through the Year 2035 of the People's Republic of China* proposes major goals in six areas including the economy, reform, social civilization, ecological civilization, people's livelihood, and national governance. Notably, it sets quantitative targets to reduce energy consumption per unit of GDP and CO_2 emissions per unit of GDP by 13.5% and 18% respectively compared to 2020, as well as increase the forest coverage rate to 24.1%. China has been solidly implementing its NDC through the national plan. The "14th Five-Year Plan" requires that the average annual growth of GDP be kept within an appropriate range, the total factor productivity grow faster than GDP, the domestic market be stronger, the economic structure be further optimized, the innovation capacity be significantly improved, the industrial foundations and the modernization level of industrial chains be markedly improved, and the agricultural foundation be strengthened, the balance of development between urban and rural areas and between regions be significantly enhanced, significant progress be made towards a modernized economy, the territorial space be better developed and protected, remarkable results be achieved in a shift towards eco-friendly work and lifestyle, and energy and resources be more rationally allocated and much more efficiently used. The "14th Five-Year Plan" further clarifies China's long-term vision for 2035, i.e. enhancing economic and technological strength, and comprehensive national strength; increasing economic aggregate and the per capita income of urban and rural residents; making major breakthroughs in core technologies in key areas; achieving new industrialization, enhanced IT application, urbanization, and agricultural modernization; and completing building a modern economic system. Eco-friendly work and lifestyle will be advanced to cover all areas of society. Carbon dioxide emissions will steadily decline after reaching a peak, achieve fundamental improvement in the ecological environment, and largely accomplish the goal of building a Beautiful China.

To implement the national overall strategy, in July 2024, the *Opinions of the Central Committee of the Communist Party of China and the State Council on Accelerating Comprehensive Green Transformation of Economic and Social Development* was issued, which puts forward clear requirements for green transition in key sectors, the formation of green production and lifestyle, and the policy and standard system to support green development. In August 2024, the General Office of the State Council issued the *Work Plan for Accelerating the Establishment of a Dual-Control System for Carbon Emissions*. It has been proposed that during the 15th Five-Year Plan period, a dual carbon emissions control system will be implemented, focusing primarily on intensity control with supplementary carbon emissions control. It further defines actions such as improving the planning system for carbon emissions, establishing a local carbon emission target evaluation and assessment system, exploring an early warning and control mechanism for carbon emissions in key industries, improving the enterprise-level energy efficiency and carbon reduction management system, carrying out carbon emissions evaluation for fixed asset investment projects, and accelerating the establishment of a product carbon footprint management system.

(ii) Accelerating the Optimization and Adjustment of Energy Structure

A number of policy documents were released, including the *Opinions on Improving Institutional Mechanisms and Policy Measures for Green and Low-Carbon Energy Transition*, the *14th Five-Year Plan for the Modern Energy System*, the *Medium- and Long-term Plan for Hydrogen Energy Development (2021-2035)*, the *Benchmark and Baseline Levels for Cleaner and More Efficient Coal Use in Key Sectors(2022 Edition)* and the *14th Five-Year Plan for Renewable Energy Development*. These documents clearly outline the key actions for green and low-carbon energy transitions, and highlight the need to promote the substitution and transformation of coal consumption, vigorously develop new energy sources, develop hydropower based on local conditions, actively and safely develop nuclear power, accelerate the construction of a new power system, comprehensively enhance energy efficiency management capabilities, implement key energy efficiency and carbon reduction projects, improve energy efficiency of key energy-consuming equipment, and strengthen energy efficiency and carbon reduction of new infrastructure.

Developing and utilizing non-fossil energy sources at a faster pace. We have accelerated the construction of large-scale wind and solar power bases, orderly promoted the construction of offshore wind power bases, and actively supported the development of distributed new energy. In 2022, the wind and PV power generation reached 119 GWh, totaling over 1000 TWh for the first time. From 2020 to 2022, the newly installed capacity exceeded 100 GW for three consecutive years. Efforts have also been made to steadily advance the construction of medium and large-scale hydropower projects. Actively and safely develop nuclear power in an orderly manner. Steadily develop biomass energy, geothermal energy, solar thermal energy, and hydrogen energy, and promote the integrated development of hydrogen production, storage, transport and utilization. By the end of 2022, China's installed capacity of non-fossil energy reached 1270 GW, accounting for 49.6% of the total installed capacity. Among this, the installed capacity of wind and PV power reached 760 GW, and the installed capacity of hydropower reached 410 GW. In 2022, new renewable energy installations reached 152 GW, accounting for 76.2% of the total newly added power generation capacity.. It has become the mainstay of China's new power installations, with an accumulative installed capacity of 1213 GW, surpassing coal-fired power installations for the first time, marking a historic breakthrough.

Making big strides in cleaner and more efficient coal use. We have aggressively pushed forward with "three-pronged upgrades" for coal-fired power units, included encompassing energy conservation and carbon reduction renovations, flexibility improvements, and heating supply upgrades. This initiative aims to adjust and optimize the structure of coal-fired power generation, phase out outdated coal power capacity in an orderly manner, and continuously reduce the proportion of coal power installed capacity and electricity generation. We have also strictly controlled the capacity of traditional coal chemical industry, and launched modern coal chemical projects with new technology, low energy consumption and better benefits in an orderly manner. The standard coal consumption for power supply at thermal power plants of 6,000 kW and above nationwide was further decreased from 304.9 g/kWh in 2020 to 300.8 g/kWh in 2022, a decrease of about 64.5 g/kWh compared to 2005.

Building a new power system. We have accelerated the construction of a nationwide unified power market system, and continuously promoted the construction of a power market that integrates medium and long-term, spot, and ancillary service transactions. Expanded the scale of cross-provincial and regional allocation of renewable energy and promoted the high-level utilization of non-fossil energy. The world's first flexible DC power grid project was completed in Zhangbei, helping to realize 100% green power supply for Winter Olympic venues; a pumped storage hydropower station was completed in Guangdong, and the installed capacity of pumped storage in Guangdong, Hong Kong and Macao Greater Bay Area reached 9.68 GW. Shifts towards electricity and clean energy sources have been advanced in sectors such as industry, transport and construction. Clean heating solutions have been tailored to the specific needs of northern China. We've seen a 76% clean heating rate across the region in 2022. Switching away from scattered coal burning has made a real difference in improving air quality. We have pushed ahead with pilot projects to make better use of nuclear energy, and launched multiple nuclear heating projects.

Boosting the low-carbon transition of the energy sector through fiscal taxation policies. On September 1, 2020, the *Resource Tax Law of the People's Republic of China* was officially implemented. The law imposes a resource tax on energy minerals, water and gas minerals, and other items listed in the resource tax schedule. Resource tax exemptions are granted for mineral products from depleted mines, as well as for the extraction of associated minerals, low-grade ores, and tailings. Resource tax incentives also continue to be provided for unconventional clean energy sources such as shale gas.

(iii) Fostering Green and Low-Carbon Transitions of the Industrial Sector

The *14th Five-Year Plan for Green Industrial Development* was released, laying out the key goals, major tasks, and action plans. A number of policy documents were issued, including the *Guideline on Promoting the High-Quality Development of the Iron and Steel Industry*, the *Notice on Issuing the 14th Five-Year Plan for National Drug Safety and High-Quality Development*, the *Guiding Opinions on Promoting High-Quality Development of the Petrochemical and Chemical Industry during the 14th Five-Year Plan Period*, the *Guiding Opinions on High-Quality Development of the Chemical Fiber Industry*, the *Guiding*

Opinions on High-Quality Development of the Industrial Textile Industry, the *Guiding Opinions on Promoting High-Quality Development of the Light Industry,* the *Notice on Issuing the Action Plan for Improving Industrial Water Efficiency*, the *Notice on Issuing the Action Plan for Improving Industrial Energy Efficiency*, and the *Notice on Issuing the Implementation Plan for Carbon Peaking in the Industrial Sector*. These measures are aimed at fostering green and low-carbon production methods, building a green and low-carbon development landscape for the manufacturing industry, promoting green and low-carbon development in the industrial sector, achieving carbon peaking in industries such as steel, non-metallic mineral products, non-ferrous metals, and petrochemicals, and resolutely curbing the blind development of "two high" projects. China has issued the *Guiding Opinions on Promoting the Development of the Energy Electronics Industry*, the *Implementation Opinions on Accelerating the Green and Intelligent Development of Inland River Vessels*, and the *Action Plan for Accelerating the Green, Low-Carbon and Innovative Development of Power Equipment* ; and developed carbon reduction roadmaps for industries such as automobiles, paper, and textiles, to cultivate new business formats in related industries, and enhance the supply capacity of green equipment. China has also issued the *Action Plan for Green and Low-Carbon Development of the Information and Communication Industry (2022-2025)*, to accelerate the green and low-carbon development of information infrastructure.

Driving the transformation and upgrading of traditional industries. China has issued the *Guiding Opinions on Integrating Energy Efficiency, Carbon Reduction and Recycling to Accelerate the Upgrading of Products and Equipment in Key Areas*, to gradually promote the upgrade of products and equipment in key areas, and accelerate the building of a waste recycling system. Continued efforts have been made to cut overcapacity, to support green and intelligent transformation of enterprises. In 2021 and 2022, the energy consumption per unit of added value of industrial enterprises above designated size decreased by 5.6% and 1.4% respectively. 1536 green factories, 99 green industrial parks, and 219 green supply chain management companies were created. 216 demonstration companies for green product design in the industrial sector were cultivated.

Accelerating the development of new green and low-carbon industries. In 2022, China's new energy vehicles continued to grow, with production and sales hitting 7.058 million and 6.887 million respectively, up by 96.9% and 93.4% year-on-year. Domestic sales of new energy passenger vehicles under domestic brands accounted for 79.9%, up by 5.4 percentage points year-on-year. Exports of new energy vehicles soared to 679,000, a 120% increase year-on-year. By the end of 2022, a total of 5.21 million charging piles and 1,973 battery swap stations had been built nationwide. In 2022 alone, 2.593 million charging piles and 675 battery swap stations were newly built, indicating that the construction of charging and battery swap infrastructure has accelerated significantly. By the end of 2022, China had been the world's top producer of PV modules for 15 years running, accounting for over 70% of global output in polysilicon, wafers, cells, and modules. A special "Industrial Green Development" section was launched on the National Industry and Finance Cooperation Platform, with 86 green financial products launched online, and helping businesses secure RMB 67.9 billion in green financing.

Boosting the energy efficiency and carbon reduction in the industrial sector through fiscal taxation policies. The *Announcement on Releasing the Catalogue of Corporate Income Tax Incentives for Environmental Protection, Energy Efficiency, and Water Conservation Projects (2021 Edition) and Catalogue of Corporate Income Tax Incentives for Comprehensive Utilization of Resources (2021 Edition)* was issued, providing corporate income tax incentives for companies engaged in air pollution prevention and control, and comprehensive utilization of wastewater, waste gas, and waste residues. The *Announcement on Improving the Value-Added Tax Policy for Comprehensive Resource Utilization* was issued, implementing a policy of immediate refund of value-added tax for the comprehensive utilization of co-produced minerals, associated minerals, waste residues, wastewater, and waste gas. China has increased the budget allocation for state-owned capital operations and prioritized support for carbon peaking and carbon neutrality.

(iv) Advancing Green, Low-Carbon Development in the Building Sector

The *Opinions on Promoting the Green Urban and Rural Development* was issued, clarifying the objectives, ideas and priorities for green urban and rural development. China has issued the *Implementation Plan for Carbon Peaking in the Urban and Rural Development Sector*, the *14th Five-Year Plan for Building Energy Efficiency and Green Building Development*, and the *14th Five-Year Plan for Science and Technology for Housing and Urban-Rural Development*. These lay out the main targets and key tasks for the 14th Five-Year Plan period, aiming to transform urban and rural development modes, and cut down on energy and resource use in buildings.

Advancing green retrofits of public institutions. The *14th Five-Year Plan for Energy and Resource Conservation in Public Institutions* was issued, which sets targets for controlling the total energy consumption, carbon emissions, and energy/carbon intensity of public institutions. The *Implementation Plan for Deepening Green and Low-Carbon Leadership Actions in Public Institutions to Promote Carbon Peaking* was issued. It clearly defines the goals and tasks for the green and low-carbon development of public institutions, and proposes key measures such as accelerating the green and low-carbon transformation of energy use and improving the green and low-carbon operation of buildings. The *Opinions on Encouraging and Supporting Public Institutions to Adopt Energy Cost Management Services* was issued, to promote the adoption of EMC and other market-based approaches by public institutions at all levels to carry out green retrofits of existing buildings.

Pushing forward with pilot programs for green construction. In December 2020, the General Office of Ministry of Housing and Urban-Rural Development issued a notice to launch pilot programs for green construction in Hunan, Shenzhen, and Changzhou. The goal is to create green construction application scenarios, develop systematic solutions, and provide experiences for green construction nationwide. In March 2021, the *Technical Guidelines for Green Construction (Trial)* was issued, proposing specific technical and management measures in areas such as green planning, green design, green construction, and green delivery, and providing technical support for the pilot work of green construction.

Giving full play to the exemplary and leading role. As of 2022, China had motivated 89.7% of county-level and above agencies of CCP and government to establish resource-saving offices, created 1,506 demonstration units for resource-saving public institutions, selected 192 leading public institutions in energy efficiency, and recognized 695 exemplary cases of energy and resource conservation in public institutions. We have actively carried out thematic events such as National Energy Efficiency Awareness Week, National Low-Carbon Day, Green Mobility Awareness Month, and Public Transport Awareness Week; and organized 8 training sessions on energy efficiency management for public institutions, as well as 4 lectures on green and low-carbon transition of public institutions.

(v) Accelerating the Establishing of A Green and Low-Carbon Transport System

China has issued the *Notice on Issuing the 14th Five-Year Plan for the Development of a Modern Integrated Transport System*, the *14th Five-Year Plan for Green Transport Development*, the *14th Five-Year Plan for Civil Aviation Development,* and the *14th Five-Year Plan for Green Development of Civil Aviation*. The aim is to comprehensively promote the green and low-carbon development of the transport industry, drive the low-carbon transition of transport equipment, advance the construction of a low-carbon transport system, accelerate the construction of green transport infrastructure, continuously increase the application of new energy vehicles, and pursue the new trend of low-carbon transport. In the issuance of the *14th Five-Year Plan for Railway Development* and the revision of the *Medium and Long-term Railway Network Plan*, emphasis has been placed on incorporating the concepts of ecological protection and green development into the entire process of railway planning, construction, operation, and maintenance. This would further optimize the layout and structure of the railway network, better leveraging the backbone role of railways in the integrated transport system.

Continuously optimizing the transport structure. China has issued the *Work Plan for Promoting the Development of Multimodal Transport and Optimizing the Transport Structure (2021-2025)*, to promote the shift of bulk cargo and medium-long distance freight transport from highway to railway, and from highway to waterway. We have continuously promoted the creation of multimodal transport demonstration projects, and guided the exploration and application of innovative "single-bill" and "single-container" systems for multimodal transport. We have developed a work plan to optimize the transport structure for multimodal transport development, formulated standards such as *Intermodal loading unit identification* and *Classification and codes of intermodal transport cargo*, and strengthened the connection of rules between different modes of transport. By the end of 2022, a total of 116 multimodal transport demonstration projects had been launched in four batches. In 2022, the demonstration routes basically covered the national integrated transport hubs and the main framework of the three-dimensional transport network. In 2022, the national railway and waterway freight volume increased by 432 million tons and 937 million tons respectively compared to 2020, with growth rates of 9.49% and 12.31% respectively.

Thoroughly implementing the strategy of prioritizing the development of urban public transport. The public are encouraged to prioritize public transport. In 2022, 35.3 billion passengers were transported on urban buses nationwide. By the end of 2022, a total of 87 cities across the country had participated in the creation of National Public Transport Cities, with 46 cities passing the assessment and being awarded the title of "National Public Transport Demonstration City". There were 78,000 public transport routes operating nationwide, with a total route length of 1.66 million km, and nearly 20,000 km of dedicated bus lanes. The new energy public transit vehicles totaled 542,600, accounting for 77.2% of the fleet. The new energy taxis amounted to 299,600, accounting for 22.0%.

Steadily phasing out the China III diesel trucks and below. The task of eliminating China III and below diesel trucks in the Beijing-Tianjin-Hebei region and surrounding areas, as well as the Fenwei Plain, has been completed. By the end of 2021, more than 1.1 million diesel trucks had been eliminated. The management of fuel consumption limits for road transport vehicles has been strengthened, and vehicle models that meet the safety and energy efficiency requirements have been published in accordance with the procedures. By the end of 2022, more than 40 batches of compliant road transport vehicle models had been announced. The *Measures for the Management of Technical Demonstration Stations for Maintenance (Repair) of Vehicle Emission Performance* was issued, to improve the maintenance (repair) capabilities for vehicle emission performance and strengthen the energy efficiency and carbon reduction efforts of in-use vehicles.

Launching pilot projects for boosting strengths in green and low-carbon transport and demonstration projects of green urban freight delivery. We have launched pilot projects for boosting strengths in green and low-carbon transport, to drive the green and low-carbon transition and high-quality development of the transport sector, with focus on adjusting the transport structure, promoting green mobility, conserving and intensifying the use of resources, improving energy efficiency and reducing carbon emissions of infrastructure, and fostering the application of new energy and clean energy vehicles and vessels. To build a "concentrated, efficient, green, and smart" urban freight delivery service system, we have organized and carried out 77 green urban freight delivery demonstration projects in three batches, forming a concentrated and efficient urban freight delivery chain. By the end of 2022, the demonstration cities had accumulatively added 260,000 new energy logistics and distribution vehicles, with a total fleet of over 410,000 vehicles, accounting for around 50% of the total nationwide increase.

Launching special actions for green, low-carbon, and circular development of civil aviation. Efforts have been made to deepen the electrification of airport operations, strengthen the establishment of the industry's energy consumption and GHG emissions statistical system, and complete the annual carbon emissions management for civil aviation flight activities. By the end of 2022, the proportion of electric vehicles in national airports was around 24%. For airports with a passenger throughput of over 5 million, auxiliary power unit (APU) substitute devices were installed where possible, saving about 240,000 tons of aviation fuel per year and reducing CO_2 emissions by about 760,000 tons. The mechanism for setting up and using temporary flight routes have been optimized. From 2020 to 2022, a total of 1.382 million flights used temporary flight routes, reducing the flight distance by 50.333 million km, saving 272,000 tons of fuel consumption, and reducing 857,000 tons of CO_2 emissions.

Boosting the green development of inland water transport. The *Guiding Opinions on Accelerating the Green and Intelligent Development of Inland River Vessels* was issued, which aims to actively promote the adoption of new energy and clean energy vessels, encourage the development of vessels powered by LNG and batteries, foster the use of shore power for vessels docking in key regions such as the Yangtze River Economic Belt, accelerate the retrofits of shore power receiving facilities for vessels on the Yangtze River, and significantly increase the use of shore power.

Encouraging and guiding green mobility. The *Action Plan for the Creation of Green Mobility* was issued. 109 cities were mobilized to encourage green mobility, with the green mobility rate in 97 cities, including Beijing, reaching more than 70%, and the satisfaction rate of green mobility services being no less than 80%. Events such as Green Mobility Awareness Month, Public Transport Awareness Week, National Energy Efficiency Awareness Week and National Low-Carbon Day have been organized to encourage the public to prioritize the use of public transport, cycling, walking and other green mobility modes.

(vi) Consolidating and Enhancing Ecosystem Carbon Sinks

China has formulated and implemented the *Wetland Protection Law of the People's Republic of China*, and issued the *Outline of the 14th Five-Year Plan for the Protection and Development of Forestry and Grassland*, which clearly defines the overall thinking, targets, and key tasks for the protection and development of forestry and grassland during the 14th Five-Year Plan period. The *Outline of the National Land Greening Plan (2022-2030)* was issued, which comprehensively deploys China's land greening work in the current and future periods, and further strengthens the foundation for mitigating and adapting to climate change. The *Implementation Plan for Strengthening and Improving the Carbon Sequestration Capacity of Ecosystems* was issued, which puts forward the goals and a package of measures for China's ecosystem carbon sink in the coming period, and highlights the leading role of forests in carbon sinks of terrestrial ecosystems, aiming to enhance the carbon sequestration and sink enhancement capacity of ecosystems, and increase the adaptability of natural ecosystems to climate change. The *Guiding Opinions on Scientific Greening* and the *Several Opinions on Strengthening the Protection and Restoration of Grasslands* were issued to guide local governments to carry out ecological protection and restoration in a scientific manner, effectively improving the quality and stability of ecosystems. The *National Wetland Protection Plan (2022-2030)* was published, which includes peatland wetlands and mangrove forests within the planning scope. Research on forestry and grassland for carbon neutrality has been carried out.

Conducting large-scale national land greening to increase carbon sinks. We have continuously expanded green cover while increasing carbon sinks. Between 2020 and 2022, we completed over 14.2 million hectares of afforestation and greening, improved 9.1107 million hectares of grasslands by planting grass, and reclaimed 5.3833 million hectares of desertified and rocky land. We have implemented a system where all afforestation and greening tasks are reported with location data, and assigned with map-based markers. This would ensure that afforestation, grassland improvement, and desertification control projects can be tracked on the map. The State Council has established a coordinated mechanism to strengthen comprehensive prevention and control of desertification and advance the construction of key ecological projects such as the "Three-North Shelterbelt Forest Program", helping enhance the carbon sink capacity of desert ecosystems.

Carrying out pilot programs for sustainable forest management and forestry carbon sequestration. A pilot program for sustainable forest management was launched in 2020. The list of pilot cities (counties) and state-owned forest farms for forest carbon sequestration was released in 2022. Work has been done to encourage pilot innovations and explorations, with the core objective of enhancing forestry carbon sequestration capacity. Combine local realities, we have developed innovative forest carbon enhancement techniques, effectively improved carbon sinks accounting and reporting capabilities, and explored mechanisms and pathways for realizing the value of forestry carbon sinks. The *Guidelines for Validation and Certification of Forestry Carbon Sequestration Projects* was issued to consolidate the carbon sequestration function of ecosystems, enhance the carbon sequestration capacity of ecosystems, and strengthen the basic support for ecosystem carbon sequestration.

Comprehensively strengthening the integrated protection and restoration of mountains, rivers, forests, farmlands, lakes, grasslands and deserts. Sustained support has been provided to relevant provinces (autonomous regions, municipalities) in carrying out grassland ecosystem restoration and management through the grassland ecosystem restoration projects. From 2021 to 2022, a total of RMB 12.395 billion in central funds were invested to support the relevant provinces (autonomous regions and municipalities) in carrying out 6.28 million hectares of grassland improvement and ecological restoration. This has effectively restored the grassland vegetation and enhanced the grassland's carbon sequestration capacity. From 2020 to 2022, 19 projects were included in the first and second batches of central government financial support for the 14th Five-Year Plan period, with central government subsidies of RMB 2 billion allocated to each project, and RMB 29.4 billion disbursed. These projects are all located within the "Three Zones and Four Belts"[12]-based national ecological security barrier system. The implementation of these projects has played a positive role in enhancing the stability, diversity, sustainability, and carbon sequestration capacity of ecosystems in key ecological regions such as the Yellow River basin and the Yangtze River basin. In 2020, the *Special Action Plan for Mangrove Protection and Restoration (2020-2025)* was released, which outlines the tasks for mangrove protection and restoration, and sets the goals for mangrove planting and restoration by 2025. Starting in 2021, pilot carbon stock surveys and carbon sinks monitoring have been carried out for key areas with ecosystems like mangrove forests.

Strictly protecting natural ecological spaces and maintaining the stability of ecosystem carbon pools. China has implemented a comprehensive forest chief system, built a nature reserve system mainly based on national parks, and established an integrated forest and grassland fire prevention and control system. China has also strengthened pest and disease

[12] The Qinghai-Tibet Plateau ecological barrier zone, key ecological zones of the Yellow River (including the Loess Plateau ecological barrier), key ecological zones of the Yangtze River (including the Sichuan-Yunnan ecological barrier), northern sand prevention belt, northeastern forest belt, southern hilly mountainous belt, and coastal zones.

control in forests and grasslands, and tightened up the management of land use permits and timber harvesting. We have strengthened oversight and law enforcement, and severely cracked down on illegal and unlawful acts that damage woodlands and forests. China has formulated and revised several laws, including the *Land Administration Law*, the *Forest Law*, the *Law on Prevention and Control of Desertification*, the *Wetland Protection Law*, the *Yellow River Protection Law*, the *Yangtze River Protection Law, and* the *Qinghai-Tibet Plateau Ecological Protection Law*, to effectively protect the carbon storage functions of natural ecosystems like forests, grasslands, wetlands, rivers and lakes, oceans, deserts, and permafrost, and strengthen the foundation of ecosystem carbon sinks.

Formulating and implementing ecological restoration plans, and building a solid national ecological security barrier. The *Master Plan for Major Projects on the Protection and Restoration of Key Ecosystems Nationwide (2021-2035)* was issued, which clearly defines the national ecological security barrier system based on the "Three Zones and Four Belts", and systematically sets out the major ecological protection and restoration tasks by 2035. From 2020 to 2021, 9 supporting specialized plans were issued one after another, laying out a series of key projects for the construction of the "Three Zones and Four Belts"-based national ecological security barrier system by 2035. Starting from 2020, provincial-level territorial space ecological restoration plans have been developed. As of the end of 2022, 21 provinces (autonomous regions and municipalities) had issued their respective provincial-level territorial space ecological restoration plans.

Bolstering technological support and safeguards. A key research on "Forest Carbon Sink Formation and Management Response Mechanisms in the Context of Carbon Neutrality" has been carried out, which focuses on monitoring, measuring, enhancing, and realizing the value of forest carbon sinks. Projects like "Strategic Research on Grassland and Forestry for Carbon Neutrality" and "Strategic Research on Achieving the Vision of Carbon Neutrality in Forestry and Grassland" have been launched. Efforts have been made to accelerate the construction of ecological stations, improve the layout of stations, optimize management services, and provide technological support for addressing climate change and achieving the "dual carbon" goals.

(vii) Enhancing Control of Non-CO_2 GHG Emissions

The *14th Five-Year Plan for the Modern Energy System* proposes to "promote the green and low-carbon exploitation of fossil energy, strengthen the green mining, washing and processing of coal, increase efforts to harness and utilize methane from oil and gas fields, and accelerate the application of CO_2 enhanced oil recovery technology. By 2025, the utilization of coal mine gas will reach 6 billion cubic meters". In October 2021, China submitted the *China's Achievements, New Goals and New Measures for Nationally Determined Contributions*, which for the first time clearly outlines the direction for controlling methane emissions in the energy sector: "We'll effectively control methane emissions from coal and oil/gas extraction by smartly managing coal production capacity, boosting methane drainage and utilization, controlling VOCs emissions from the petrochemical industry, encouraging green completion techniques, and promoting associated gas recovery."

In November 2023, the *Methane Emissions Control Action Plan* was released. As China's first comprehensive and specialized policy document on methane emission control, the Action Plan defines the methane emission control targets for key areas during the 14th Five-Year Plan and 15th Five-Year Plan periods, as well as 8 key tasks for methane emissions control, including strengthening the construction of a methane emissions monitoring, accounting, reporting and verification system, promoting methane emissions control in energy and agriculture, strengthening methane emission control in waste and wastewater treatment, enhancing the coordinated control of pollutants and methane, fostering technological innovation and methane emission control supervision, accelerating the building of a legal and regulatory policy system, and strengthening global methane governance and cooperation.

In the coal sector. We have vigorously promoted the drainage and utilization of coal mine gas, deployed coal mine gas prevention and control tasks on an annual basis, facilitated the implementation of support policies for gas drainage and utilization, increased central budget investment and funding, and bolstered basic research, technical consulting, engineering services, and standards system. In June 2020, the *Interim Measures for the Management of Special Funds for the Development of Clean Energy* was issued. Through the central general public budget arrangement, special funds were used to provide subsidies for the extraction and utilization of unconventional natural gas such as coalbed methane (coal mine gas), based on the principle of "more subsidies for more production". In November 2020, the *Notice on Further Strengthening the Environmental Impact Assessment Management of Coal Resource Development* was issued, stipulating that "methane with a volumetric concentration of 8% or more should be comprehensively utilized, provided that safety is ensured. We encourage exploring comprehensive utilization of methane drainage with a concentration between 2% (inclusive) and 8%, as well as ventilation air methane." The revision of the *Emission Standard of Coalbed Methane/Coal Mine Gas* was carried out.

In the oil and gas sector. Oil and gas companies have been encouraged to control methane emissions. In May 2021, state-owned enterprises such as CNPC launched the "China Oil and Gas Methane Emissions Reduction Alliance". Major oil and gas companies have subsequently announced their carbon peaking and carbon neutrality targets, as well as methane emissions reduction action plans. They have explored methane emission control across the entire oil and gas industry chain, and have committed to reducing the average methane emission intensity in natural gas production processes of member companies to below 0.25% by 2025, approaching world-leading levels, and striving to reach world-class levels by 2035. Between 2020 and 2022, China completed four rounds of monitoring for oil field station leaks, covering a total of 19 stations and more than 680,000 monitoring points.

In the industrial sector. The Kigali Amendment officially came into effect for China on September 15, 2021 (temporarily not applicable to Hong Kong Special Administrative Region). In September 2021, the *List of Controlled Ozone Depleting Substances in China* was released, which includes HFCs. In October 2021, the *List of Controlled Imports and Exports of Ozone Depleting Substances in China* was released, and a licensing system for the import and export of the listed HFCs was implemented starting from November 1. In accordance with relevant requirements, China has strengthened the management and control of HFCs emissions, strictly controlled certain HFCs chemical production projects, and strengthened the environmental management of related projects. Enterprises are not allowed to directly discharge HFC-23 as a by-product. In 2020, the treatment rate of HFC-23 reached 95.5%, reducing HFC-23 emissions by 828 $MtCO_2eq$. Moreover, China has gradually phased out the use of SF_6 in the power grid, and promoted energy-efficient power facilities with low GWP.

In the agriculture sector. The *Law of the People's Republic of China on the Promotion of Revitalization of Rural Areas* and the *Law of the People's Republic of China on the Protection of Black Soil* were promulgated, providing legal framework for emissions reduction and carbon sequestration in agriculture and rural areas. In November 2021, the *Ten Technical Models for Emissions Reduction and Carbon Sequestration in Agriculture and Rural Areas* was released, covering CH_4 emission reduction technologies for rice fields, enteric fermentation in ruminants, livestock and poultry manure management, as well as rural biogas comprehensive utilization. In January 2022, the *Guiding Opinions on Promoting the Construction of Ecological Farms* was released, which stipulates that we should explore policies for low-carbon compensation targeting ecological farms, with a focus on reducing CH_4 emissions from rice fields, N_2O emissions from agricultural land, CH_4 emissions from enteric fermentation, and CH_4 and N_2O emissions from manure management. The *Implementation Plan for Emissions Reduction and Carbon Sequestration in Agriculture and Rural Areas* issued in May 2022 has laid out key tasks in three areas - crop farming, animal husbandry, and fisheries. These tasks include reducing methane emissions from rice paddies, lowering the intensity of enteric methane emissions from ruminants, and decreasing CH_4 and N_2O emissions from livestock manure management. It has also prioritized reducing CH_4 emissions from rice fields as one of the ten major actions to promote emissions reduction and carbon sequestration in agriculture and rural areas. China has developed a new rice cultivation model that incorporates straw return to the field, boosting productivity while significantly reducing CH_4 emissions; promoted the cultivation of water-saving and drought-resistant rice varieties, with annual planting areas exceeding 200,000 hectares in Anhui, Hubei, Zhejiang, and Hainan; and implemented actions to reduce fertilizer usage and improve efficiency, thereby lowering N_2O emissions from farmlands.

In the waste sector. In January 2021, the *Guiding Opinions on Coordinating and Strengthening Work Related to Addressing Climate Change and Eco-Environment Protection* was issued, which calls for strengthening the environmental management of centralized treatment facilities for sewage and waste, and coordinating the control of GHGs such as CH_4 and N_2O. Promoting the thermal energy utilization technologies such as sludge biogas co-generation and Water-Source Heat Pumps (WSHP) in wastewater treatment plants, and enhancing sludge disposal and comprehensive utilization. In November 2020, the *Several Opinions on Further Promoting the Classification of Municipal Solid Waste* was released, which highlights the need to deepen Municipal Solid Waste (MSW) classification and accelerate the construction of MSW incineration facilities. In 2021, China's landfill waste treatment volume was decreased by around 57% from its peak level, with landfill waste treatment accounting for less than 30%, significantly reducing CH_4 emissions generated during the waste treatment process. By the end of 2022, the volume of city and county-level sewage treatment in China reached 626.889 billion cubic meter and 11.141 billion cubic meters respectively, with sewage treatment rates reaching 98.1% and 96.9%.

(viii) Promoting Synergies Actions for Pollution-Carbon Reduction

In January 2021, the *Guiding Opinions on Coordinating and Strengthening Work Related to Addressing Climate Change and Eco-Environmental Protection* was issued, which formally lays out the principle requirements of unified planning, unified deployment, unified implementation, and unified inspection for work related to addressing climate change and eco-environmental protection, and clarifies the goals and tasks in the areas of strategic planning, policies and regulations, institutional systems, pilot demonstrations, and international cooperation, marking the transition of pollution-carbon reduction policies from "weak correlation" to "strong integration".

In July 2021, the *Notice on Carrying Out Pilot Carbon Emission Environmental Impact Assessments for Key Industry Construction Projects* was issued. Pilot programs have been firstly carried out in key industries such as power, steel, non-metallic mineral products, non-ferrous metals, petrochemicals, and chemicals in Hebei, Jilin, Zhejiang, Shandong, Guangdong, Chongqing, and Shaanxi. Pilot programs for carbon monitoring and assessment, along with pilot programs for collaborative control of pollution-carbon reduction based on the "Three Lines and One List" approach, have been proceeding smoothly. September the *Pilot Program for Carbon Monitoring and Assessment* was issued. Building on existing environmental monitoring work and experience, the pilot program has explored to develop high-quality technical methods and operational models for carbon monitoring and assessment with focus on key industries, cities, and regions. October saw the release of the *Notice on Piloting Carbon Emission Evaluation in Industrial Park Planning and Environmental Impact Assessments*. The pilot program has explored technical methods and approaches for incorporating carbon emission evaluations into industrial park planning and environmental impact assessments by prioritizing national and provincial industrial parks involved in key carbon-emitting industries or already undergoing planning and environmental impact assessments with a foundation in carbon emission evaluation.

In November 2021, the CPC Central Committee and the State Council issued *Opinions on Deepening the Fight Against Pollution*, calling for Synergies of Pollution-Carbon Reduction, and outlining seven measures to advance the carbon peaking action. A strategic roadmap to tackle key elements will be designed with focus on carbon reduction. During the 14th Five-Year Plan period, we will strictly control the growth of coal consumption. The coal consumption in the Beijing-Tianjin-Hebei region and its surrounding areas will decrease by around 10%, the Yangtze River Delta region by around 5%, and the Fenwei Plain will see negative growth in coal consumption. In principle, the addition of new self-provided coal-fired units will no longer be permitted. Support will be provided for the implementation of clean energy alternatives for existing self-provided coal-fired units, and there will be encouragement for self-provided power plants to transition into public power plants. We'll push for a simultaneous increase in natural gas use and decrease in coal use, prioritizing natural gas for households and clean heating. We'll boost the share of electricity in overall energy consumption. We aim to basically eliminate scattered coal use in key plain areas. We'll steadily expand the pilot program for clean heating to more cities and steadily improve clean heating in northern regions.

In June 2022, the *Implementation Plan for Synergies of Pollution-Carbon Reduction* was issued, promoting the synergies of pollution-carbon reduction through integrated planning, deployment, implementation, and assessment. The guiding principles are capturing synergy and efficiency gains, strengthening source control, optimizing technical approaches, fostering innovative mechanisms, and encouraging pilot programs. The goals are "by 2025, establish a basic framework for synergies of pollution-carbon reduction, achieve significant progress in structural optimization and green & low-carbon development in key regions and sectors, develop a number of replicable best practices, and effectively improve the synergy between pollution control and carbon reduction; and by 2030, significantly enhance the synergy capacity of pollution-carbon reduction, contributing to the carbon peaking target, and achieve significant progress in collaborative efforts of carbon peaking and air quality improvement in key regions for air pollution control". By 2030, the sales volume of new energy vehicles in the key regions for air pollution control will account for around 50% of the total new vehicle sales.

(ix) Establishing A Sound National Carbon Market

In 2021, the national carbon emissions trading market (mandatory carbon market) was officially launched online. In 2024, the national GHG voluntary emissions reduction trading market (voluntary carbon market) was launched. The mandatory and voluntary markets have their respective focuses, operate independently, yet complement and interconnect with each other, collectively forming China's carbon market system. This has achieved a "dual-wheel drive" of using market mechanisms to control and reduce GHG emissions, gradually shaping China's carbon pricing mechanism centered on the national carbon market, and effectively promoting the green and low-carbon development of China's economy and society. The national carbon emissions trading market has successfully completed two compliance cycles, covering an annual CO_2 emissions of about 5.1 billion tons, and including 2257 key emitters, making it the world's largest carbon market in terms of GHG emissions coverage. By the end of 2023, China's national carbon emissions trading market had an accumulative trading volume of 440 million tons, with a turnover of about RMB 24.9 billion. The market ran smoothly overall, the price discovery mechanism showed initial effectiveness, and companies showed significantly improved awareness and capability to reduce emissions, basically achieving the expected goals.

Establishing a relatively comprehensive system and framework. The State Council has issued the *Interim Regulations on the Management of Carbon Emissions Trading*, and the MEE has introduced management measures and rules on carbon emissions registration, trading, and settlement, as well as technical specifications and supervisory requirements for carbon emissions accounting, reporting and verification of the power generation industry. The requirements and regulations for key steps such as registration, emissions monitoring, accounting, reporting, verification, quota allocation, quota trading, and quota settlement have been clearly defined, initially forming a legal system and working mechanism for national carbon emissions trading market composed of administrative regulations, departmental rules, and operating rules for trading and registration organizations.

Creating a basic infrastructure system consisting of "one network, two organizations, and three platforms". We have built the "National Carbon Market Information Network" to centrally release authoritative information and news on the national carbon market; set up the national carbon emission rights registration and trading institutions to meticulously manage quota registration, allocation, settlement, and trading. The national carbon emission allowance registration system, trading system, and management platform—the 3 major infrastructure components—have been established and are operating stably. This has achieved online processing for all business management stages, centralized data management throughout the entire process, and scientifically-based integrated decision-making. As a result, the foundational support system for the national carbon emission allowance market is now basically in place.

Significantly improving carbon emission accounting and management capabilities. We have established a normalized and long-term regulatory mechanism for carbon emissions data quality, implemented "national-provincial-municipal" three-level joint reviews, and fully utilized information technologies such as big data and blockchain for intelligent early warning, eliminating data issues in the "germination" stage. We have developed a dynamic compliance risk monitoring mechanism to urge enterprises to complete quota settlements on time and in full. All enterprises have set up internal control systems for carbon emission management, and incorporated carbon asset management into their daily operations, significantly improving their management level and accounting capabilities.

Launching the national GHG voluntary emissions reduction trading market. China has been actively promoting the launch of the national voluntary GHG emissions reduction trading market, and has issued the *Measures for the Management of GHG Voluntary Emissions Reduction Trading (Trial)*, supporting social entities to voluntarily develop GHG emissions reduction projects. The emission reductions of these projects will be quantified and certified through scientific methods, and traded in the market for corresponding benefits. China has released the first methodologies for 4 types of projects: afforestation carbon sequestration, grid-connected offshore wind power, grid-connected solar thermal power, and mangrove planting; and encouraged projects with additionality, uniqueness, authenticity, and conservativeness to apply for registration as certified voluntary emissions reductions (CERs). China has set up national voluntary GHG emission reduction registration and trading institutions, developed and launched online the national voluntary GHG emission reduction registration and trading systems, ensuring interoperability with the national carbon emission rights registration system and the national carbon market management platform. On January 22, 2024, China launched the national voluntary GHG emissions reduction trading market, and Vice Premier Ding Xuexiang attended the launch ceremony. On the first day of operation, 375,000 tons of emission reductions were traded, with a turnover of RMB 23.835 million, and the market operated smoothly.

(x) Other Relevant Developments

Boosting carbon reduction actions through circular economy. The *Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste* was revised to promote green development, and foster the development of cleaner production and the circular economy. The *Notice on Issuing the 14th Five-Year Plan for the Development of the Circular Economy* and the *Notice on Issuing the Implementation Plan to Accelerate the Comprehensive Utilization of Industrial Resources* were issued, to promote the circular development of industrial parks, strengthen the comprehensive utilization of bulk solid waste, and improve the resource recycling system.

Fostering innovations in green and low-carbon science and technology. China has published the *Science and Technology Innovation Plan for the Energy Sector in the 14th Five-Year Plan Period* and the *Implementation Plan for Science and Technology Support for Carbon Peaking and Carbon Neutrality (2022-2030)*. The aim is to improve the innovation systems and mechanisms, strengthen innovation capabilities and talent development, bolster fundamental applied research, and accelerate the R&D and deployment of advanced, practical technologies. We have vigorously implemented green, low-carbon, and advanced technology demonstration projects, and promoted the full chain demonstration and application of advanced technologies for source carbon reduction, process carbon reduction, and end-of-pipe carbon fixation. We have fostered the creation of a cradle for original technologies such as cleaner and efficient coal utilization and CCUS, built a national green and low-carbon building technology innovation center, established the offshore wind power industry technology innovation alliance, CCUS technology innovation alliance, China new energy storage industry innovation alliance, and global low-carbon metallurgy innovation alliance, and created an industry exchange platform for green and low-carbon technology.

Carrying out a national survey and demonstration of carbon sequestration resources. China is evaluating the potential for carbon sequestration resources in the major sedimentary basins bordering China's seas, and updating the assessment of the potential for carbon sequestration resources in the main onshore sedimentary basins. A batch of suitable target areas or sites for carbon sequestration in the Ordos Basin and the Yellow River Delta will be selected; a demonstration base for the complete CCUS industrial chain at the Shengli Oilfield with million-ton-level capabilities will be constructed; and the site selection for a major demonstration project of saline aquifer carbon storage at the Yulin Energy and Chemical Base in Shaanxi will be initiated.

Mobilizing community-wide green and low-carbon actions. China has issued the *Work Plan for Strengthening the Higher Education Talent Training System for Carbon Peak and Carbon Neutrality*, strengthened the publicity and education of ecological civilization, organized national low-carbon day events, promoted green and low-carbon lifestyles, guided enterprises to fulfill their social responsibilities, strengthened the training of leading officials, and launched the "National Ecological Day", raising the awareness of ecological civilization in the whole society, and fostering their ideological and operational consciousness in environmental protection.

Regarding discontinued measures. China's mitigation policies and actions are consistent; there are no discontinued measures compared to previous reports.

II. Effects of Mitigation Policies and Actions

Given the data availability and existing related methodologies, the assessment of the impact and effects of China's mitigation actions focuses on CO_2 emission reductions from Energy. The quantified mitigation actions mainly include comprehensive energy conservation and emission reduction, development of non-fossil energy, enhancement of natural gas supply capacity, hydropower development, nuclear power development, development of non-hydro renewable energy, and industrial energy efficiency improvement (see Table 2-4).

Table 2-4 Overview of Mitigation Actions and Effects

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
Accelerating the Optimization and Adjustment of Energy Structure									
Comprehensive energy conservation and emission reduction	Improve and implement the dual control system for energy consumption intensity and total energy consumption, the total emissions control system for major pollutants; launch key energy conservation and emission reduction projects; develop sound policy mechanisms for energy conservation and emission reduction; promote significant improvements in energy utilization efficiency; ensure continuous reduction of total major pollutant emissions; capture synergies of energy conservation, carbon reduction, and pollution control; continuously improve eco-environment quality; and ensure completion of energy conservation and emission reduction targets during the 14th FYP period, laying a solid foundation for achieving carbon peaking and carbon neutrality goals.	By 2025, the national energy consumption per unit of GDP will decrease by 13.5% compared to 2020, and the total energy consumption will be reasonably controlled. Energy conservation and emission reduction policies and mechanisms will become more robust, with the energy efficiency of key industries and the control of major pollutant emissions essentially reaching international advanced levels, achieving significant results in the green transition of economic and social development.	Government regulation	Implemented	All sectors	CO_2	2005	Ministries and commissions under the State Council	NE
Development of non-fossil energy	Accelerate the development of wind power and solar power, develop hydropower appropriately based on local conditions, proactively and safely advance nuclear power in an orderly manner, and develop other renewable energy sources as appropriate.	By 2025, the proportion of non-fossil energy consumption will increase to around 20%, and the share of non-fossil energy power generation will reach around 39%.	Government regulation	Implemented	Energy	CO_2	2005	NDRC, NEA	Compared to 2005, 2021 achieved a reduction of 1,730 Mt CO_2[15].

[13] For mitigation actions with quantified greenhouse gas reductions estimates, the starting year of each action listed in the table is used as the baseline year; for mitigation actions without quantified greenhouse gas reductions estimates, the starting year listed is the beginning year of the "14th Five-Year Plan."

[14] Emission reductions estimates listed in the table correspond to specific mitigation actions, as emission reductions from various actions are interrelated and should not be summed.

[15] Emission reductions = (non-fossil energy consumption in the current year - baseline year non-fossil energy consumption) × baseline fossil fuel composite emission factor. The composite emission factor for fossil energy consumption is calculated as the CO_2 emissions from fossil energy consumption divided by the total fossil energy consumption. Data for calculating the composite emission factor for fossil energy consumption is sourced from the China Energy Statistical Yearbook 2023.

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
Enhancement of natural gas supply capacity	Ramp up domestic natural gas exploration and development, actively expand exploration and development of unconventional resources, and accelerate the development of shale gas and coalbed methane.	By 2025, annual natural gas production will reach over 230 billion m^3.	Government regulation	Implemented	Energy	CO_2	2005	NDRC, NEA	Compared to 2005, 2021 achieved a reduction of 390 Mt CO_2[16] .
Hydropower development	Develop hydroelectric power based on local conditions; actively promote the construction of hydropower bases, implement rectification of small hydropower stations, and advance green retrofits and modernization upgrades following the principles of prioritizing ecology, taking an integrated approach, developing in moderation, and ensuring baseline requirements; promote synergistic complementarity between hydroelectric, wind, and solar power in the Southwestern region.	By 2025, conventional hydropower installed capacity will reach around 380 GW, with pumped storage hydropower installed capacity exceeding 62 GW and capacity under construction around 60 GW.	Government regulation	Implemented	Energy	CO_2	2005	NDRC, NEA	Compared to 2005, 2021 achieved a reduction of 960 Mt CO_2[17] .
Nuclear power development	actively and safely develop nuclear power in an orderly manner; Actively and orderly promote the construction of coastal nuclear power projects, maintain a steady construction pace, and reasonably deploy new coastal nuclear power projects under the premise of ensuring safety; conduct demonstrations of comprehensive nuclear energy utilization,	By 2025, nuclear power installed capacity is expected to reach around 70 GW.	Government regulation	Implemented	Energy	CO_2	2005	NDRC, NEA	Compared to 2005, 2021 achieved a reduction of 360 Mt CO_2[18] .

[16] Emission reductions = (current year natural gas consumption - baseline year natural gas consumption) × (baseline fossil fuel composite emission factor - natural gas emission factor). The composite emission factor for fossil energy consumption is calculated as the CO_2 emissions from fossil energy consumption divided by the total fossil energy consumption. Data required for calculating the composite emission factor for fossil energy consumption and the emission factor for natural gas is from the China Energy Statistical Yearbook 2023.

[17] Emission reductions = (hydropower generation in the current year - baseline year hydropower generation) × baseline fossil fuel power CO_2 emission factor. Hydropower generation data is from the historical China Energy Statistical Yearbook series, and the baseline year fossil energy power CO_2 emission factor is calculated based on the *2021 Power CO_2 Emission Factor Calculation Instructions*.

[18] Emission reductions = (nuclear power generation in the current year - baseline year nuclear power generation) × baseline fossil fuel power CO_2 emission factor. Nuclear power generation data is from the historical China Energy Statistical Yearbook series, and the baseline year fossil energy power CO_2 emission factor is based on the *2021 Power CO_2 Emission Factor Calculation Instructions*.

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
	promoting the integrated application of nuclear energy in areas such as clean heating, industrial heat supply, and seawater desalination.								
Development of non-hydro renewable energy	Implement renewable energy substitution actions, enhance renewable energy consumption and storage capabilities, consolidate and improve the core competitiveness of the renewable energy industry, accelerate the construction of a new power system, and foster large-scale, high-proportion, market-driven, and high-quality development of renewable energy, effectively supporting the building of a clean, low-carbon, safe, and efficient energy system.	In 2024, the national non-hydropower renewable energy electricity consumption responsibility proportion will reach around 18%, and the scale of renewable energy non-electricity utilization will exceed 60 Mtce.	Government regulation	Implemented	Energy	CO_2	2005	NDRC, NEA, MNR, MEE, MOHURD, MARA, CMA and NFGA	Compared to 2005, 2021 achieved a reduction of 1,170 Mt CO_2 [19].
Fostering Green and Low-Carbon Transitions of the Industrial Sector									
Industrial energy efficiency improvement	Foster changes in energy efficiency technology and innovations in energy efficiency management, systematically improve energy efficiency regulatory capabilities and service levels, comprehensively enhance the efficiency of key energy-consuming process, equipment and products across the entire chain, steadily and systematically shift the focus of industrial energy conservation from individual entities to the whole process, and actively advance high-efficiency, low-carbon, and green energy usage, laying a solid energy efficiency foundation for	By 2025, energy efficiency across key industrial sectors will be comprehensively improved. Data centers and other key areas will see significant energy efficiency gains, with the proportion of green, low-carbon energy utilization rising markedly. Energy-saving and efficiency-enhancing processes, technologies and equipment will be widely applied. Standards, services, and regulatory systems will gradually be perfected. Key products in industries such as steel, petrochemicals, non-ferrous metals, and	Government regulation	Implemented	Energy, IPPU	CO_2	2005	MIIT, NDRC, MOF, MEE, SASAC, SAMR	Compared to 2005, 2021 achieved a reduction of 5,100 Mt CO_2[20] .

[19] Emission reductions = (non-hydropower renewable energy generation in the current year - baseline year non-hydropower renewable energy generation) × baseline fossil fuel power CO_2 emission factor. Non-hydropower renewable energy generation includes wind, solar, and biomass generation, with data sourced from the historical China Energy Statistical Yearbook series. The baseline year fossil energy power CO_2 emission factor is based on the *2021 Power CO_2 Emission Factor Calculation Instructions*.
[20] Emission reductions = (baseline year industrial value-added energy consumption per unit - current year industrial value-added energy consumption per unit) × current industrial value-added × baseline fossil fuel composite emission factor. Industrial value added is calculated at constant prices, while unit industrial value-added energy consumption is determined by dividing the total industrial energy consumption by industrial value added, and the composite emission factor for fossil energy consumption is calculated by dividing CO_2 emissions from fossil energy consumption by total fossil energy consumption. Industrial value-added data is sourced from the China Statistical Yearbook 2023, and data for calculating the composite emission factor for fossil energy consumption is from the China Energy Statistical Yearbook 2023.

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
	achieving the carbon peaking and carbon neutrality goals in the industrial sector.	non-metallic mineral products will reach international advanced energy efficiency levels, with energy consumption per unit of added value for industrial enterprises above designated size dropping by 13.5% compared to 2020.							
Carbon peaking in the steel industry	Strictly implement regulations on capacity replacement, project filing, environmental impact assessment, and energy conservation evaluation review to effectively control steel production capacity; strengthen industrial collaboration, and build a community of clean energy and steel industry; encourage steady and moderate advanced electric furnace short-process development in the steel industry; promote the demonstration and scale-up of low-carbon iron-making technology; optimize product structure, and increase the application ratio of low-carbon products with high strength, high toughness, corrosion resistance, weather resistance, and material and energy efficiency.	By 2025, scrap steel processing enterprises will have an annual processing capacity exceeding 180 million tons, with short-process steel-making accounting for over 15%; by 2030, breakthrough applications of technologies such as hydrogen-rich carbon circulation blast furnace smelting, hydrogen-based direct reduced iron shaft furnaces, and CCUS will be achieved, with short-process steel-making accounting for over 20%.	Government regulation	Implemented	Energy, IPPU	CO_2	2021	NDRC, MOST, MIIT, MEE, SASAC, SAMR and NEA	NE
Carbon peaking in the petrochemical industry	Enhance the supply capacity of natural gas, ethane, propane, and increase the proportion of low-carbon feedstocks; promote and apply technologies like direct crude oil cracking for ethylene production and next-generation ion membrane electrolyzer; develop technologies for producing high-value chemicals with renewable energy.	By 2025, "Reducing oil and increasing chemicals" will make positive progress, with the yield of refined petroleum products from new integrated refining and chemical projects dropping to below 40% of crude oil processing volume, and the deployment of large-scale CCUS industrial demonstration projects will be accelerated; by 2030, short-process synthesis technologies such as one-step syngas-to-olefins will achieve large-scale application.	Government regulation	Implemented	Energy, IPPU	CO_2	2021	NDRC, MOST, MIIT, MEE, SASAC, SAMR and NEA	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
Carbon peaking in the non-metallic mineral products industry	Comprehensively improve the green and low-carbon development level of the non-metallic mineral products industry, and ensure the timely achievement of carbon peaking, with deepening supply-side structural reforms as the key task, amount control as the foundation, resource comprehensive utilization level enhancement as the key, and low-carbon technological innovation as the driving force.	During the 14th FYP period, the non-metallic mineral products industry will make noticeable progress in structural adjustment. The energy-efficient and low-carbon technologies will be further promoted, and the energy consumption and carbon intensity of key products like cement, glass, and ceramics will be steadily decreased. The comprehensive energy consumption per unit of cement clinker will be dropped by more than 3%; During the 15th FYP period, the non-metallic mineral products industry will achieve major breakthroughs in the industrialization of key green and low-carbon technologies. The level of primary fuel substitution will be significantly increased, and a green, low-carbon, and circular industrial system will be basically established. The non-metallic mineral products industry will hit its carbon peak before 2030.	Government regulation	Implemented	Energy, IPPU	CO_2	2021	MIIT, NDRC, MEE, MOHURD	NE
Carbon peaking in the non-ferrous metals industry	Enhance Synergies of Pollution-Carbon Reduction across the entire industrial chain, accelerate the creation of a green and low-carbon development pattern, and ensure the timely achievement of carbon peaking by optimizing smelting capacity, adjusting and optimizing the industrial structure, strengthening technology-based energy conservation and carbon reduction, promoting clean energy substitution, and building a green manufacturing system, with deepening supply-side structural reforms as the key task.	During the "14th Five-Year Plan" period, the non-ferrous metals industry's structure and energy consumption structure will be significantly optimized. Low-carbon process research and development will achieve important progress, with key product types seeing further reductions in unit energy consumption and carbon emission intensity. The supply of recycled metals will reach over 24%. During the "15th Five-Year Plan" period, the non-ferrous metals industry's energy structure will be substantially improved, with renewable energy usage in electrolytic aluminum reaching over 30%, and a basic establishment of an	Government regulation	Implemented	Energy, IPPU	CO_2	2021	MIIT, NDRC, MEE	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
		industrial system focused on green, low-carbon, and circular development. The non-ferrous metals industry will hit its carbon peak before 2030.							
Advancing Green, Low-Carbon Development in the Building Sector									
Carbon peaking in the urban and rural development	Coordinate development and security, carry out urban renewal and rural development initiatives, accelerate the transformation of urban and rural development methods, enhance the quality of green & low-carbon development, and continuously meet the people's needs for a better life.	By 2030, carbon emissions in the urban and rural development will reach their peak. The policy system and institutional mechanisms for green and low-carbon urban and rural development will be basically established; building energy efficiency and waste recycling rate will be significantly improved, with energy and resource utilization efficiency reaching international advanced levels; energy structure and methods will be more optimized, with renewable energy applications more fully utilized; urban and rural development will achieve positive progress in green and low-carbon transition, basically reversing the trend of "massive construction, massive consumption, and massive emissions"; the overall integrity, systematization, and growth capacity of cities will be enhanced, with "urban maladies" being initially resolved; building quality and engineering standards will be further improved, and the quality of living environments will be significantly enhanced; green lifestyles will become widespread, and initial progress towards low-carbon operations will be achieved. By 2060, we aim to comprehensively achieve green and low-carbon transition in urban and rural development methods. We'll realize systemic reforms, build a beautiful living environment,	Government regulation	Implemented	Energy, IPPU, Waste	CO_2	2021	MOHURD, NDRC	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
		fully modernize carbon emission governance in the construction sector, and ultimately enhance people's quality of life in urban and rural areas.							
Building energy efficiency and green building development	Improve the quality of green, low-carbon development in buildings, reduce building energy and resource consumption, and transform urban and rural development approaches, laying a solid foundation for achieving carbon peaking in the urban and rural development by 2030.	By 2025, energy efficiency retrofits will be completed for over 350 million m^2 of existing buildings, with more than 50 million m^2 of ultra-low and near-zero energy buildings constructed. Prefabricated buildings will account for 30% of urban new buildings, nationwide PV installed capacity on buildings will increase by over 50 GW, geothermal energy building applications will cover more than 100 million m^2, renewable energy replacement rate in urban buildings will reach 8%, and electricity will comprise over 55% of building energy consumption.	Government regulation	Implemented	Energy	CO_2	2021	MOHURD	NE
Accelerating the Establishing of A Green and Low-Carbon Transport System									
Development of green transport	Prioritize energy conservation and carbon reduction in transport, synergistically promote high-quality development of transport and high-level environmental protection, accelerate the formation of green and low-carbon transport modes, foster harmonious development between transport and nature, and provide strong support for rapidly boosting strengths in transport.	By 2025, the CO_2 emissions per unit of transport turnover for operating vehicles and vessels will decrease by 5% and 3.5% compared to 2020, NOx emissions from operating vessels will decrease by 7% compared to 2020; new energy vehicles will account for 72% in urban public transit, 35% in taxis (including ride-hailing), and 20% in urban logistics distribution; clean energy container trucks at international container hub ports will reach 60%; shore power usage at Yangtze River Economic Belt ports and water service areas will increase by 100% compared to 2020; container rail-water intermodal transport will grow by an average of 15% annually; and 60 cities with over 1 million permanent residents will achieve a green mobility rate of over 70%.	Government regulation	Implemented	Transport	CO_2	2021	MOT	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
Optimization of the transport structure	Deepen the green and low-carbon transition of transport in major coal producing regions of Beijing-Tianjin-Hebei and surrounding areas, as well as Shanxi, Shaanxi, and Inner Mongolia; accelerate the development of rail-water intermodal transport in the Yangtze River Delta region and the Guangdong-Hong Kong-Macau Greater Bay Area.	During the 14th FYP period, container rail-water intermodal transport volume will grow by an average of over 15% annually.	Government regulation	Implemented	Transport	CO_2	2021	MOT	NE
Encouragement of Green Mobility	Promote green mobility in municipalities directly under the central government, provincial capital cities, cities specifically designated in the state plan, existing national transit hub cities, and other urban areas with a permanent population of over 1 million, and encourage participation of surrounding small and medium-sized cities; prioritize creating around 100 green mobility cities, and guide the public to primarily choose eco-friendly modes such as public transit, walking, and cycling, continuously improving urban green mobility levels.	By 2025, more than 60 cities will achieve a green mobility rate of over 70%.	Government regulation	Implemented	Transport	CO_2	2021	MOT	NE
New Energy Promotion and Application	Launch initiatives to promote electric delivery trucks and hydrogen fuel cell vehicles, implement urban green freight distribution demonstrations, advance shore power applications, and construct near-zero logistics hubs and stations.	Pilot applications of electric trucks and hydrogen fuel cell vehicles are being conducted. Efforts are being deepened to construct and utilize shore power in key regions, key provinces and cities, and on key shipping routes, with a focus on increasing the usage rate of shore power facilities. Important port areas and freight terminals are being encouraged to accelerate the application of new energy sources and renewable energy..	Government regulation	Implemented	Transport	CO_2	2021	MOT	NE
Consolidating and Enhancing Ecosystem Carbon Sinks									
Consolidation and Enhancement of Forest	Comprehensively protect natural forests; continue the full cessation of commercial logging in natural forests; incorporate natural forests and public welfare forests into a unified management and protection	By 2025, the forest coverage rate will reach 24.1%, and the forest stock volume will reach 19 billion m^3.	Government regulation	Implemented	LULUCF	CO_2	2021	NFGA	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
Carbon Sinks	system; strengthen natural enclosure, and continuously increase the total volume of natural forest resources; strengthen conservation of natural young and medium-sized forests and carry out restoration of degraded secondary forests; strengthen forest management; establish and implement a decision-making management mechanism for the cultivation, protection and utilization of forests based on forest management planning and forest management programmes; implement a forest quality precision enhancement project, strengthen forest cultivation and restoration of degraded forests in the eastern and southern regions, intensify efforts to improve artificial pure forests, cultivate multi-layered, mixed-age forests, and build national reserve forests.								
Consolidation and Enhancement of Grassland and Wetland Carbon Sinks	Strengthen grassland protection and restoration: strictly enforce grazing bans and balance livestock with grassland capacity, accelerate grassland ecological restoration, and promote grassland regeneration and recovery. Strengthen wetland protection and restoration: comprehensively protect wetlands, restore degraded wetlands, and enhance wetland management.	By 2025, the comprehensive vegetation coverage of grasslands will reach 57%.	Government regulation	Implemented	LULUCF	CO_2	2021	NFGA	NE
Enhancing Control of Non-CO_2 GHG Emissions									
CH_4 Emissions Control	Accelerate the formation of a CH_4 emission regulatory system, promote Synergies of Pollution-Carbon Reduction, and effectively control CH_4 emissions in an orderly, and efficient manner.	During the 14th FYP period, CH_4 emission control policies, technologies, and standards systems will be gradually established. Basic capabilities such as CH_4 emission statistics, accounting, monitoring, and supervision will be effectively enhanced, and significant progress will be made in CH_4 resource utilization and emissions control. The CH_4 emission intensity	Government regulation	Implemented	Energy, Agriculture and Waste	CH_4	2021	MEE, MFA, NDRC, MOST, MIIT, MOF, MNR, MOHURD, MARA, MEM, NEA	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
		per unit of agricultural products in crop farming and animal husbandry will remain stable with a slight decline, while the MSW recycling rate and the hazard-free disposal rate of urban sludge will be continuously improved. During the 15th FYP period, policies, technologies, and standards for CH_4 emissions control will be further refined, with significant improvements in basic capabilities such as CH_4 emission statistics, accounting, monitoring, and supervision. The capacity for controlling and managing CH_4 emissions will be effectively enhanced. Coal mine gas utilization will be further improved, and the CH_4 emission intensity per unit of agricultural products in crop farming and animal husbandry will be further reduced. Thereafter, onshore oil and gas extraction will strive to realize zero conventional flaring.							
Enhanced CH_4 Comprehensive Utilization in the Energy Sector	Control of CH_4 emissions from oil and gas fields, and encourage companies to drainage and utilize associated gas and flare gas in accordance with local conditions; encourage and guide coal enterprises to increase methane drainage and utilization in coal mines.	By 2025, the annual utilization of coal mine gas will reach 6 billion m^3; by 2030, the collection rate of oil field associated gas will reach international advanced levels.	Government regulation	Implemented	Energy	CH_4	2021	NDRC, NEA	NE
Resource Utilization of Livestock and Poultry Manure	With focus on large-scale livestock and poultry farms, improve storage and treatment facilities for animal manure, promote the adoption of closed-off manure processing, gas collection and utilization techniques, establish resource utilization ledgers for animal manure, explore implementing nutrient balance management for animal manure, and enhance the level of manure treatment and resource recycling; develop rural biogas based on local	By 2025, the comprehensive utilization rate of livestock and poultry manure will reach over 80%; by 2030, it will reach over 85%.	Government regulation	Implemented	Agriculture	CH_4, N_2O	2021	MEE, MARA, MOHURD, MWR, National Rural Revitalization Administration (NRRA)	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
	conditions, promote centralized biogas supply for heating and grid-connected power generation, and expand applications such as using biogas as vehicle fuel or integrating it into natural gas pipelines.								
CH_4 Emissions Control from Waste	Promote MSW reduction at the source, implement sorting and recycling, and enhance the MSW resource utilization system; systematically advance the construction of kitchen waste processing facilities; strengthen comprehensive remediation of MSW landfills and improve the level of landfill gas recovery and utilization.	By 2025, the national MSW resource utilization rate will reach around 60%.	Government regulation	Implemented	Waste.	CH_4	2021	NDRC, MOHURD	NE
Enhanced CH_4 Collection and Utilization in Wastewater Treatment	Comprehensively enhance the efficiency of urban domestic sewage collection and treatment, and steadily improve the level of hazard-free and resource utilization of sludge; encourage wastewater treatment projects with resources to use methods like anaerobic sludge digestion to generate biogas and strengthen its recovery and utilization.	By 2025, the hazard-free disposal rate of urban sludge will reach over 90%.	Government regulation	Implemented	Waste.	CH_4	2021	NDRC, MOHURD, MEE	NE
Establishing A Sound National Carbon Market									
National Carbon Emissions Trading Market	Fully harness the role of market mechanisms in controlling GHG emissions, steadily advance the establishment of a nationwide unified carbon emissions trading market, and make new contributions to effectively controlling and gradually reducing carbon emissions, and promoting green and low-carbon development in China.	Market mechanisms will be leveraged to control and reduce GHG emissions, and promote the green and low-carbon development of economic and social sectors.	Economic instruments	Implemented	Cross-cutting sectors	CO_2	2021	MEE	NE
National GHG Voluntary Emissions Reduction Trading Market	Quantify and certify the GHG emission reductions for renewable energy, forestry carbon sinks, and CH_4 utilization projects within Chinese territory.	Efforts will be made to reduce carbon emissions and increase carbon sinks, avoid and reduce GHG emissions, and achieve GHG emissions removals.	Economic instruments	Implemented	Cross-cutting sectors	All gases	2021	MEE	NE

Name	Description	Objectives	Type of instrument	Status	Sector(s) affected	Gases affected	Start year of implementation[13]	Implementing entity or entities	Estimates of GHG emission reductions[14]
Improving the Fiscal Taxation, Financial, Investment, and Pricing Policies and Standards for Green Development									
Building a Policy System to Support Green and Low-Carbon Development through Fiscal Measures	Actively build a fiscal taxation policy system that fosters efficient resource utilization and green, low-carbon development, better combine proactive government and effective market mechanisms, and support the timely achievement of carbon peaking and carbon neutrality goals.	By 2025, fiscal policy instruments will continue to diversify, and an initial framework of fiscal taxation policies for green and low-carbon development will be established, strongly supporting regions and industries in accelerating their green and low-carbon transitions. By 2030, a fiscal taxation policy system for green and low-carbon development will be basically formed, and long-term mechanisms for green and low-carbon development will be gradually established, facilitating the smooth achievement of the carbon peaking goal. Before 2060, a mature and comprehensive policy system supporting green and low-carbon development through fiscal measures will be in place, driving the successful realization of the carbon neutrality goal.	Economic instruments	Implemented	All sectors	All gases	2021	MOF	NE
Green Finance Evaluation Scheme for Banking and Financial Institutions	Encourage banking and financial institutions to actively expand green finance services, continuously strengthen financial support for high-quality and green & low-carbon development, and coordinate the implementation of green finance evaluations.	The capacity for financial support of green, low-carbon, high-quality development will be enhanced, and the incentive and constraint mechanisms for green finance will be optimized.	Economic instruments	Implemented	All sectors	All gases	2021	PBC	NE
Carbon Reduction Supporting Tool	Guide financial institutions to actively support three key low-carbon areas: clean energy, energy conservation and environmental protection, and carbon reduction technologies through the carbon reduction supporting tool, and provide low-cost funding support covering 60% of the loan principal for eligible loans.	Low-cost central bank re-lending funds will be leveraged to guide financial institutions in increasing credit support for key carbon reduction sectors.	Economic instruments	Implemented	Energy, IPPU	CO_2	2021	PBC, NDRC, MEE	Nearly 200 Mt

Part III Climate Change Impacts and Adaptation

China, with its large population, vast territory, abundant resources, complex climate conditions, and frequent extreme weather, has already experienced significant impacts from climate change on both its natural ecosystems and socioeconomic systems, with increasing damages and losses. The Chinese government considers proactive climate change adaptation a critical component of the national strategy to address climate change. It actively implements policies and actions, as set out in *China's Achievements, New Goals and New Measures for Nationally Determined Contributions*, achieving significant results in priority areas for climate change adaptation. China also actively engages in international cooperation on climate change adaptation and related joint research, promoting mutual learning and knowledge sharing. These efforts have effectively enhanced the capacity of China and other developing countries to adapt to climate change, raising awareness among decision-makers and the public alike. However, China faces numerous challenges in advancing adaptation actions, such as weak climate change monitoring, early warning, and risk management capabilities, insufficient adaptability in natural ecosystems, and limited adaptive capacity within economic and social systems.

Chapter 1 National Circumstances and Institutional Arrangements

1. Overview of National Circumstances Relevant to Climate Change Adaptation

(i) Topography and Geomorphology

China features diverse terrain, including five basic landforms: plateaus, hills, mountains, basins, and plains. Approximately 67% of China's land area is composed of mountains, plateaus, and hills, while 33% is covered by basins and plains. The topography generally decreases in elevation from west to east, forming a three-step layout. The first step is the Qinghai-Tibet Plateau, with an average elevation of over 4,000 meters, serving as an essential ecological security shield, a strategic resource reserve, and a biodiversity repository of high-altitude species. It nurtures ten significant rivers, including the Yellow River, Yangtze River, and Lancang-Mekong River, and slopes from northwest to southeast. The second step, averaging 1,000 to 2,000 meters in elevation, includes large basins and plateaus such as the Inner Mongolia Plateau, Loess Plateau, Yunnan-Guizhou Plateau, Tarim Basin, Junggar Basin, and Sichuan Basin. The third step, primarily composed of vast plains interspersed with hills and low mountains, has an elevation mostly below 500 meters. This step includes the Liaodong Hills, Shandong Hills, Jiangnan Hills, and extensive plains such as the Northeast Plain, North China Plain, Middle and Lower Yangtze Plain, and Pearl River Delta Plain. China's eastern lands host inland seas like the Bohai Sea and marginal seas such as the Yellow Sea, East China Sea, and South China Sea, with seawater depth increasing progressively from north to south. The long coastline has a wide continental shelf (Figure 3-1).

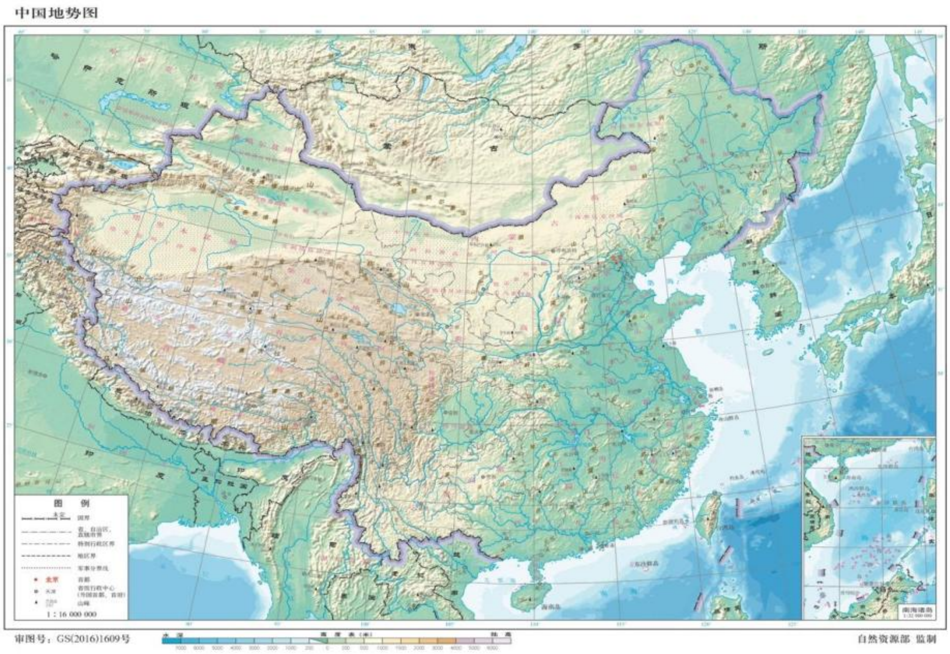


Figure 3-1 China's Topography

(ii) Climate and Climate Disasters

China has a complex climate, with monsoon climates in the east, temperate continental climates in the northwest, and alpine climates on the Qinghai-Tibet Plateau. Most of China lies in the northern temperate zone, with a significant latitude difference of 50° from north to south. This results in marked differences in solar height and temperature between northern and southern regions. China's climate is characterized by hot, rainy summers; cold, dry winters; and simultaneous periods of high temperature and heavy rainfall. Annual precipitation decreases from the southeast coast toward the northwest inland. See Chapter II of this part for the change trend of annual average temperature and precipitation data.

China frequently experiences extreme weather and climate events, with droughts, floods, cold waves, and typhoons being the primary impactful hazards. Marine disasters mainly include storm surges, sea waves, and red tides. Droughts are prevalent in the north, while both droughts and floods occur in the south. Southeastern coastal regions are often struck by tropical storms from June to September, while cold air from Mongolia and Siberia triggers cold waves in autumn and winter, leading to low temperatures, strong winds, sandstorms, and frost. In recent years, climate disasters have shown spatial and temporal unevenness, with most incidents occurring in the summer and autumn, heavily impacting central and western areas. Flood disasters are most severe in the north and south but less so in central regions. Consecutive summer and autumn droughts have occurred in the Yangtze River basin, while low temperatures, rain, snow, and ice have significantly impacted the southwest and south-central regions, with severe snow disasters in Xinjiang, and severe storm surges affecting Shandong and Guangdong.

(iii) Natural Resources

1. Land Resources

China's land resources are diverse, featuring extensive distributions of farmland, forest land, grasslands, deserts, and tidal flats, but limited arable land per capita. The Northeast Plain, North China Plain, Middle and Lower Yangtze Plain, Pearl River Delta Plain, and Sichuan Basin are key farmland areas. Grasslands are mainly in the north and west, while forests are concentrated in the northeast, southwest, and south. Detailed land use data can be found in Chapter 6 of Part I.

2. Water Resources

China is one of the world's richest countries in terms of rivers and lakes, with 2,221 rivers covering an area of over 1,000 square kilometers each, and over 2,800 natural lakes larger than 1 square kilometer. China's water resources are unevenly distributed, with higher availability in summer and autumn and significant annual variations. Spatially, eastern and southern regions have more water than western and northern areas. China's per capita water resource is only one-fourth of the world average. In 2022, China's total water resources were 2,708.81 billion cubic meters, with surface water at 2,598.44 billion cubic meters and groundwater at 792.44 billion cubic meters (with 110.37 billion cubic meters being non-overlapping surface and groundwater resources). Total water resources accounted for 45.3% of total precipitation. Per capita water resources amounted to 1,918.8 cubic meters, with a total water supply of 599.82 billion cubic meters, representing 22.1% of the water resources for that year[21].

China has substantial hydropower resources, concentrated primarily in the Yangtze River Basin, Yarlung Tsangpo Basin, and Yellow River Basin. The southwestern provinces of Sichuan, Yunnan, and Tibet are particularly rich in hydropower resources.

3. Marine Resources

According to the *United Nations Convention on the Law of the Sea* and China's claims, China has jurisdiction over an area of about 3 million square kilometers of marine territory. China's coastline stretches around 32,000 kilometers, with approximately 18,000 kilometers along the mainland and 14,000 kilometers around islands. There are over 11,000 islands, more than 20,000 marine species[22], and abundant marine resources.

4. Biodiversity

China hosts all major terrestrial ecosystems on Earth, with 212 types of forest, 36 types of bamboo forest, 113 types of shrub, 77 types of meadow, 52 types of desert, and 30 types of natural wetland. Marine ecosystems include mangroves, coral reefs, seagrass beds, islands, bays, estuaries, and upwelling zones. Artificial ecosystems include farmland, plantations, constructed wetlands, artificial grasslands, and urban areas[23].

---

[21] Source: China Water Resources Bulletin 2022.
[22] Source: China Natural Resources Statistical Bulletin 2022.
[23] Source: China Ecological Environment Status Bulletin 2021.

In terms of species diversity, *Catalogue of Life China 2022 Annual Checklist* lists 138,293 species and sub-species (125,034 species and 13,259 sub-species). The *List of National Key Protected Wild Animals* includes 980 species and 8 categories of wild animals, and the *List of National Key Protected Wild Plants* includes 455 species and 40 categories of wild plants.

China has extensive genetic resources, including 528 types of cultivated crops across 1,339 crop varieties, over 1,000 economic tree species, over 7,000 ornamental plant species, and 948 domesticated animal breeds[24].

(iv) Socioeconomic Conditions

1. Economic Development

See Chapter 1 of Part II for details.

2. Population

For regions, as of 2020, China's eastern region had a population of 564 million (39.93% of the total), the central region had 365 million (25.83%), the western region had 383 million (27.12%), and the northeastern region had 99 million (6.98%)[25].

Other demographic details are in Chapter 1 of Part II.

3. Health and Public Sanitation

In 2022, China had 1.033 million healthcare institutions, 9.75 million hospital beds, and a total of 14.411 million healthcare personnel, including 4.435 million licensed (assistant) physicians and 5.224 million registered nurses. Healthcare institutions handled 8.42 billion outpatient visits and 25 million admissions[26].

4. Infrastructure Development

In 2022, China's municipal fixed asset investments totaled RMB 2.66 trillion, down 3.13% year-over-year. The investment in road and bridge construction, rail transit, drainage, landscaping, and underground utility corridors accounts for 38.4%, 22.7%, 10.1%, 6.4%, and 1.3% respectively. China's urban water supply coverage was 99.39%, urban green space coverage in built-up areas was 39.29%, and per capita park green space in cities was 15.29 square meters[27]. Rural toilet coverage reached 77.5%, rural sewage treatment coverage was approximately 31%[28], and rural tap water coverage was 87.4%[29].

In 2022, investments in water conservancy construction totaled RMB 1089.32 billion, with allocations as follows: flood control (33.3%), water resources (41.1%), soil and ecological

[24] Source: China Ecological Environment Status Bulletin 2022.
[25] Source: National Bureau of Statistics Seventh National Census Bulletin (No. 3).

[26] Source: Statistical Bulletin on the Development of China's Health Sector 2022.

[27] Source: 2022 Bulletin on China's Urban Construction Status.

[28] Source: Report on Environmental Conditions and Environmental Protection Goals Completion for 2022 by the State Council.

[29] Source: Statistical Monitoring Report on the Outline for the Development of Chinese Children (2021–2030) 2022.

conservation (14.9%), and other specialized projects (10.7%). China has built 95,296 reservoirs with a total storage capacity of 988.7 billion cubic meters, and has completed 252,000 kilometers of standard-compliant levees, achieving a levee compliance rate of 76.1%. These levees protect 640 million people along rivers and streams[30].

II. Institutional Arrangements Related to Climate Change Adaptation

The Chinese government has taken proactive steps to gradually establish and improve institutional structures for climate change adaptation. The MEE, as the leading department for adaptation work, is responsible for organizing the formulation of major strategies, plans, and policies for climate adaptation. Alongside other departments, it co-leads participation in international climate negotiations, oversees China's compliance with UNFCCC, strengthens information sharing and support, and promotes enhanced climate adaptation actions across various sectors and regions to boost China's resilience to climate change. The National Development and Reform Commission, Ministry of Science and Technology, Ministry of Finance, Ministry of Natural Resources, Ministry of Housing and Urban-Rural Development, Ministry of Transport, Ministry of Water Resources, Ministry of Agriculture and Rural Affairs, Ministry of Culture and Tourism, National Health Commission, Ministry of Emergency Management, People's Bank of China, Chinese Academy of Sciences, China Meteorological Administration, National Energy Administration, National Forestry and Grassland Administration, and the National Disease Control and Prevention Administration are responsible for advancing climate adaptation within their respective areas. Each province (autonomous region and municipality) in accordance with national requirements, has established provincial leadership teams responsible for coordinating climate adaptation actions within their jurisdictions, thereby forming a collaborative working mechanism led by environmental departments, supported by relevant departments, and with professional teams providing assistance.

Chapter 2 Climate Change Impacts, Vulnerability Assessment, and Loss and Damage Status

I. Climate Change Characteristics and Trends

(i) Characteristics of Climate Change

1. Characteristics of Surface Temperature Change

From 1901 to 2022, China's annual average surface temperature showed a significant upward trend, with a warming rate of 0.16°C per decade, exhibiting clear decadal fluctuations (Figure 3-2). From 1961 to 2022, the annual average surface temperature displayed a notable increase, with a warming rate of 0.30°C per decade. All eight regions[31] in China showed significant warming trends, with the Tibetan Plateau warming at the fastest rate, while the southern and southwestern regions experienced relatively slower warming. The annual average maximum

---

[30] Source: China Water Development Statistical Bulletin 2022.

[31] North China, Northeast China, East China, Central China, South China, Southwest China, Northwest China, and Qinghai-Tibet region.

and minimum temperatures in China increased at rates of 0.25°C per decade (Figure 3-3(a)) and 0.40°C per decade (Figure 3-3(b)), respectively.

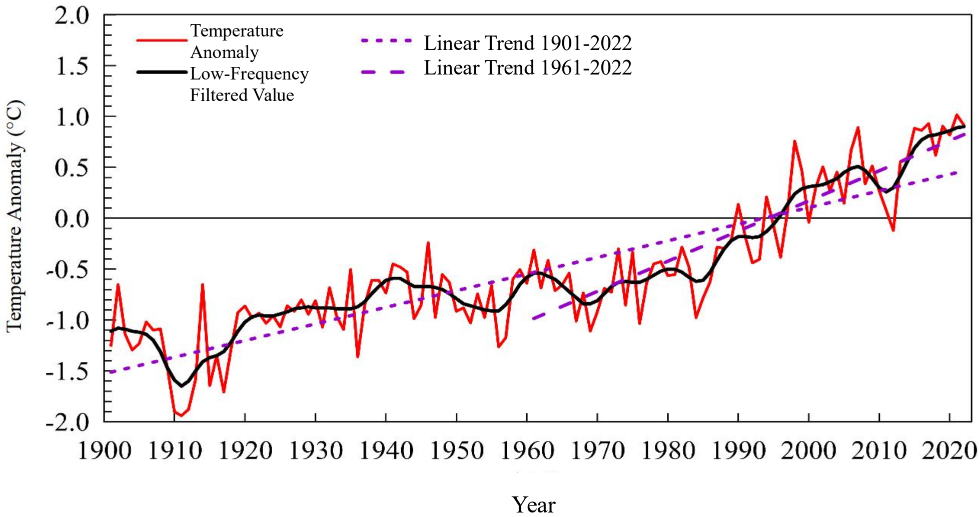


Figure 3-2 Annual Mean Surface Temperature Anomalies in China 1901–2022 (Baseline Period 1981–2010)

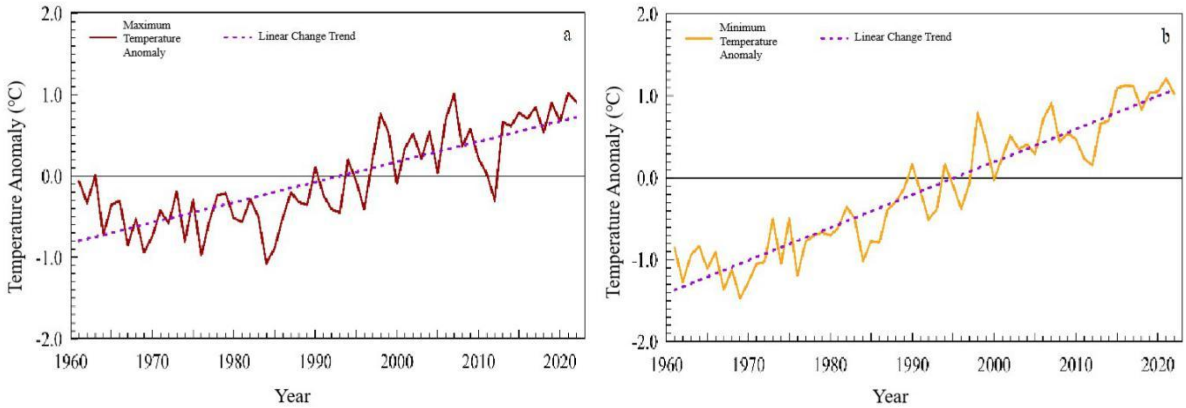


Figure 3-3 Annual Average Maximum and Minimum Temperature Anomalies in China 1961–2022

(a) Maximum Temperature, (b) Minimum Temperature

2. Characteristics of Precipitation Change

From 1901 to 2022, there was no significant trend in China's average annual precipitation, but there have been notable decadal oscillations on a 20-30-year scale. From 1961 to 2022, China's average annual precipitation showed an increasing trend, with an average rate of increase of 4.9 mm (0.8%) per decade, along with evident decadal variations (Figure 3-4). During the 1990s, precipitation was generally above average in China, while in the 2010s, it was generally below average. Since 2012, overall precipitation has increased. The trends in average annual precipitation have varied across China's eight regions. The Tibetan Plateau experienced a significant increase in average annual precipitation, while the southwestern region showed an overall decreasing trend. No clear linear trend was observed for average annual precipitation in northern, northeastern, eastern, central, southern, and northwestern regions, although there were decadal fluctuations. The annual number of precipitation days in

China showed a significant downward trend, with an average decrease of 1.9 days per decade (Figure 3-5(a)). The number of heavy rainfall station days (daily precipitation ≥50 mm) in China showed an increasing trend, with an average increase of 4.2% per decade (Figure 3-5(b)).

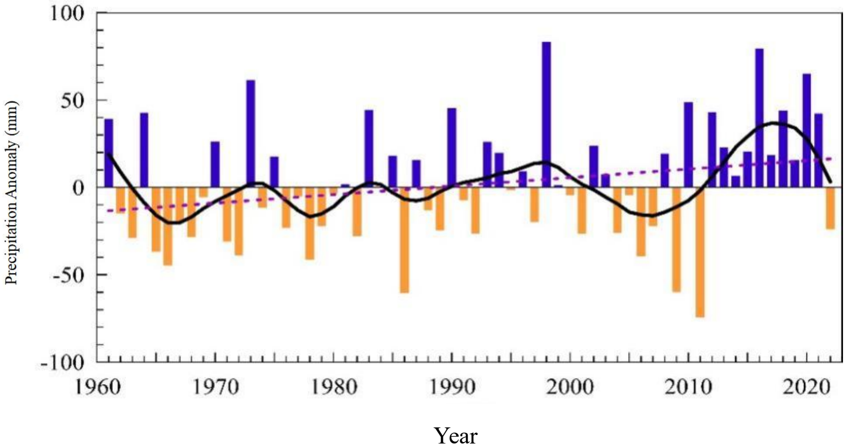


Figure 3-4 Annual Average Precipitation Anomalies in China 1961–2022

(Dashed Line Indicates Linear Trend Line)

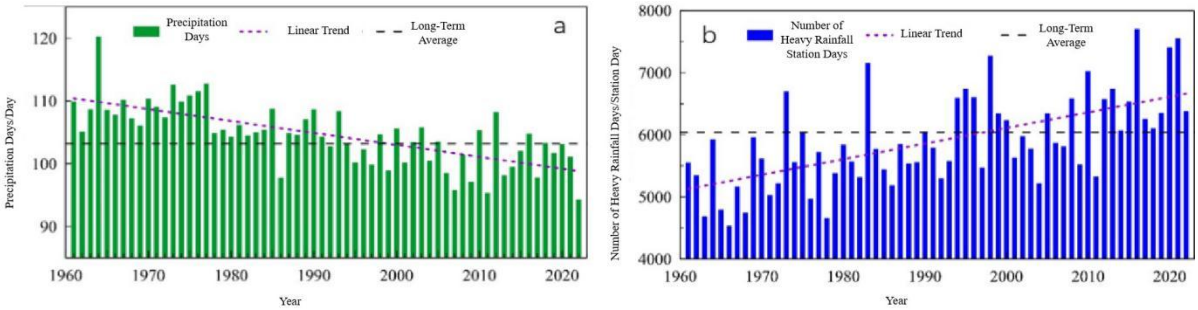


Figure 3-5 Annual Average Precipitation Days and Annual Heavy Rainfall Station Days in China 1961–2022

(a) Annual Precipitation Days, (b) Annual Heavy Rainfall Station Days

3. Characteristics of Other Variables

From 1961 to 2022, average wind speed showed an overall decreasing trend, with an average decrease of 0.14 meters per second per decade. The annual average sunshine hours displayed a significant decreasing trend, with an average decrease of 24.2 hours per decade. The annual accumulated temperature above 10°C showed a marked increasing trend, with an average increase of 64.5°C per decade.

(ii) Future Trends in Climate Change

1. Temperature

According to model simulations from the sixth phase of the Coupled Model Intercomparison Project (CMIP6), China’s average annual temperature is expected to continue rising. Compared to 1995–2014, under the Shared Socioeconomic Pathways (SSP) 1-2.6 and SSP5-

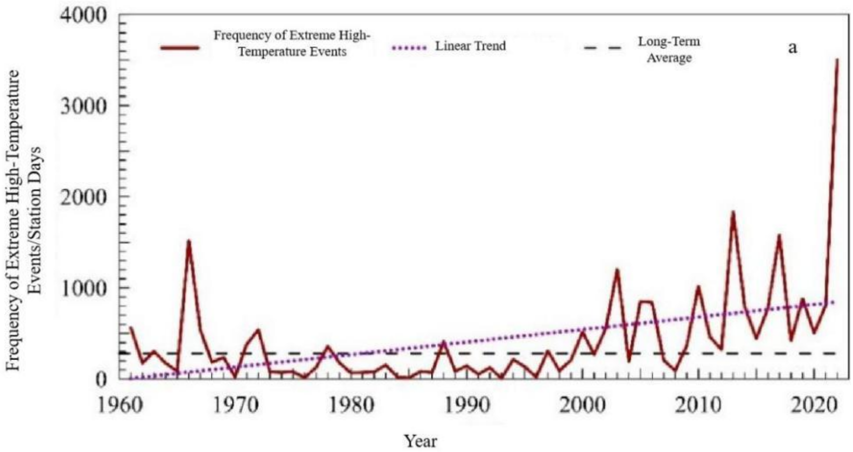
8.5 scenarios, annual average temperatures are projected to increase by 1.6°C (0.9°C–2.2°C) and 5.3°C (3.5°C–7.1°C), respectively, by the end of the 21st century. Temperature increases are expected to be more pronounced in the northeast, northwest, and Tibetan Plateau regions.

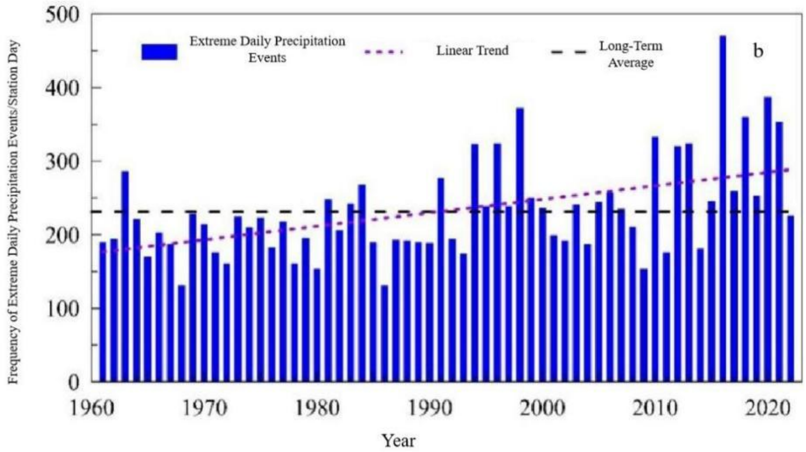
2. Precipitation

Results from the sixth phase of the global climate model comparison project indicate that average annual precipitation in China is generally expected to increase in the future. Compared to 1995–2014, under the SSP5-8.5 emissions scenario, average precipitation is projected to increase by 8% (2%–13%) in the mid-21st century and by 17% (8%–27%) in the late 21st century. Precipitation increases of more than 25% are expected in northern China, Inner Mongolia, eastern northwest China, and the Tibetan Plateau, while areas south of the Yangtze River are expected to see an increase of about 10%.

(iii) Characteristics and Trends of Extreme Weather and Climate Events

From 1961 to 2022, the frequency of extreme high-temperature events in China showed a significant upward trend, with distinct periodic changes. Since the late 1990s, the frequency of such events has been notably high (Figure 3-6(a)). The frequency of extreme daily precipitation events also increased (Figure 3-6(b)). Regional drought events exhibited clear decadal variation, with higher frequencies observed from the late 1970s to the 1980s, lower frequencies in the 1990s, higher frequencies from 2003 to 2008, and an overall decline since 2009 (Figure 3-6(c)).





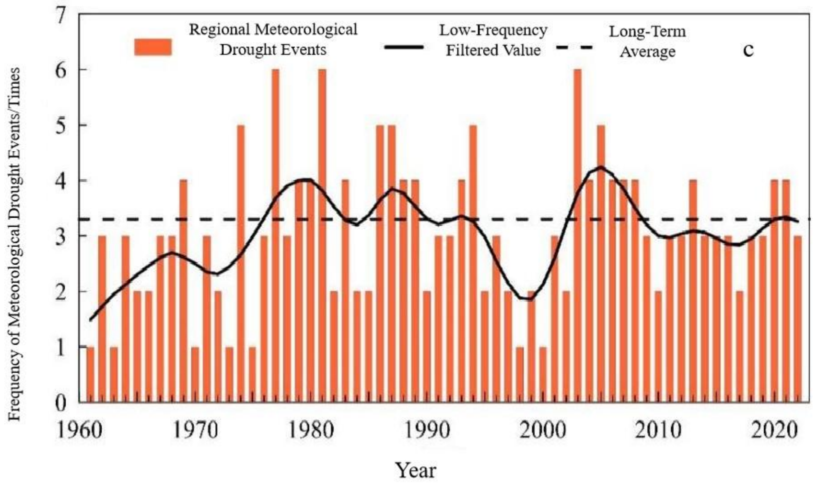


Figure 3-6: Frequency and Trends of Extreme Weather Events and Climate in China 1961–2022

(a) Extreme High-Temperature Events, (b) Extreme Daily Precipitation Events, (c) Regional Meteorological Drought Events

II. Climate Change Impacts and Vulnerability Assessment of Natural Ecosystems[32]

(i) Climate Change Impacts on and Vulnerability of Water Resources

Water resources are one of the areas most directly and sensitively affected by climate change. Climate change has intensified the spatial and temporal imbalance in the distribution of water resources, increased the frequency of extreme water-related events, and, along with rising temperatures and increased evaporation, has overall increased the vulnerability of water resource systems, raising risks for their development and utilization.

1. Observed Impacts

The total amount of water resources in China has remained generally stable. Hydrological patterns and water cycle processes in certain river basins and regions across China have shown varying degrees of change, although the basic characteristics of water distribution in terms of summer floods, winter droughts, water scarcity in the north, and abundance in the south remain unchanged. Over the past 60 years, the overall observed runoff of major rivers has shown a declining trend, with different characteristics across various river basins. Northern rivers, such as the Liao River, Songhua River, Yellow River and Hai River, have seen a general trend of decreasing runoff, whereas southern rivers, such as those in the Yangtze River Basin, the Pearl River Basin and Southeastern rivers, have not shown significant changes in runoff patterns over the years.

Surface water resources have shown different trends across various regions and periods over the past 60 years. In terms of regions, surface water resources in areas such as the Songhua River, Yangtze River, Pearl River and Southeastern rivers have seen an overall

[32] The observed impacts and evaluation results for future potential impacts are sourced from publicly available official data, as well as published literature and publications that have undergone peer review.

increasing trend, while the Liao River, Hai River, Yellow River, Huai River and Southwestern rivers have seen a decreasing trend. The rate of increase or decrease in regional water resources has varied in different time periods. For example, compared to 1956 to 1979, surface water resources in the Yangtze River Basin increased by 7.1% and 0.1% from 1980 to 2000 and 2001 to 2018, respectively, while those in the Yellow River Basin decreased by 9.3% and 14.0% over the same periods.

Groundwater resources have generally remained stable. Between 2001 and 2016, China's groundwater resources saw a slight decline compared to 1956–1979 and 1980–2000, with noticeable regional variations. In northern regions, the groundwater resources of the Northwestern rivers, Songhua River, and Huai River areas showed some growth, while those in the Hai River, Liao River, and Yellow River regions experienced slight declines.

2. Future Potential Impacts

Under a 2.0°C warming scenario, it is projected that future runoff in 14 out of 19 river basins in China will increase due to sustained increases in precipitation. Compared to 1971–2000, five sites in cold, high-altitude areas may experience decreases in future runoff, with evapotranspiration increasing significantly by 10%–20%. Annual average runoff in the headwaters of the Yangtze and Yellow Rivers is likely to continue decreasing, mainly due to significant temperature increases. By the mid-21st century, the vulnerability of water resource systems will increase overall, and areas classified as moderately vulnerable or higher will expand significantly. The suddenness, extremeness, and irregularity of water-related disasters are expected to become more pronounced, and new issues such as water scarcity, ecological water damage, and water pollution will become increasingly urgent.

(ii) Climate Change Impacts on and Vulnerability of Terrestrial Ecosystems

Climate change impacts on China's terrestrial ecosystems vary significantly across regions, with negative effects outweighing positive effects overall. Forest distribution is shifting northward, productivity is increasing, the growing season is lengthening; forest areas in the north are shrinking, while tropical rainforest areas are expanding; and fire and pest risks are intensifying. Grassland productivity varies by region, with vulnerability increasing; wetland area is expanding in the Qinghai-Tibet Plateau, while wetlands are severely degrading in northeast China. Desertification is expanding, with structural and functional changes in desert ecosystems. The distribution range of wild species are shifting, habitats or suitable ranges are decreasing, and climate change risks to endangered and rare species are increasing.

1. Observed Impacts

Climate change has impacted forest phenology, distribution, composition, productivity, as well as forest fire and pest occurrences. Over the past 60 years, the start of the forest vegetation growing season has generally advanced, by an average of 2.55 days per decade, while the end has generally been delayed by an average of 1.98 days per decade. Climate change has led to an increase in the suitable distribution area of tropical rainforest species, while the suitable distribution area of subtropical evergreen species has decreased. The southern boundary of northern deciduous coniferous species has shifted northward, with a reduction in distribution area. The distribution range of needle- and broad-leaved tree species in Northeast China has shifted northward. Net primary productivity (NPP) has significantly increased in areas such as the eastern edges of Northeast China, southeastern Shaanxi, southern Yunnan, and eastern Guangxi. Since 2000, increased precipitation in northern China has led to improved vegetation quality in the Three-North Shelterbelt region. Climate warming will increase the risk of forest fires. Warming also supports insect overwintering, which exacerbates pest severity, and high-altitude forest areas face a heightened risk of pest outbreaks.

Climate change has notably effected phenology, distribution, and productivity of grasslands. Grassland plant green-up has advanced slightly, yellowing has been delayed, and the growing season has lengthened. Alpine meadows on the Qinghai-Tibet Plateau are shifting northward, with species diversity and community stability decreasing in alpine grasslands. The productivity of alpine grasslands on the Qinghai-Tibet Plateau and southern grasslands is significantly increasing, while typical steppe and desert steppe productivity is decreasing. Increased precipitation in western grassland regions has had variable effects on forage yield and livestock carrying capacity, with southwestern Xinjiang and eastern Tibet experiencing the greatest increases, while productivity has declined in northern and eastern Xinjiang and southern Qinghai.

Climate change affects the distribution and ecological functions of wetlands. From 1990 to 2021, the total area of lakes on the Qinghai-Tibet Plateau increased by 10,689 square kilometers, and the total number of lakes increased by 423. Rising temperatures have led to glacier melting and permafrost thawing, which was the primary driver of lake expansion in the endorheic basin of the Qinghai-Tibet Plateau. Marsh wetlands on the Qinghai-Tibet Plateau have undergone severe degradation. Between 1970 and 2010, freshwater marshes, salt marshes, and marshy meadows decreased by 46.6%, 53.9%, and 15.6%, respectively, and between 2008 and 2016, the riverine wetland area on the Plateau increased by 3.5%. From 1980 to 2015, northeast China experienced severe marsh wetland degradation, with a 30.8% decrease in wetland area and a 69.8% increase in patchiness. Climate warming threatens biodiversity within wetland systems, leading to declines in population sizes.

Climate change affects the structure and function of desert ecosystems. Warming has led to increased evaporation, intensifying water scarcity, constrained vegetation growth, and decreasing NPP in desert ecosystems. Climate change exacerbates soil erosion in desert ecosystems, further accelerating land degradation and desertification. Persistent warming and reduced precipitation alter the composition of mosses, lichens and cyanobacteria communities in deserts, reducing moss abundance, cover and biomass, while increasing infiltration and evaporation in biological soil crusts, heightening desert ecosystem vulnerability.

Under the combined impacts of human activity and climate change, the distribution ranges of wild flora and fauna are shifting. More than 100 reptile species, 80~100 amphibian species, and 400~600 bird species have shifted northward and westward, and the distribution range of over 120~200 mammalian species has changed. Climate change significantly affects the distribution ranges of wild plants, primarily causing northward migrations, with mosses being the most responsive to climate change. The ranges of over 1,000 angiosperm species have shifted, while ferns and gymnosperms have been less affected.

2. Future Potential Impacts

Climate change will further impact the geographic distribution, structure and function of forest ecosystems. Under RCP2.6, RCP4.5, RCP6.0, and RCP8.5[33] scenarios, the end date of the vegetation growing season in China is projected to be delayed by 8 days, 13.4 days, 15.6 days, and 24.2 days, respectively, by the end of the 21st century. Future warming will support the migration of forests to higher elevations and latitudes. Northern and temperate deciduous forests, temperate evergreen coniferous forests, and tropical forest belts will migrate northward, with the area of tropical and warm temperate forests expanding while the area of temperate and northern forests may decrease. Climate change will alter forest NPP. Multi-model ensemble assessments indicate that in an RCP2.6 scenario, the forest area with reduced NPP will decrease, while under RCP8.5, forest areas with reduced NPP are expected to increase after 2050. Plantations are particularly susceptible to extreme events and pest infestations, leading to lower productivity and decreased ecological benefits. Under all RCP scenarios, the probability of forest fires in China from 2021 to 2050 is projected to increase, with North China showing the most significant rise.

Future climate change will alter the distribution and productivity of China's grassland ecosystems. Rising temperatures will cause the alpine grassland boundary to shift to higher elevations. Due to warming, the area of alpine meadows on the Tibetan Plateau will decrease while the alpine steppe area will increase, and the suitable area for temperate grasslands will shrink. Compared to 1987–2016, total biomass in grasslands is projected to undergo a significant decline in both RCP4.5 and RCP8.5 scenarios. NPP in alpine grassland ecosystems will decrease. In most of western Inner Mongolia, the NPP of grasslands will decline, while in the northeast, meadow and typical grassland, NPP will increase. Soil carbon stocks in alpine meadow, alpine steppe, temperate meadow steppe, typical steppe, alpine desert and temperate desert are all expected to decline.

Future climate change is expected to lead to a reduction in China's wetland area and degradation of its functions. In the RCP8.5 scenario, climate suitability for wetlands in Northeast China will shrink significantly, with severe wetland degradation anticipated. Approximately 30% of the wetlands in the Greater Khingan Range will vanish by 2050 and 60% by 2100. Changes in the distribution of alpine wetlands on the Tibetan Plateau and a reduction in its area are projected due to future climate change scenarios, with key wetland functions (such as carbon sequestration, water retention and habitat provision) facing risk.

Climate change will expand the area of desertified land. Under the RCP4.5 scenario, the area of desertified land in China's arid regions is expected to continue expanding, especially in western regions where desertification will intensify, but under RCP2.6 and RCP8.5 scenarios the desertified area may slightly decrease.

[33] RCP refers to Representative Concentration Pathways.

Climate change will alter the behavior, migration timing and routes of wildlife, leading to habitat shrinkage for some endangered bird species, reduced suitable habitat areas, and species extinctions. Under future climate change, China's wildlife ranges will shrink significantly, habitats will degrade, and 5–20% of species will face a high risk of endangerment or extinction. The distribution range of moss species will decrease, their habitats are projected to degrade, and some of them will migrate to the west. ferns will migrate to higher elevations and latitudes, while the suitable habitat for gymnosperms will decrease and fragment. Most angiosperms will migrate westward with a reduced range of suitable habitats, and 9–34% of wild plant species will face high endangerment risk. Additionally, climate change, particularly rising temperatures, will cause harmful algal blooms to increase in scale and frequency, posing an increased threat to production of other aquatic plants.

(iii) Climate Change Impacts on and Vulnerability of Coastal ocean and Areas

In the context of continued ocean warming and increasing climate hazard factors, sea level rise in coastal China seas is evident, and the exposure of coastal ecosystems and economic and social assets in coastal areas is increasing, along with climate vulnerability and comprehensive risk.

1. Observed Impacts

Sea surface temperature (SST) and sea level in coastal China sea have risen significantly. Since the 1960s, climate warming has caused notable increases in SST and sea level in coastal China seas, particularly accelerating sea level rise in the 21st century. The annual average SST increased by 1.02±0.19°C from 1960 to 2022, far above the global ocean average, with especially pronounced warming in winter. The Bohai Sea, Yellow Sea and East China Sea (collectively referred to as the East China Seas (ECS)) exhibited SST rises of 1.95±0.38°C and 1.26±0.32°C in winter and summer, respectively, with warming rates reaching 0.31°C/decade and 0.20°C/decade, 2 to 3 times the global ocean average during the same period (Figure 3-7). The South China Sea (SCS) experienced relatively lower annual SST increase rates of 0.19°C/decade in winter and 0.14°C/decade in summer. The sea level changes along China's coast have shown an accelerating upward trend. From 1980 to 2022, China's coastal sea level rose at a rate of 3.5 mm/year, and from 1993 to 2022, the rate increased to 4.0 mm/year from 1993 to 2022, exceeding the global ocean average for the same period[34].

[34] China Sea Level Bulletin 2022.

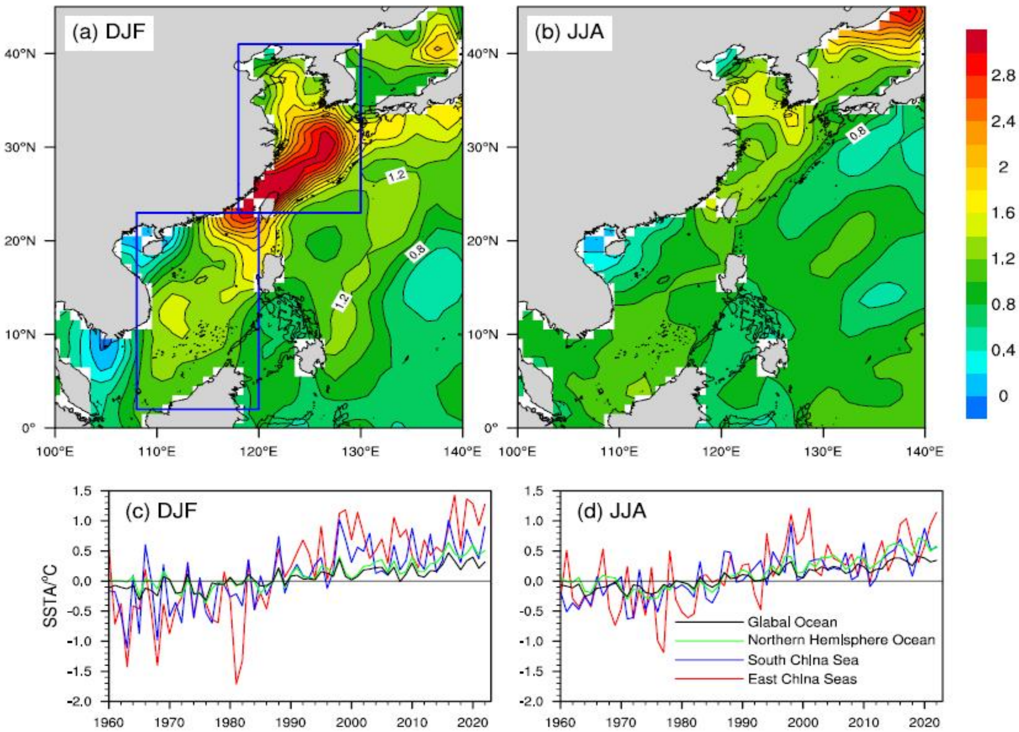


Figure 3-7 Spatial distribution and time series anomaly of SST rise in the East China Seas (Bohai Sea, Yellow Sea, East China Sea), and South China Sea during the winter (a and c) and summer (b and d) from 1960−2022 [35] (unit: °C)

Rapid, significant increases in ocean temperatures have heightened the frequency and intensity of marine heatwaves. From 1982 to 2022, the frequency and intensity of marine heatwaves (MHWs) in China's coastal waters showed a marked upward trend, with the northern SCS (particularly Beibu Gulf in Guangxi) and the waters adjacent to the Yangtze River Estuary being the most frequently affected, averaging over 25 MHW days per year. Marine heatwaves have severely impacted marine organisms, ecosystems and aquaculture in the coastal China sea. For instance, an extreme MHW event in August 2018 in the Yellow and Bohai Seas caused mass mortality of cultured sea cucumbers, resulting in economic losses of around RMB 15 billion.

Ocean warming has exacerbated the outbreak of marine ecological disasters, with serious declines in coastal fishery resources. Since 1980, the warming seas have intensified nutrient imbalance, ocean acidification and hypoxia zones, particularly in the Yangtze and Pearl River estuaries. Ocean warming has altered marine phenology, affecting biological growth and development cycles, shifting species composition and the geographic distribution of species, and increasing the frequency of marine ecological disasters, such as red tides, green tides, and jellyfish blooms. Marine ecosystem vulnerability has markedly increased, with decadal increases in red tides in the Yangtze Estuary and adjacent waters. MHWs and

[35] SST (Sea Surface Temperature): Panel a and c represent winter (DJF, December to February) from 1960 to 2022, while panel b and d represent summer (JJA, June to August). Adapted from Cai, R., Tan, H., Kontoyiannis, H., Robust Surface Warming in Offshore China Seas and Its Relationship to the East Asian Monsoon Wind Field and Ocean Forcing on Interdecadal Time Scales, Journal of Climate, 2017, 30(22): 8987–9005. Using HadISST data, updated to 2022.

human activities have caused severe degradation of coral reefs in the SCS, with coral reef cover around islands falling from 60% to 20%, leaving the coral reef ecosystem highly vulnerable.

Rising sea levels along China's coast have exacerbated coastal erosion, seawater intrusion, and saltwater intrusion in estuarine areas. Since the 1990s, approximately 22% of China's coastline has retreated landward, with notable retreat along the Yellow River Delta coastline. Coastal erosion has severely impacted some areas of China's coast. Over the past 30 years, coastal mangrove ecosystems in Guangxi's Fangchenggang have experienced severe erosion along a length of 4 kilometers, with maximum erosion distances reaching 122 meters. Saltwater intrusion in the Pearl River Estuary has seriously affected the quality of drinking water in estuarine areas. Coastal mangrove ecosystems in China also face threats from rapid sea level rise and increased typhoon frequency.

2. Future Potential Impacts

The coastal China seas are projected to warm significantly, and the sea levels will continue to rise. It is estimated that by the end of the 21st century, under the high emissions of GHG scenario (RCP8.5), SST in the ECS and SCS will exceed 3.24°C and 2.92°C, respectively, compared to the level of 1980–2005, probably among the world's most significantly warming ocean regions (Table 3-1). The intensity and duration of MHWs in coastal China seas are expected to increase significantly, posing serious threats to marine organisms and ecosystems, and exacerbating disaster risks related to sea level rise. By 2050, most of areas in Shanghai will be situated below the high tide line under the RCP8.5 scenario. By 2100, the current once-in-a-century extreme water levels in multiple coastal regions of China are projected to become events occurring every few years and even less than once a year, thereby further intensifying the risk of disasters.

Ocean acidification, hypoxia, and nutrient imbalance will lead to further deterioration of marine ecosystems, with more pronounced shifts in species composition and geographic distribution. Harmful ecological events such as red tides, green tides, and large-scale jellyfish blooms will increase, with some coastal wetlands and mangroves in estuarine areas being submerged under the RCP8.5 scenario, while warm-water coral reefs will vanish on a large scale. Major fishery resources, such as small yellow croaker and anchovies in the ECS, will shift further north; cold-water fishery resources, such as walleye pollock in the Yellow Sea, will decline, and ecosystem health in the Yangtze and Yellow River estuaries will decrease significantly.

Table 3-1 Projected Average SST Changes in the Bohai Sea, Yellow Sea, East China Sea, and South China Sea (relative to 1980–2005, unit: °C[36])

Region	RCP2.6			RCP4.5			RCP8.5		
	2020–2029	2050–2059	2090–2099	2020–2029	2050–2059	2090–2099	2020–2029	2050–2059	2090–2099
Bohai Sea, Yellow Sea, East China Sea	0.63±0.41	0.71±0.30	0.74±0.49	1.01±0.49	1.36±0.51	1.75±0.65	1.07±0.62	1.73±0.72	3.24±1.23
South China Sea	0.58±0.35	0.65±0.41	0.69±0.50	0.87±0.38	1.16±0.40	1.51±0.45	0.89±0.42	1.47±0.44	2.92±0.77
Global Ocean	0.53±0.45	0.60±0.51	0.62±0.53	0.78±0.51	1.13±0.54	1.47±0.62	0.87±0.63	1.35±0.77	2.89±1.32

Future landing typhoons are expected to increase, posing a threat to coastal areas and critical infrastructure. Under various GHG emission scenarios (RCP2.6, RCP4.5 and RCP8.5), strong typhoons making landfall on the Chinese mainland is projected to increase, to intensify, and to shift further northward, likely posing additional threats to critical coastal infrastructure, including nuclear power plants, coastal airports, port facilities, flood control and drainage systems, and oil platforms. Changes in extreme coastal water levels in the future may pose a more severe threat to coastal areas.

III. Climate Change Impacts and Vulnerability Assessment of Socioeconomic Systems[37]

(i) Agriculture and Food Security

Climate change has significantly affected cropping systems, crop variety distributions, growth, yield, quality, pest occurrence and spread, as well as agricultural meteorological disasters, through changes in temperature, precipitation, and sunshine hours. Future climate change will further increase the vulnerability of agricultural systems, exacerbating climate risks.

1. Observed Impacts

Agricultural climate resources, especially thermal resources, have significantly increased, leading to substantial changes in cropping systems and crop variety distributions, with multiple cropping systems shifting northward and multi-cropping indexes rising. In the past 60 years (1960–2020), China's thermal resources have significantly increased, with active accumulated temperature days above 10°C rising at an average rate of 56°C days per decade, with greater increases observed in northern regions than in southern regions. Warming has led to longer available period for crop growing, particularly in the high latitudes of northeastern China, where higher annual average

[36] Tan H, Cai R, Huo Y, et al. Projections of changes in the marine environment in coastal China seas over the 21st century based on CMIP5 models[J]. Journal of Oceanology and Limnology, 2020, 38(6): 1676-1691

[37] The observed impacts and evaluation results for future potential impacts are sourced from publicly available official data, as well as published literature and publications that have undergone peer review.

temperature, increased accumulation of active temperatures, shorter frost periods, and faster crop growth rate have shortened crop growth periods. Rising temperatures have lengthened the crop growing season while shortening the growth period, moving further northward of the northern planting boundary of rice in Northeast China, winter wheat in North and Northwest China, and corn in Northeast and Northwest China, extending multiple cropping boundaries to higher latitudes and altitudes, and increasing multiple cropping areas and cropping indexes. The boundaries for medium and medium-late maturing crop varieties have shifted northward expanding in area. Heat- and drought-tolerant crops have expanded in area, with optimal planting periods occurring earlier. Early- and medium-maturing varieties have gradually transitioned to late-maturing types, and strongly cold-tolerant crops are gradually replaced by cold-tolerant and weakly cold-tolerant crops. From 1960 to 2020, effective precipitation during the crop growing period did not show a significant trend, while total radiation decreased, reducing sunshine hours. From 1981 to 2007, annual sunshine hours during the crop growing season decreased by 125.7 hours compared to 1961–1980, resulting in a decreased photosynthesis for some crops.

Pest and disease damage has shown a significant increasing trend, making control efforts more challenging, with warmer winters causing a structural shift in pest and disease species. Warming has increased overwintering pest populations, advancing their first appearance, migration and outbreak periods, and extending the duration of infestations. Major crop pest species and populations have shown increased growth and reproductive cycles, with increased severity of damage. The northern boundary of pest and disease occurrence has shifted northward, with the upper elevation limit rising and damage zones expanding. In warm winter years, the northern boundary of rice planthopper overwintering in China can shift 2–4 latitudinal degrees northward. Warmer winters have led to earlier and more severe outbreaks of wheat stripe rust and fusarium head blight, with the onset of occurrence shifting from March to February. Previous researches indicate that for each 1°C rise in average annual temperature, the area affected by disease increases by 60.944 million hectares, and for each 100-hour reduction in average annual sunshine, the affected area rises by 34.188 million hectares. From 1970 to 2016, the rate of crop pest and disease occurrence rapidly increased, with climate warming contributing to over 1/5th of the increase in pest and disease incidence. Annual growth rates of pest and disease occurrences in staple grains, including wheat, maize and rice, have notably increased, with the damage degree rising by 10%–20% under warming climate.

Agricultural meteorological disasters have intensified, characterized by increased frequency and severity of drought, flooding and high-temperature disasters, with more frequent compound disasters. In the past 50 years (1961–2014), both the scope and severity of agricultural drought disaster have significantly risen, with comprehensive loss rates increasing by an average of 0.5% per decade. Agricultural flooding rates caused by extreme precipitation events have generally trended upwards. Summer heatwaves have intensified crop heat stress, with the most severe impacts observed in summer maize, as well as increasing impacts on other crops such as rice, while high temperatures reduce photosynthesis efficiency during critical stages such as the heading and flowering periods. Climate change has led to the increase of the frequency and intensity of dry-hot wind disaster, the expansion of the occurrence area, and the heavier damage to grain-filling and yield in wheat.. The frequency of low-temperature freeze damage has significantly declined, but warmer winters have shortened overwintering periods for crops, such as wheat and rapeseed, causing earlier heading and bolting, making them more vulnerable to late-spring frosts and increasing cold-damage risk. Additionally, the frequent and simultaneous occurrence of agricultural meteorological disasters has increased the risk of compound disasters.

Climate change effects on major staple crops in China vary by crop type and region, with predominantly negative impacts. Higher temperatures in Northeast China contribute to yield increasing of corn, rice, and soybeans; in the Huang-Huai-Hai region, warming and drying trends limit yield increase for wheat and maize; in South China, rising temperatures, high frequent heavy rains, and intensified pest and disease issues affect rice yield improvement and quality; and in the arid and semi-arid areas of Northwest China, the agricultural water use is declining and the crop productivity is inhibited. Long-term trials across multiple sites indicate that for each 1°C increase in average temperature during growing season, corn yields decline by 0.83 tons per hectare, and for each 100 MJ reduction in cumulative photosynthetically active radiation, corn yields decrease by 0.85 tons per hectare. For each 1°C rise in temperature, early rice yields drop by 8%, with no negative impact observed on late rice yields. From 1961 to 2010, rising average temperatures during crop growing seasons have led to a 5.5% reduction in nationwide winter wheat yields. From 1981 to 2009, reduced radiation levels caused yield declines of 1.5%–8.7% in rice-wheat rotation systems.

2. Potential Future Impacts

The average temperature during crop growth seasons is expected to increase, shortening the growth periods of crops, and causing the cultivation boundaries of most crops to shift northward. Compared to the 2000s, the average temperature during the rice growing season in China is projected to increase by 1.7°C to 3.4°C in the 2050s and by 2.3°C to 4.1°C in the 2070s. In a scenario where temperatures increase by 2.0°C, the growth period of corn in China is projected to shorten by 10.8% to 22.5%, and that of wheat by 6.9%; under the same warming scenario, rice growth period would shorten by 4.5 to 18 days, and wheat by 8 to 18 days. Climate warming is expected to cause China's multi-cropping boundary to continue to expand to high latitudes and high altitudes. In a medium GHG emission scenario (A1B), over the next 20-30 years, the boundaries for double-cropping and triple-cropping areas will likely shift northward to varying extents.

The frequency, area and severity of pest and disease outbreaks affecting most crops in China are anticipated to increase, leading to higher pesticide usage. A warmer climate is conducive to the overwintering and reproduction of crop pathogens, increasing risks in previously cooler climate zones. The northern migration times of pests in spring are expected to start earlier, with fall migrations southward occurring later, and the geographic range of diseases will be expanded. The risk of outbreaks and disasters from warm-temperature and cold-sensitive pests and diseases will significantly increase. The safe overwintering boundary for crop pests will shift northward, and the number of generations of pests will rise. The area of highly suitable and moderately suitable habitats for fruit tree pests will increase. Rising temperatures and increased precipitation will accelerate the volatilization, degradation and loss of pesticide ingredients. With climate factors compounding, future pesticide usage is projected to rise significantly.

Agricultural meteorological disasters and extreme climate events will become more frequent, increasing food yield instability. Climate change and extreme climate events will lead to fluctuations in grain production in China with extreme climate events occurring more frequently. Rising temperatures and uneven precipitation will heighten the risk of heat stress, droughts and floods, which will make rice, corn, soybeans, rapeseed and cotton yields in China more unstable and vulnerable. Between 2021 and 2070, under various RCP scenarios, heat stress events will increase significantly, with the largest increase under the RCP8.5 scenario. In particular, high-temperature stress will become more frequent during the heading, flowering and maturation stages of rice in the Yangtze River basin.

The fertilization effect of CO_2 cannot fully offset the negative impacts of climate change on crop yields. Under warming scenarios, grain protein content will decrease. Without considering the CO_2 fertilization effect, crop yields are projected to decline in the 2020s, 2050s, and 2090s. Even when considering this effect, CO_2 fertilization cannot counteract the yield reduction caused by climate change after the 2050s. Under a 2.0°C warming scenario, the yields of single cropping rice, early rice and late rice are projected to decrease by 5.3%, 4.3% and 5.8%, respectively. Wheat yields are expected to increase by 8.6%, while corn yields will decrease by 1.7%. Although future increases in atmospheric CO_2 concentration will help counterbalance some adverse effects of rising temperatures, it will reduce the protein content in grain crops, affecting their nutritional quality. Studies indicate that once CO_2 concentrations reach 550 ppm, the protein content of wheat, corn, rice and soybeans will decrease by approximately 5.0% to 7.8%.

(ii) Health and Public Health

Climate change has increasingly complicated human living conditions and is severely threatening public health and public safety in China. As a populous country undergoing a rapid aging process, China is situated in a region highly affected by climate change. Climate change can impact public health through various complex pathways, causing injuries and increasing risks and burdens of both infectious and non- communicable chronic diseases.

1. Observed Impacts

High temperatures and heatwaves induced by climate change lead to more heat-related deaths. The number of heatwave-related deaths in China rose from 3,680 in the 1980s to 15,500 in the 2010s, peaking at a record high in 2022, with a clear upward and accelerating trend. Between 2010 and 2019, the rate of increase in heatwave-related deaths was 2.8 times that between 1980 and 2009. The most vulnerable groups to heatwaves include the elderly, individuals with chronic underlying health conditions, women, outdoor workers, and low-income populations.

Climate change is increasing the epidemic risk of vector-borne diseases. Compared to 1986–2005, the climatic suitability index for dengue virus transmission increased by 68% in

2021, expanding the area suitable for its spread. Within a certain temperature range, every 1°C increase in maximum temperature is associated with to a 11.9% increase in dengue incidence, a 15.8% increase in malaria incidence, and a 1.6% increase in the incidence of hemorrhagic fever with renal syndrome.

Climate change also elevates the risk of chronic non-communicable diseases. A study of 272 major cities in China found that approximately 14.33% of non-accidental mortality was related to suboptimal temperatures, with the highest mortality rates associated with moderate cold and moderate heat. In particular, temperature-related cardiovascular mortality accounted for about 17.48%, and respiratory disease mortality for approximately 10.57%. In cities with temperate and subtropical monsoon climates and high urbanization but limited centralized heating, the health risks and disease burdens associated with suboptimal temperatures were more pronounced. Other studies show that high temperatures and heatwaves significantly increase the risk of circulatory system diseases and their subtypes; they include ischemic heart disease, stroke, myocardial infarction and arrhythmias. Cold spells elevate mortality from ischemic heart disease, heart attack, ischemic stroke and hemorrhagic stroke. Between 1961 and 2020, heatwaves and cold spells caused health-related economic losses of about RMB 1.28 trillion and RMB 1.51 trillion, respectively. Research also indicates that suboptimal temperatures can negatively affect mental health, with older adults, women, those with lower education levels, and agricultural workers being particularly affected by high temperatures.

2. Future Potential Impacts

Under future climate scenarios, as extreme weather events increase in frequency and intensity in China, mortality risk will further rise. Compared to 1986–2005, the frequency of heatwaves in China will increase by 10.3, 5.2 and 2.6 times by the end of the 21st century under the RCP8.5, RCP4.5, and RCP2.6 scenarios, respectively. Under the high-emission RCP8.5 scenario, heatwave-related deaths in China are projected to continue rising, reaching an annual average of 72,259 by the end of the century. The projected increase in heatwave-related deaths in China will be driven mainly by rapidly rising temperatures, population growth and the degree of aging, with climate effects playing a primary role. Furthermore, the burden of heatwave-related deaths will display significant spatial heterogeneity, with nearly half of the deaths occurring in eastern and central China, covering urban clusters in the Shandong Peninsula, the North China Plain and the Yangtze River Delta.

Future climate change will also increase the risk of infectious disease outbreaks. The number of people in China exposed to vector-borne Aedes aegypti and Aedes albopictus mosquitoes is expected to rise significantly, with high-risk areas for dengue fever expanding further. Under the RCP2.6 and RCP8.5 climate scenarios, by 2100 dengue high-risk areas will encompass 277 counties (districts) with a population of 233 million and 456 counties (districts) with a population of 490 million, respectively. China is also likely to become a high-risk area for bacterial dysentery. Compared to 2014–2016, by the end of the 21st century, the attributable risk of bacterial dysentery is projected to increase by 20% in North China, 15% in Northeast China, 12% in Northwest China, and 11% in South China[38].

(iii) Infrastructure and Major Projects

Climate change has already affected the safe operation of infrastructure and major projects in China. Under future climate change scenarios, the risks will continue to increase, necessitating close attention to the adverse impacts of climate change. For instance, significant changes have been observed in the permafrost along the Qinghai-Tibet Railway, which may impact the stability of the railway's foundation. From 1996 to 2006, the average annual temperature of permafrost at a depth of 6.0 meters increased by approximately 0.43°C, with an average warming rate of 0.39°C per decade. Between 1996 and 2007, the average thickness of the active layer along the Qinghai-Tibet Railway increased by 46 cm, with an average rate of increase of 5.8 cm per year. If temperatures rise by 2.0°C after 2050, permafrost that is extremely unstable under high-temperatures will fully degrade into seasonal permafrost; and permafrost that is unstable under high-temperatures will mostly transform into extremely unstable permafrost. If temperatures rise by 2.6°C by 2050, highly unstable permafrost may transform into seasonal permafrost around 2030, and after 2050 some high-temperature unstable permafrost areas may also transition to seasonal permafrost.

IV. Loss and Damage Related to Climate Change Impacts

Climate change has already caused varying degrees of impact across different sectors, with related losses and damages continuously increasing, particularly in recent years as extreme weather and climate events have caused significant economic losses and casualties. In response, the Chinese government has taken proactive strategies, policies and actions to avoid, mitigate and address losses and damages associated with climate change impacts. See Chapter III of this part for more details.

1. Losses and Damages Caused by Meteorological Disasters

From 2020 to 2021, China experienced severe losses due to heavy rain and flooding. Regional and seasonal droughts were notable, although the damage caused was relatively less severe. Relatively fewer typhoons were generated or made landfall, resulting in minimal losses. There were numerous high-temperature days, with extreme temperatures particularly intense in the south. Strong convective weather showed concentrated spatial and temporal distribution with relatively minor losses, and low-temperature freezing damage and snow disasters were mild. In 2022, regional and seasonal droughts became pronounced, with continuous summer-autumn drought affecting the Yangtze River basin. Heavy rain occurred frequently, leading to severe flooding in South China, Northeast China and Northwest China, and flood situations emerged in the Pearl River and Song-Liao River basins. There was an abnormally low number of landfalling typhoons, but those that did occur had strong intensity and broad impact areas. There was a high number of high-temperature days, with eastern and central China experiencing the most intense heat wave since 1961, which also ended

[38] North China includes Beijing, Hebei Province, and Shanxi Province; Northeast China includes Heilongjiang Province, Jilin Province, and Liaoning Province; Northwest China includes Shaanxi Province, Gansu Province, Ningxia Hui Autonomous Region, Qinghai Province, and Xinjiang Uygur Autonomous Region; South China includes Guangdong Province, Guangxi Zhuang Autonomous Region, and Hainan Province.

unusually late. There were noticeably more cold wave events, with a period of continuous low temperatures, rain and snow in the south in February, and a severe cold wave from late November to early December that caused sharp temperature drops in many places. Strong convective weather events were relatively few but caused severe localized damage. The losses and damages caused by meteorological disasters and their secondary and derivative impacts nationwide from 2020 to 2022 are shown in Table 3-2.

Table 3-2 Losses and Damages Caused by Meteorological Disasters in China 2020–2022

Year	Crop Disaster Area (million hectares)		Population Affected		Direct Economic Loss (RMB billion)	Direct Economic Loss from Urban Meteorological Disasters (RMB billion)
	Disaster-Affected Area	Crop Area with Complete Loss	Population Affected (million)	Number of People Dead or Missing		
2020	19.958	2.706	138.142	483	368.09	235.17
2021	11.718	1.631	106.75	755	321.58	208.13
2022	12.063	1.351	111.656	279	214.73	155.65

2. Typical Extreme Weather and Climate Events and Their Losses and Damages

High Temperature Heatwaves. In 2020, 2021 and 2022, China experienced 3, 9 and 4 regional high-temperature events, respectively. The national average numbers of high-temperature days (daily maximum temperature ≥ 35°C) were 8.0, 9.1 and 14.3 days, exceeding the historical average by 1.1, 2.2 and 6.3 days, respectively. In 2022, eastern and central China experienced the most intense heatwave since 1961, adversely affecting agriculture and power supply, with electricity usage in many areas, such as Zhejiang and Shanghai, reaching historic highs. The national average exposure to heatwaves was 21 days (an increase of 15.6 days compared to 1986–2005), with approximately 50,900 heatwave-related deaths, more than double the number in 2021, along with increases in heatwave-related hospitalizations and emergency visits.

Heavy Rain and Flooding. In 2020, 2021 and 2022, China experienced 37, 36 and 38 regional heavy rain events, respectively, resulting in severe flood-related losses. In 2021, northern China experienced its second-highest rainfall since 1961, with particularly intense and extreme rain events during the flood season, leading to severe flood damage in areas such as Henan Province. Compared with the period 1986–2005, the population exposed to extreme rainfall events from 2000 to 2022 increased by 23.0%.

Box 3-1 Losses in the July 2021 Severe Rainfall Disaster in Henan Province[39]

From July 17 to July 23, 2021, Henan Province experienced an unprecedented severe rainfall event, mainly affecting Jiaozuo, Xinxiang, Hebi, Anyang and Zhengzhou. This extreme rainfall disaster led to serious urban flooding, river flooding, mountain torrents and

[39] "7.20" Major Rainstorm Disaster Investigation Report on the Zhengzhou, Henan Incident: https://www.mem.gov.cn/xw/bndt/202201/t20220121_407106.shtml.

landslides, causing significant casualties and property losses. A total of 14.786 million people in 150 counties (cities and districts) across Henan Province were affected, with 398 people dead or missing and direct economic losses amounting to RMB 120.06 billion.

On July 20, 2021, Zhengzhou recorded its highest daily rainfall, reaching 624.1 mm, nearly equal to the city's annual average rainfall (640.8 mm). The peak hourly rainfall was 201.9 mm, far exceeding the drainage capacity of the city. More than half of the city's underground spaces in residential areas and important public facilities were flooded, with widespread power, water and network outages. The death toll in Zhengzhou alone was 380, with direct economic losses amounting to RMB 40.9 billion.

Regional Droughts. From 2020 to 2021, meteorological droughts in China were lighter than usual, but there were noticeable regional and seasonal characteristics, significantly affecting provinces such as Liaoning, Inner Mongolia, Yunnan and Hebei. In 2022, drought impacts were more severe in China, with prominent regional and seasonal droughts. There were seasonal spring-summer droughts in areas like the Huang-Huai-Hai and northwest regions, and a prolonged summer-autumn drought across the Yangtze River basin, with broad coverage, long duration and severe intensity. Table 3-3 shows losses and damages caused by floods and droughts in China during 2020–2022.

Table 3-3 Losses and Damages Caused by Floods and Droughts in China 2020–2022

Disaster Type	Year	Affected Population (million)	Number of People Dead or Missing	Collapsed Houses (10,000 units)	Affected Crop Area (million hectares)	Direct Economic Loss (RMB billion)
Flooding	2020	78.68	279	9.0	7.20	268.6
	2021	59.01	590	15.2	4.76	245.9
	2022	33.85	171	3.0	3.41	128.9
Drought	2020	24.135	-	-	5.081	24.92
	2021	20.689	-	-	3.426	20.09
	2022	52.452	-	-	6.090	51.29

Chapter 3 Actions and Challenges in Adapting to Climate Change

I. Strategies and Goals for Climate Change Adaptation

(i) Integrating Climate Change Adaptation into the National Economic and Social Development Plans

China places high importance on climate change adaptation, implementing a proactive national strategy for addressing climate change by integrating adaptation and mitigation equally. It incorporates climate change adaptation concepts and requirements into medium- and long-term plans for national economic and social development.

The *Outline of the 12th Five-Year Plan for National Economic and Social Development of the People's Republic of China* included a dedicated chapter on "actively cope with global climate change" for the first time, stating in the section "increase adaptability to climate change" that a "We will formulate an overall national strategy for combating climate change and strengthen our scientific research and observation to influence our analysis of climate change." Climate change factors should be fully considered in the layout of productivity, infrastructure, and the planning and construction of major projects. Increasing adaptability to climate change, particularly in response to extreme climate events, should be prioritized, accelerating research and promotion of adaptation technologies and enhancing adaptation levels in key sectors like agriculture, forestry, and water resources, as well as in coastal and ecologically vulnerable areas. Improved monitoring, early warning, and prevention of extreme weather and climate events should be emphasized to bolster the capability to defend against and reduce natural disasters.

The *Outline of the 13th Five-year Plan for National Economic and Social Development of the People's Republic of China* continued to dedicate a chapter to "Respond to Global Climate Change," with the section on "Proactively Adapting to Climate Change" emphasizing the need to consider climate change in activities such as urban and rural planning, infrastructure construction, and productivity layout. It highlighted timely development and adjustment of relevant technical standards, the implementation of climate change adaptation action plans, strengthening systematic observation and scientific research on climate change, improving forecasting and early warning systems, and enhancing the ability to cope with extreme weather and climate events.

The *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives Through the Year 2035 of the People's Republic of China* specified in the chapter on "Coping with climate change" that "we will intensify the observation and assessment of the impact of global warming on vulnerable areas in China, and enhance the capacity of urban and rural construction, agricultural production, and infrastructure, to adapt to climate change." New requirements for the next stage of climate change adaptation work were laid out.

(ii) Issuing the *National Climate Change Adaptation Strategy*

To proactively respond to global climate change and coordinate climate change adaptation efforts nationwide, nine Chinese government departments jointly issued the *National Climate Change Adaptation Strategy* in 2013 (implementation period: 2014–2020). This strategy defined key tasks for infrastructure, agriculture, water resources, coastal areas and associated marine areas, forests and other ecosystems, human health, tourism, and other sectors to adapt to climate change. Following the relevant land and spatial development contents in the national main functional area plan, the strategy proposed specific adaptation tasks with varying focuses based on the impacts of climate change on different regions' livelihoods, dividing key regions in China into three main adaptation zones: urbanization, agricultural development, and ecological security. This division provides guidance for coordinated climate change adaptation efforts across regions. As China's first strategic plan specifically targeting climate change adaptation, the *National Climate Change Adaptation Strategy* is significant for enhancing China's comprehensive climate adaptability. The strategy adheres to principles of prioritizing key areas, proactive adaptation, reasonable adaptation, coordinated collaboration, and broad participation. It set an overall goal of significantly enhancing adaptability, fully implementing key tasks, and forming a basic regional adaptation framework by 2020, thus providing guidance for coordinated adaptation efforts.

To further reinforce climate change adaptation, in June 2022, the MEE, along with 17 other departments, jointly issued the *National Climate Change Adaptation Strategy 2035*, outlining key tasks such as climate change monitoring, prediction, early warning, and risk management, enhancing the adaptability of natural ecosystems, strengthening the adaptability of economic and social systems, and building a regional adaptation framework. The strategy considers multiple dimensions, including climate risks and adaptation, key sectors and regional frameworks, and natural ecosystems and economic society, providing strategic basis and guidance for improving climate resilience and effectively mitigating the adverse impacts and risks of climate change.

The *National Climate Change Adaptation Strategy 2035* highlights "Reinforce Climate Change Monitoring, Prediction, Early Warning, and Risk Management" as a separate chapter and places it in a prominent position, reflecting the importance given to climate change monitoring, prediction, early warning, impact and risk assessment, and emergency disaster prevention and mitigation. Key areas are categorized into two dimensions: natural ecosystems and economic society. Urban and rural living environments, as well as sensitive secondary and tertiary industries such as finance, energy, tourism, and transportation, are added as priority areas for climate adaptation, helping to further enhance adaptability across all sectors. The integration of climate change adaptation with land and spatial planning is established, with tasks for adapting to climate change across eight major regions and five key strategic areas proposed based on the principles of full coverage and key highlights, forming a multi-layered regional framework for climate change adaptation. Specific goals for 2025, 2030, and 2035 are set out in terms of the policy and institutional framework for climate change adaptation, climate change monitoring, prediction, and early warning, impact and risk assessment, disaster prevention and control capacity-building, actions in key fields and key regions, the adaptation regional framework, adaptation technologies and standards, and the building of a climate-resilient society.

(iii) Climate Change Adaptation Goals During the 14th Five-Year Plan

As a crucial part of climate change response, climate change adaptation has been incorporated into the policy systems of relevant departments such as the State Council and its subordinate Ministry of Natural Resources, Ministry of Agriculture and Rural Affairs, Ministry of Water Resources, National Forestry and Grassland Administration, and China Meteorological Administration. From 2020 to 2022, the Central Committee of the Communist Party of China, the State Council, and relevant ministries formulated and issued documents in 13 specific areas of climate change adaptation. These included climate impact and risk assessment, comprehensive disaster prevention and reduction, water resources, terrestrial ecosystems, marine and coastal zones, agriculture and food security, health and public health, urban and living environments, enhancing tourism adaptability, improving climate resilience in the energy sector, disaster prevention and emergency preparedness in transportation, spatial planning for climate change adaptation, and adaptation in key strategic areas. These documents have effectively guided and promoted the implementation of adaptation efforts in key sectors, yielding substantial progress. The goals for each sector are as follows:

Water Resources. By 2025, China aims to significantly enhance capabilities for flood and drought defense, secure and intensive utilization of water resources, optimized allocation of water resources, and ecological protection and restoration of rivers and lakes, thereby greatly improving national water security. The country's total water consumption will be kept below 640 billion cubic meters, with water consumption per RMB 10,000 of GDP and per RMB 10,000 of industrial added value reduced by approximately 16% compared to 2020 levels, and the effective utilization coefficient of agricultural irrigation water raised to 0.58. The water resources allocation project system will be further improved, with an additional 29 billion cubic meters of water supply capacity from new water projects, nearly all prefecture-level and above cities having established emergency backup water sources, and rural tap water coverage reaching 88%.

Terrestrial Ecosystems. By 2025, key ecological zones of national importance, ecological protection redlines, and priority national nature reserves will focus on ecosystem protection and restoration, addressing core ecological issues in critical areas. Forest coverage will reach 24.1%, forest stock volume will increase to 19 billion cubic meters, comprehensive vegetation coverage in grasslands will reach 57%, the area of nature reserves dominated by national parks will account for over 18% of terrestrial land area, and one million mu of desertified land will be restored.

Marine Ecosystems. By 2025, China aims to fundamentally curb marine ecological degradation, fully protect and restore damaged and degraded key marine ecosystems, effectively protect marine biodiversity, and continuously strengthen marine ecological security and climate resilience. Marine ecosystem quality and stability will steadily improve. The natural shoreline retention rate will be maintained at no less than 35%, at least 400 kilometers of coastline will be restored, and coastal wetland areas will cover no less than 20,000 hectares. Comprehensive governance and beautiful bay construction will advance in approximately 50 bays.

In the agriculture sector. By 2025, agricultural resources such as arable land and water will be effectively protected, and utilization efficiency will be significantly improved. The ecological health of farmland will be restored, biodiversity effectively protected, farmland ecosystems will be stabilized, and climate adaptability will be strengthened. High-standard farmland totaling 1.075 billion mu will be built, with fertilizer and pesticide utilization rates for main crops reaching 43%, plastic film recycling rates reaching 85%, and comprehensive utilization rates of livestock and poultry manure reaching over 80%. Additionally, degraded farmland treatment will be expanded by 14 million mu.

Disaster Prevention and Reduction. By 2025, modernization of the emergency management system and capacity will make substantial progress, forming a unique Chinese emergency management system with unified command, professional preparedness, quick response, and coordinated efforts at all levels. A cohesive and effective national emergency response system will be established, with mechanisms to prevent and address major safety risks constantly improving. Emergency rescue forces will be comprehensively strengthened, and advancements will be made in legal, technological, and information-based capabilities for emergency management. Safety production, comprehensive disaster prevention and reduction efforts will improve, natural disaster prevention will significantly advance, and society-wide capability to prevent and manage disaster incidents will be greatly enhanced.

II. Progress on Climate Change Adaptation

(i) Strength Monitoring, Early Warning, and Risk Management

The comprehensive meteorological observation network has been promoted, high-quality development of integrated meteorological observation operation services has been promoted. The *14th Five-Year Plan for the Development of Integrated Meteorological Observations Service* prioritizes enhancing observation station networks, operational support, and observation products. Additionally, the *Guidelines on Urban Meteorological Observation Capacity Building* was issued to promote the establishment of integrated meteorological observation network in urban areas and provide top-level design and guidance. An integrated meteorological observation system now includes nearly 70,000 ground automatic meteorological stations, over 200 weather radar stations, more than 120 radiosondestations, and 9 FengYun meteorological satellites operating in orbit. A three-dimensional multi-circle observation network on the earth system, which primarily focuses on the atmosphere and coordinates ground, air, and space elements, was also preliminarily established. It plays a crucial role in integrated disaster prevention, mitigation, relief efforts, efforts of addressing climate change, and advancing ecological civilization.

Strengthen Climate Change Monitoring, Prediction, Early Warning, and Risk Assessment. Enhance the capacity of climate system monitoring and analysis. In-depth research on intelligent forecasting and early warning technologies has been conducted using new-generation information technologies such as numerical models and artificial intelligence. The development of a prototype system for rapid detection and attribution of extreme events has been begun. Departmental collaboration has been strengthened, and a high-level meteorological early warning “call-response” mechanism has been reinforced. The accuracy and precision of meteorological forecasting and early warning are continually improving. A comprehensive seamless meteorological forecasting system has been established, covering basic meteorological elements, catastrophic weather, climate events, and impact forecasts. This system operates across various time scales, from hours and days to months, seasons, and years, and spans from the Chinese region to the global level.

Pre-disaster coordination has been strengthened, and the mechanism for joint consultation, warning, and release was optimized, integrating large-scale, high-intensity, and potentially disaster-prone heavy rainfall warning information into the criteria for initiating flood control emergency response. A scientifically science-based warning response coordination mechanism has been established, promoting proactive disaster prevention and response measures.

Preparedness for extreme weather events has been strengthened through annual trend forecasts, national-level meteorological risk warnings for geological disasters, and a system of expert presence. A major service bulletin system has been established for the joint release of major precipitation processes such as typhoons and rainstorms. On April 15, 2022, the national-level geohazard meteorological risk warning system for geological disasters was launched. The *Technical Guidelines for Climate Change Impact and Risk Assessment (Trial)* was compiled and the *Outline for High Quality Development of Meteorology (2022-2035)* was issued. Investigation into meteorological disaster-causing factors and risk assessment have been completed. The *Blue Book on Climate Change of China 2023*, the *Blue Book on Marine Climate Change of China 2022*, the *China Climate Bulletin (2021, and 2022)*, the *National Eco-meteorological Bulletin 2022*, the *Greenhouse Gas Bulletin*, and the *China Wind and Solar Energy Resources Bulletin* were released. Additionally, the *Polar Climate Change Annual Report* was also newly introduced. The *Regional Climate Change Assessment Report of China* and the *National Climate Change Assessment Report* were also completed.

Strengthen Comprehensive Disaster Prevention, Mitigation, and Post-Disaster Reconstruction. *The 14th Five-Year Plan for National Comprehensive Disaster Prevention and Reduction* was issued, deploying major projects for comprehensive disaster prevention and reduction to adapt to climate change. The establishment of a joint mechanism and the creation of national comprehensive disaster reduction demonstration communities have enhanced grassroots capacities in this regard. Key projects for the prevention and control of natural disasters have been promoted, optimizing the regional distribution of disaster prevention, mitigation, and relief resources. The promotion of nine key projects for natural disaster prevention and control has helped to improve the monitoring, early warning, and comprehensive risk prevention system for natural disasters. The first national comprehensive natural disaster risk survey was completed, leading to the establishment of a national comprehensive natural disaster risk basic database. The implementation of information technology projects for natural disaster monitoring and early warning has been accelerated. A reward mechanism for reporting illegal and irregular outdoor fire use in forests and grasslands has been established. The second phase of the forest lightning fire prevention and control technology research project has been initiated. The construction of the forest and grassland fire prevention perception system was accelerated. Fire risk assessment and real-time fire monitoring based on changes in weather conditions have been strengthened. Efforts to strengthen disaster prevention and mitigation technology research and development were supported, with significant natural disaster risk prevention and emergency rescue included in the relevant key special implementation scheme of the *14th Five-Year National Key Research and Development* Plan and the project guide of 2021. A distinctive Chinese emergency rescue force system has been established, featuring the national comprehensive fire rescue team as the core force, professional rescue teams for coordination, military emergency forces for rapid response, and social forces providing support. Six national and regional emergency rescue centers have been established. Furthermore, the emergency rescue aviation system has been strengthened, including the breakthrough in large firefighting aircraft and enhancing aviation rescue capabilities. A robust emergency rescue command mechanism has been developed. Emergency drills were organized. Reconstruction of disaster-damaged rural housing has accelerated. A technical expert steering group for post-disaster farmhouse restoration and reconstruction was established, and it provided guidance for the restoration efforts in various regions. Since 2022, effective measures have been taken to prevent and control flood and drought disasters. Fourteen numbered floods in major rivers, 1,334 rivers experiencing warning level floods, and 76 rivers experiencing floods that broke records since data collection began were successfully managed. Safety in preventing ice floods in northern rivers, such as the Yellow River, was ensured. In 2022, the significant flood in the Pearl River Basin and Beijiang River's largest flood since 1915 were effectively controlled, securing flood control in the Pearl River Delta. The "23·7" (July 2023) super large flood in the Haihe River Basin was actively defended against, safeguarding important cities and facilities like Daxing Airport. Also in 2022, in response to the most severe and prolonged meteorological and hydrological drought in the Yangtze River Basin since complete data was available in 1961, unprecedented intrusion of saltwater in the Yangtze River Estuary,, as well as the most severe drought in parts of Southwest and Northwest China since 1961 in 2023, ensuring water supply in drought-affected areas and seasonal irrigation demand for crops.

(ii) Enhance Climate Adaptability of Natural Ecosystems

Enhancing the Climate Adaptability of Water Resources and Watershed/Aquatic Ecosystems. Surveys and evaluations on water resources, completing annual groundwater level measurements and groundwater monitoring projects for China’s nine major river basins, ecologically fragile regions, and water conservation areas were conducted. China has put increasing efforts into water resource conservation and management. China has explored the establishment of strict constraints on water usage. During the 14th Five-Year Plan period, clear targets have been set for controlling the water consumption’s total volume and intensity at both national and provincial levels. A National Water Conservation Campaign has been advanced across the board. In 2022, China’s water consumption per RMB 10,000 of GDP and of industrial value-added reduced by 7.6% and 17.7%, respectively, compared to the 2020 levels. Additionally, the coefficient of effective utilization of irrigation water in farmland has been increased from 0.565 to 0.572, and the rural tap water coverage increased from 83% to 87%, the irrigated area for irrigation districts of over 10,000 acres expanded from 500 million mu to 532 million mu, and the utilization of unconventional water sources grew from 13.2 billion cubic meters to 17.58 billion cubic meters. These measures have significantly improved water consumption efficiency and effectiveness. China has actively promoted water resource tax reform to enhance the conservation, development, and utilization of water resources. China has implemented major projects on national water network and achieved significant progress in several major projects. China has strengthened the climate adaptability of water infrastructure by promoting the construction of water control and drought relief improvement projects, completing 11,000 kilometers of small and medium-sized river management, and undertaking remediation of 175 key mountain flood channels. China has implemented the Mother River Recovery Action to assure ecological flow, optimized water resource allocation and management, implemented ecological water replenishment. These measures have maintained year-round water flow in the Yongding River for 4 consecutive years after 26 years of intermittent flow, and achieved full connectivity of the Grand Canal for 3 consecutive years after a century of cutoff. Implement small watershed integrated management, slope land integrated improvement, risk mitigation and reinforcement of dangerous silt dams, construction of new silt dams, and sediment dams under key national soil and water conservation projects.

Enhancing the Climate Adaptability of Terrestrial Ecosystems. China has carried out ecological quality monitoring and issued the *National Ecological Quality Supervision and Monitoring Plan (2023-2025)*. In 2022, the National Ecological Quality Index (EQI) stood at 59.6, indicating a Class II ecological quality. In 2022, a national survey and monitoring of forests, grasslands, and wetlands was conducted. The system of ecological restoration plans and policies was improved by organizing and preparing provincial land spatial ecological restoration plans. Issue the *Opinions on Encouraging and Supporting Social Capital Participation in Ecological Conservation and Restoration* to build a market-oriented investment mechanism for ecological protection and restoration. Legislative work on ecological conservation for the Qinghai-Tibet Plateau, Yellow River protection, farmland protection and quality improvement, and Miyun Reservoir protection is underway. Coordinate key ecological function area restoration, coastal zone protection, and water control and drought relief improvement projects. All nine special construction plans for major projects supporting the *Overall Plan for the Protection and Restoration of Nationally Important Ecosystems (2021-2035)* have been issued Strengthen the protection of biodiversity in terrestrial ecosystems by issuing the *Opinions on Further Strengthening Biodiversity Conservation*, the *List of Important Habitats for Terrestrial Wildlife (First Batch)*, the *National Action Program for the protection of Bird Migration Corridors (2021-2035)*, the *Program on the Layout of the National Botanical Gardens System*, and the *Program on the Construction of the National Wildlife Conservation Project (2021-2030)* have been issued, among other documents..

Enhancing the Climate Adaptability of Marine and Coastal Areas. A comprehensive risk assessment system for coastal climate change has been established to support decision-making, and the monitoring and impact assessment of sea level changes have been strengthened. We continue to implement the "chip" project for ocean forecasting. We monthly released reports on *Global Sea Temperature and Heat Content Monitoring*, annually publish the *Blue Book on Marine Climate Change in China, Ocean and China Climate Outlook,* a monthly report on *Global Marine Climate Monitoring*, and a monthly report on *China Offshore Marine Climate Monitoring*. Our capacity to predict ocean climate continues to improve, highlighted by the establishment of the El Niño-Southern Oscillation (ENSO) monitoring and prediction system with statistics and dynamics integrated, alongside the development of key technologies for ensemble forecasting and artificial intelligence in ocean climate prediction. Annual monitoring and impact assessments of sea level changes have been completed, and the *China Sea Level Bulletin* and the *China Marine Disaster Bulletin* was issued. We have supported the implementation of 47 marine ecological protection and restoration projects in coastal cities, and coastal zone protection and restoration projects have been continuously implemented.

We have promoted the transformation of marine development towards circular utilization Coastline protection has been strengthened, with a strictly review process implemented to access the necessity and rationality of construction projects that occupy coastline areas. Guidance was also provided to social investment into blue carbon protection and restoration projects for mangroves, seagrass beds, coastal salt marshes, seaweed farms and other coastal zones. We issued the *Marine Ecological Environment Protection Plan for the 14th Five-Year and the Action Plan for Comprehensive Management of Key Sea Areas*, emphasizing land-sea and sea-river coordination, and advancing integrated management of key sea areas and the building of "beautiful bays".

(iii) Strengthening the Climate Adaptability of Socioeconomic Systems

Enhancing the Climate Adaptability of Agriculture and Food Security. We carried out the third national agricultural climate resource census and zoning, and promoted high-yield, high-quality, and stress-resistant varieties suitable for different regions to improve grain yield and crop climate adaptability. During critical periods such as the flood season and the "Three Autumn" period (harvesting, ploughing and sowing in autumn), agricultural disaster prevention and reduction plans were issued. We established designated field monitoring points and national soil moisture monitoring stations, promoting water-saving and drought-resistant crop varieties and coverage, drip and sprinkler irrigation, and integrated water and fertilizer technologies.. Based on shifts in ecological relationships due to climate change and the new characteristics of pests and diseases, we have advanced unified control and green prevention technologies, promoted pesticide reduction and efficiency improvement. Additionally, we have strengthened the prevention and control of invasive alien species by establishing a comprehensive management system encompassing source prevention, monitoring, early warning, governance and restoration, to safeguard agricultural biodiversity. We established a food security system with climate adaptability, and strengthened the development of high standard farmland to stabilize food production. Also, we implemented a robust system for fallow farmland rotation and increased investment in agricultural water conservancy facilities. We carried out pilot demonstrations of climate-smart agriculture, explored innovative models tailored to various regions, targeting different crop types, regional agricultural climate conditions, and cultivation methods used by farmers. Adhering to the principles of "government guidance, market-based operation, voluntary participation, and coordinated promotion", we implemented an agricultural insurance premium subsidy policy.

Enhancing the Climate Adaptability of Public Health. We expanded the demonstration in environmental health risk assessment, and promoted pilot of environmental health risk assessment, organized and carried out health risk classification and warning for heat waves and cold waves, improved the public access to extreme weather health risk alerts, and promoted its application in the first group of pilot cities of Jinan, Qingdao, and Shenzhen. We developed early warning products for high-temperature health risks and created a platform for "diagnosing" urban climate change impacts. We convened national discussions on extreme weather and issued cold wave health risk warnings for cardiovascular-sensitive populations. Additionally, we developed and published the *Guidelines for Public Health Protection Against Heat Waves*, *Guidelines for Public Health Protection Against Cold Waves*, and *Health Literacy and Interpretation of the Public Response to Climate Change* to enhance public awareness and improve response capabilities to climate-related health threats. We advanced the pilot of climate change health adaptation communities and implemented community health risk interventions for extreme weather events. To harness expert knowledge and technical support, a Climate Change and Health Expert Committee was established. We drafted the *National Action Plan for Climate Change Health Adaptation* (2024-2030) and identified phased goals for climate change health adaptation, continuously improved the climate change health standard system, and accelerated the development of basic and technical standards.

Enhancing the Climate Adaptability of Infrastructure and Major Projects. We carried out pilot projects, including key technologies for enhancing the resilience of transportation infrastructure. In the design review of key projects, we carried out safety assessments such as geological hazard evaluations, flood control impact assessments, and traffic safety assessments. Essential safety measures such as lightning protection, earthquake resistance, and (wind) diversion devices have been incorporated, with wind tunnel tests conducted to verify the wind stability of large-span bridges. We guided the project to focus on high slopes, super large bridges, tunnels and other construction sites. Construction emergency plans have been developed to address potential disasters such as typhoon, rainstorm and the resulting floods, debris flows, landslides, collapses and other disasters. We have conducted studies to improve the standards of water transport engineering adaptive to climate change. During the revision of key standards such as the *Code for General Design of Seaports,* we have considered the impact of climate change, such as sea level rise.

Enhance the Climate Adaptability in Urban and Residential Environments. We have continuously implemented the *Action Plan for Urban Adaptation to Climate Change*, taking cities as the starting point, actively explored the path and model of building climate adaptive cities. The *Notice on Deepening the Pilot Program of Climate Adaptable City Construction* was issued, proposing ten key tasks. Pilot selection for climate-adaptive city construction was organized and carried out. Focus on addressing urban waterlogging, we carried out sponge city pilots in 30 cities and sponge city demonstrations in 60 cities. In 10 cities, we carried out pilot projects to enhance the system and mechanism of urban "physical examination", further adjusted and improved the urban physical examination index system, incorporating metrics such as "reduction in severe waterlogging-prone areas" and "emergency rescue capability for urban drainage and waterlogging prevention", etc. into the index system. Through this system, we identified existing challenges in urban resilience against extreme weather, such as rainstorms, and implemented targeted renovations to enhance urban safety and resilience. China issued the *14th Five-Year Plan for Urban Drainage and Flood Prevention System Construction Action Plan* to guide the construction of urban drainage and flood control systems nationwide, and established a provincially coordinated emergency drainage work mechanism. Twenty-six cities have been awarded the title of "National Forest City", with more than 100 cities having implemented on the national garden city initiative, and 3,520 "pocket parks" have been built across the country. The first batch of 19 pilot cities for regional water recycling have been selected, and 78 cities carried out pilot projects for regional utilization of recycled water. We also created 409 of “China Natural Oxygen Bars,” “China Climate-Friendly Cities (Counties),” and “Summer Tourism Destinations.”

Enhancing the Climate Adaptability of Sensitive Secondary and Tertiary Industries. Strengthen climate impact monitoring and risk warning in the energy sector, establishing a regular consultation and emergency coordination mechanism, actively carried out meteorological forecasting and analysis of its impact on energy supply. Special working groups for energy supply meteorological services for peak summer and winter periods was established to monitor meteorological changes in disaster-prone areas with a closer eye, and issue weekly special reports during critical periods. Be prepared for extreme weather conditions in the tourism industry, the *Notice on Further Improving the Open Management Level of Tourist Attractions during Summer* has been issued. Tourist attractions have been urged to closely monitor weather changes, develop targeted plans for adverse weather conditions, and provide service and assistance to tourists in special weather conditions. Enhancing the Adaptation of Transportation to Climate Change. Continuously carried out national trunk road rehabilitation projects, precision upgrades to safety facilities, and disaster prevention initiatives. 218 high-impact weather road sections were optimized from 2022-2023, resulting in a 50% reduction of accidents on these sections, with economic losses down by RMB 4.3 billion. We have organized and carried out projects to enhance the safety guarantee capacity of rural roads, including the investigation and treatment of potential safety risks on rural roads, and the renovation of old and dilapidated bridges on rural roads and life safety protection projects. Since 2022, 18,000 dilapidated bridges on rural roads have been renovated, and 240,000 kilometers of rural road life safety protection projects have been implemented.

(iv) Building Regional Patterns Adapting to Climate Change

Construct Territorial Space Adapting to Climate Change. The *National Territorial Space Planning Outline (2021-2035)* has been issued, completing the demarcation of the "three zones and three lines" [40]". We have been expediting the implementation of territorial space planning at provincial, municipal, and county levels, with a focus on prioritizing ecological considerations and adapting to climate change as fundamental principles in territorial space planning. A new pattern of national territorial space development and protection has emerged, characterized by distinct primary functions, complementary advantages, and an environmentally friendly, low-carbon approach, facilitated by spatial bottom-line constraints and strategic guidance. Enhanced supervision has been observed in key ecological function areas, ecological protection red lines, and other critical zones, leading to improved resilience of territorial space in the face of climate change. We have encouraged each provinces (autonomous regions, municipalities) to coordinated and promoted relevant departments and local governments to strengthen climate change adaptation strategies, further incorporating these strategies into territorial space planning at all levels. We have established a national urban health check and evaluation system for land space planning, incorporating an annual review and a five-year assessment cycle. Cities nationwide will routinely monitor low-carbon resilience indicators.

[40] The term "Three Zones" refers to the three types of land spaces: urban, agricultural, and ecological spaces. The "Three Lines" refer to arable land and permanent basic farmland, ecological conservation redlines, and urban development boundaries.

We optimized the regional layout of disaster prevention, reduction, and relief resources. We have also coordinated the flood control efforts for the mainstreams and tributaries, upstream and downstream areas, both sides of riverbanks, as well as in urban areas. We have also addressed the needs of coastal cities for typhoon and moisture prevention, scientifically delineated flood risk control areas, clarified comprehensive natural disaster risk prevention and control areas, optimized the layout of flood risk prevention and control facilities, and improved the ability to respond to extreme weather and natural disasters.

Strengthened Climate change risk assessment and decision-making capacity building in key regions. We have strengthened assessment of climate change impacts and risks in key regions such as the Yangtze River Economic Belt, Yellow River Basin, Beijing-Tianjin-Hebei, and Qinghai-Tibet Plateau, and organized provinces to regularly release climate change monitoring bulletins. We have organized regional climate change technology and work exchanges, issued and implemented the *Technical Guidelines for Planning Environmental Impact Assessment - Comprehensive Planning of Watersheds*, encouraging a focus on potential risks faced by watersheds in the context of climate change in watershed comprehensive planning and environmental assessment, and proposing measures to adaption to climate change.

Accelerated climate change effort in the Qinghai-Tibet Plateau. We have strengthened the construction of climate change monitoring stations and networks in the plateau climate system. We selected the Lhasa River Basin in the upper reaches of the Yajiang River, and built a scientific research demonstration platform for the integrated protection and systematic management of mountains, rivers, forests, farmlands, lakes, grasslands, and deserts, and carried out comprehensive observation, warning, and management of changes in the Earth's system at multiple levels. A carbon flux monitoring network for typical high-altitude ecosystems in the Qinghai-Tibet Plateau has been preliminarily established, and a gradient connected peak (Mount Everest) meteorological observation station has been established. A prediction system for the impact of climate change on the ecosystem, climate system, water resources, rare and endangered or unique wildlife and plants, snow-capped mountains, glaciers, permafrost, and natural disasters in the Qinghai-Tibet Plateau has been established, and ecological risk reporting and warning mechanisms have been improved. We conducted research on the impact of climate change on the Qinghai-Tibet Plateau and established an inter-ministerial coordination mechanism for ecological environment protection and climate change adaptation on the Qinghai-Tibet Plateau. We convened a cross departmental exchange meeting on climate change work on the Qinghai-Tibet Plateau, and strengthened the construction of cross departmental, multi sphere, and comprehensive observation and research capabilities on the Qinghai-Tibet Plateau.

Strengthened climate adaptability in Key River Basins. We have carried out water source conservation forests, soil and water conservation forest construction projects, as well as land comprehensive improvement projects in the Yellow River Basin. Also, we carried out key water source conservation area fencing and protection measures. We implemented the "Yellow River Basin Adaptation Plan to Enhance Climate Resilience" technical assistance project, and developed an action plan for climate change adaption in the Yellow River Basin.

We organized experts to systematically compile fundamental geographic, environmental, and climate data pertaining to the Yellow River Basin, analyzed the present-day impact of climate change on the Yellow River Basin, projected future climate change scenarios, and assessed climate risks in key areas such as water resources and ecosystems. In the Yangtze River Basin, integrate protection and restoration of water environments, water habitats, water resources, and water ecosystems. Advance flood protection projects along the Yangtze’s main dikes and promote eco-friendly transformations to enhance ecosystem integrity, diversity, stability, and sustainability. Strengthen water ecological protection and restoration in the Yangtze River Basin and special water environment treatment at the estuaries of major tributaries entering the Yangtze. Ensure the biological and ecological safety of the basin, creating a “green ecological corridor” in the Yangtze River Basin and establishing a model of harmonious coexistence between humans and nature.

(v) Strengthening Provincial-Level Climate Adaptation Actions

In August 2022, the *Guidelines for the Formulation of Provincial Adaptation to Climate Change Action Plans* was issued to provide guidance and criteria for the formulation of provincial-level action plans to adapt to climate change. These guidelines aimed to enhance the efforts of provincial-level administrative regions in adapting to climate change. Led by their respective Department (or Bureau) of Ecology and Environment, all provinces, autonomous regions, and municipalities actively drafted provincial action plans for climate change adaptation. Most provinces, autonomous regions, and municipalities established leading groups (coordinating groups, working groups, task teams) and technical support teams to formulate these plans. They also instituted working mechanisms led by the ecology and environment department, with support from relevant departments and professional teams. Each province, autonomous region and municipality has promoted interdepartmental coordination, clarified roles and responsibilities, and jointly issued provincial climate adaptation action plans, with the ecological environment department coordinating with local development and reform, science and technology, finance, natural resources, housing and urban-rural development, transportation, water resources, agriculture, culture and tourism, health, emergency management, People’s Bank of China provincial (district, municipal) branches, Chinese Academy of Sciences field offices, meteorology, energy, forestry, and grassland, marine, and other departments. In the light of actual conditions, some provinces (regions, cities) have also included defense, government services, animal husbandry, communications, and local subsidiaries of the State Grid Corporation as co-issuers, covering all key areas for climate adaptation work. Up to now, 29 provinces, autonomous regions, and municipalities have officially issued their provincial action plans for adapting to climate change.

III. Challenges in Climate Change Adaptation

Insufficient Capacity in Climate Change Monitoring, Early Warning, and Risk Management. The integrated multi-sphere observation system for atmospheric, terrestrial, marine, and space climate systems is incomplete. The existing climate observation network lacks coverage across all critical climate variables for a multi-sphere Earth system.

Capabilities for seamless weather and climate monitoring, forecasting, and early warning are limited, and key technologies for forecasting major extreme events and compound disasters are relatively underdeveloped. A systematic understanding of climate impacts on water, food and agriculture, disaster reduction, human health, energy, transportation, and the environment is lacking, with limited interdisciplinary and joint research across sectors. There is also a need for a unified, efficient service platform to support these areas.

Limited Climate Adaptability in Natural Ecosystems. Basic capabilities in the sector of water resources for climate adaptability need to be improved, and the working system for climate adaptation was far from perfect. The disaster early warning, prevention, and control capabilities of terrestrial ecosystems urgently need to enhance, and the monitoring and assessment system for key ecological functional zones, sensitive and vulnerable areas, ecological protection redlines, and high-risk areas need to be strengthened. The layout of marine environment monitoring stations lacks optimal design, and disaster forecasting accuracy needs improvement. Effective measures are still lacking for addressing risks such as ocean acidification and biodiversity loss.

Insufficient Climate Adaptability in Socioeconomic Systems. Agricultural infrastructure is not yet perfect, and management and support systems for agricultural adaptation are underdeveloped. Health risk assessments and adaptability evaluations are insufficient, and there is a need to improve the climate adaptability of vulnerable populations, evaluate the effectiveness of adaptation measures, and strengthen mechanisms for public health benefit assessment and cooperation. Existing infrastructure does not yet meet climate adaptation needs. Urban lifeline systems still lack stability and resilience in response to extreme weather and climate events. Some urban public facilities and rural water management facilities are outdated, and the comprehensive flood control and disaster reduction system is not perfect. Climate-related data in the financial sector is insufficient, and energy infrastructure lacks adequate resilience to adverse climate impacts. The construction of disaster prevention monitoring, prediction, early warning, emergency rescue, and technical standards systems for highways and high-speed railways needs to be strengthened.

Chapter 4 International Cooperation on Climate Change Adaptation

I. Conducting Joint Research on Climate Change Adaptation

Actively leverage grant funding from international organizations, such as the World Bank, the Asian Development Bank, and the Global Environment Facility (GEF), to carry out climate change adaptation projects. Successfully applied for and received approval for the Asian Development Bank's "Yellow River Basin Adaptation Plan for Climate Resilience Enhancement" and "Provincial and Municipal Climate Change Adaptability Enhancement" technical assistance projects. Collaborate with the Global Center on Adaptation (GCA) on pilot projects for climate-resilient urban construction in China to enhance urban climate adaptability.

Engage in joint research on climate change adaptation in key areas with multiple regions and countries. Work with Germany on the "Integrated Urban Climate Action for Low-Carbon &

Resilient Cities" project to support the construction of low-carbon and climate resilient cities. Cooperate with the European Union on the "China Biodiversity Fund Cooperation Project" to enhance international collaboration on climate change in fields such as ecosystem restoration. Establish the "Biodiversity Conservation Alliance for Arid Lands" and jointly establish the "Sino-Tajikistan Joint Laboratory for Conservation and Utilization of Biological Resources." Actively respond to the UN Decade of Ocean Science for Sustainable Development (2021-2030) (the Ocean Decade), hosting the UN Decade Collaborative Centre on Ocean-Climate Nexus and Coordination Amongst Decade Implementing Partners in P.R.China (DCC-OCC). Continue collaborating with neighboring countries on monitoring, protecting, and restoring typical marine ecosystems, and on environmental forecasting and disaster warning. Sign ocean cooperation agreements with Thailand, Indonesia, Vietnam, and Vanuatu. Research the impacts and feedback mechanisms of key climate-sensitive marine and polar elements, participating in the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC). Conduct multidisciplinary scientific research cruises in Russian jurisdictional waters through the "China-Russia Joint Research Center for Ocean and Climate." Collaborate with Sorbonne University's LOCEAN Laboratory on China's Arctic scientific expeditions. Rely on the Alliance of International Science Organizations to conduct research on flood and drought disaster prevention in Belt and Road countries and regions.

II. Prioritizing Knowledge Sharing on Climate Change Adaptation

Actively share China's successful experiences in climate change adaptation through experience summaries and case studies. Hold the China-Europe Climate Change Adaptation Dialogue with the European Union Delegation in China to share the formulation and implementation progress of the *National Climate Change Adaptation Strategy 2035*. Host side events on climate change adaptation at the "China Pavilion" during the UNFCCC, sharing China's policy and action experience in climate change adaptation with the international community. Jointly release typical cases of Nature-Based Solutions in China with the International Union for Conservation of Nature (IUCN), sharing China's story in addressing climate change, and co-establish the Nature-Based Solutions Asia Center. Promote international cooperation in scientific research, disaster monitoring, early warning, and capacity building in the marine sector. Hold multilateral forums, such as the China-Pacific Island Countries Scientific Cooperation Symposium on Marine Disaster Prevention and Mitigation, to enhance collaboration in marine disaster prevention and reduction. Utilize diverse forums and international conferences to strengthen China's influence in the climate adaptation field. For example, at the Second United Nations Global Sustainable Transport Conference in Beijing, call for strengthening transportation system resilience, highlighting China's achievements and experiences in building resilient transport and adapting to climate change. Hold the "UK-China Cooperation on Climate Change Risk Assessment" seminar with the British Embassy in China, facilitating discussions and exchanges on best practices for managing climate risks.

Chapter 5 Lessons and Insights in Climate Change Adaptation

I. Raising Awareness Among Policymakers and the Public

In 2022, China issued the *National Climate Change Adaptation Strategy 2035*, requiring relevant ministries and commissions to develop detailed implementation measures according to their responsibilities and prepare sector-specific climate adaptation action plans. Each province must also formulate a climate adaptation action plan based on local conditions. Local governments prioritized this task, quickly establishing mechanisms to prepare climate adaptation action plans and organizing expert groups to undertake the work.

In the same year, China compiled and issued the *Guideline for the Preparation of Provincial Climate Adaptation Action Plans*, and held national mobilization and training sessions for preparing these plans, providing key document insights. Experts provided guidance on topics like climate risk assessment, identification of climate-sensitive areas, urban climate risk, and adaptation strategy selection, while mobilizing next steps for the provincial adaptation action plan formulation.

Numerous training sessions, briefings, and discussion forums have been held to enhance experience-sharing and the promotion of successful climate adaptation cases. Held a workshop for provincial climate adaptation action plan preparation in the Yellow River Basin, where experts provided lectures on climate risk assessment and management in the region, effectively promoting plan formulation progress among relevant provinces. Held a Sino-German seminar on climate change projects and a seminar on the preparation of provincial adaptation action plans, organize relevant provinces (autonomous regions and municipalities) in the Yangtze River basin to exchange experiences in the preparation of adaptation action plans, invite experts and scholars in key fields at home and abroad to carry out capacity-building training for relevant provincial ecological and environmental authorities and research support institutions, and enhance local understanding and cognition of adaptation to climate change and climate risk assessment.

Through events like World Environment Day, National Low-Carbon Day, and Disaster Prevention and Reduction Day, China has carried out climate change adaptation-related public education to raise awareness of disaster warnings triggered by climate change. This has helped disseminate climate adaptation and disaster prevention knowledge and skills, gradually increasing public awareness and fostering broad participation in climate adaptation, effectively enhancing policymakers' and the public's understanding of climate adaptation.

II. Establishing a Long-Term, Effective, Multi-Department Coordination Mechanism

Climate change adaptation requires a coordinated, integrated framework due to the vast number of sectors and departments involved. A well-functioning, collaborative framework can support efforts to enhance climate resilience through collective action. Currently, efforts are underway to establish a cross-departmental, multi-level climate change response coordination mechanism, prioritizing climate risk prevention, assigning responsibilities across key tasks, allocating resources efficiently, breaking information barriers, and promoting data integration, sharing, and collaborative innovation.

The Ministry of Ecology and Environment, the Ministry of Natural Resources, the China Meteorological Administration, and the National Forestry and Grassland Administration have jointly worked to create and implement an inter-ministerial meeting mechanism for environmental protection and climate adaptation on the Qinghai-Tibet Plateau. This mechanism focuses on assessing climate change impacts on vulnerable regions, the effects of global climate change on the Qinghai-Tibet Plateau, and climate risk assessment frameworks, as well as enhancing climate-adaptive city construction pilots.

To ensure the compilation of provincial climate adaptation action plans, each provincial Department of Ecology and Environment has formed a leading group (or coordination group, working group, dedicated working team) with technical support, creating a framework led by environmental authorities with support from relevant departments and professional teams. As of now, 29 provincial (district, municipal)-level climate adaptation action plans have been officially issued.

III. Leveraging the Demonstrative Role of Climate-Resilient Urban Pilot Projects

China is undergoing rapid industrialization and urbanization, and to minimize adverse impacts and risks of climate change, the country seeks to enhance urban climate adaptation capacity and ensure safe city operations. In 2017, China selected 28 cities (districts/counties) to initiate climate-resilient urban pilot projects. Pilot cities are actively exploring ways to adapt, spreading adaptation concepts, innovating work mechanisms, and enhancing adaptation actions in key areas, building a foundation for improving urban climate resilience. To enhance systemic governance of urban climate risks and to comprehensively improve cities' adaptability to climate change, while building green, livable, safe, and resilient cities, China has summarized and evaluated the construction conditions, outcomes, and lessons of pilot cities. The country explores methods and pathways for advancing the pilot work, develops the *Pilot Scheme for Deepening Climate-Resilient Urban Construction*, and clarifies pilot construction ideas and key tasks. This approach aims to strengthen climate adaptation actions in key urban areas, promote policy innovation and capacity-building for urban adaptation, and select exemplary cities for preliminary implementation. By actively advancing and deepening climate-resilient urban construction, it makes a positive contribution to urban resilient and sustainable development, ecological civilization, and the construction of a beautiful China.

To realize the value of climate ecological products, unlock the potential of climate resources, and enhance meteorological services for tourism and wellness, China is piloting mechanisms for realizing the value of climate ecological products. This involves conducting surveys and assessments of climate ecological resources to understand their baseline, preparing detailed zoning maps, enhancing business capabilities for climate ecological services, conducting risk alerts and assessments for major meteorological disasters by disaster type, industry, region, and time, and strengthening ecological safety meteorological support services. To realize the value of ecological products, China is establishing a quality evaluation and traceability system for climate ecological products by region and category, adding value to climate ecological products, building climate wellness demonstration bases, conducting value assessments of climate ecological products, and promoting the application of results in local planning, key industry development, ecological protection compensation, and evaluations of ecological civilization goals.

IV. Actively Conducting International Exchanges and Cooperation in Climate Change Adaptation

As global warming intensifies, countries are increasingly concerned with climate adaptation, prompting China to broaden and deepen its international cooperation on climate adaptation in such a context of climate change and new international landscape. Through its partnership with the Global Center on Adaptation (GCA) and other international organizations, China has strengthened policy-sharing, practical cooperation, and experience-sharing in climate adaptation. This includes discussions on climate risk assessment, resilient urban planning, and mutual learning on effective practices and case studies, contributing China’s insights to enhance global climate adaptability and promote joint resilience-building against climate risks worldwide.

Part IV Finance, Technology and Capacity Building Needs and Support Received

In 2020, China announced an updated and strengthened nationally determined contribution, aiming to achieve the world's steepest dive in carbon intensity and to transition from carbon peaking to carbon neutrality within the shortest period of time in history. This embodies China's greatest effort to address global climate change based on its development stage and national circumstances. It also signifies high demand of finance, technology and capacity building in the near future. As a developing country with a population of 1.4 billion, China faces multiple challenges including economic development, people's livelihood improvement, environmental governance, and addressing climate change. Issues of unbalanced and inadequate development remain significant, making the needs for finance, technology and capacity building extremely urgent. This section primarily reports on China's finance, technology and capacity building needs up to 2030, as well as the support received in terms of finance, technology and capacity building between 2020 and 2022.

Chapter 1 Overall Situation

I. National Circumstances and Institutional Arrangements

(i) National Circumstances Related to Finance, Technology and Capacity Building

China is the largest developing country in the world. According to the statistics of the World Bank[41], China's per capita GNI in 2022 was US$12,890, which is only about one-fourth of the average level of OECD member countries. In 2022, China's per capita disposable income was RMB 36,883 (US$5,483[42]), with urban and rural residents' per capita disposable income of RMB 49,283 (US$7,326) and RMB 20,133 (US$2,993), respectively. China still faces the factual challenges of a relatively low overall per capita income level and significant income disparities between urban and rural areas.

1. Finance

Public finance. From 2020 to 2022, the national general public budget expenditure related to climate change amounted to approximately RMB 3 trillion, accounting for 3.9% of the total expenditure, with an annual per capita amount of only about RMB 700. Relevant areas include energy conservation and efficiency improvement, renewable energy, circular economy, natural ecological protection, forest resource cultivation, grassland management, natural disaster prevention and control, natural disaster relief and reconstruction, meteorological information transmission and management, meteorological observation, etc.

Investment and financing. By the end of 2022, the balance of green loan in China totaled RMB 22.03 trillion, with a per capita amount of about RMB 15,000. The carbon reduction

[41] Data source: World Bank Database, accessible at https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.
[42] Data source: The Statistical Communiqué of the People’s Republic of China on the 2022 National Economic and Social Development, with amounts in U.S. dollars converted according to the 2022 average exchange rate.

supporting tool launched in 2021 has cumulatively supported financial institutions in issuing concessional loans of over RMB 690 billion in carbon emission reduction and related fields, driving loan growth in sectors of clean energy, energy conservation and environmental protection, and ecological environment by 36.2%, 42.3% and 38.9% year-on-year, respectively. More than RMB 2.5 trillion of green bonds were issued in China, including RMB 490 billion in carbon-neutral bonds, dedicated to projects and areas with evident carbon emission reduction and removal effects. As of June 2023, the first batch of 23 pilot cities and regions for climate investment and financing had registered nearly 2,000 climate-friendly projects, involving funds close to RMB 2 trillion.

2. Technology

Addressing climate change is a key area for fundamental research and technological innovation in China. Major national science and technology infrastructure projects, such as the "Earth System Science Numerical Simulation Facility", national technology innovation centers in the "dual carbon" fields such as fuel cells, green and low-carbon buildings, and new energy vehicles, national key R&D programs such as "Renewable Energy Technologies", strategic priority research programs such as "Transformational Technologies for Clean Energy and Demonstration", and the "Nationally Promoted Low-carbon Technologies Catalog" serve as the primary methods through which China conducts scientific and technological research and development, innovation and promotion to address climate change.

3. Capacity Building

Since the introduction of the "dual carbon" goals in 2020, China has continuously improved its higher education talent development system for carbon peaking and carbon neutrality, as well as climate change-related courses and practical education systems in primary and secondary schools. It has introduced emerging professions related to addressing climate change, such as carbon emission managers, carbon management engineering technicians, and carbon sink measurement appraisers. Vocational skills training has been strengthened, and capacity building for government officials and enterprises in addressing climate change has been enhanced. Through initiatives such as the "National Energy Efficiency Promotion Week", "National Low-Carbon Day", and "World Environment Day", public awareness and knowledge dissemination has been strengthened, constantly improving the society-wide capacity to address climate change.

(ii) Institutional Arrangements for Reporting on Finance, Technology, and Capacity Building Support

Arrangements for statistics and report preparation. In order to compile the content related to finance, technology and capacity building support for addressing climate change in the National Biennial Transparency Report, China has established a statistics and report preparation mode, which is led by the Ministry of Ecology and Environment with coordination and collaboration from many ministries including the National Development and Reform Commission, Ministry of Education, Ministry of Science and Technology, Ministry of Finance, and China International Development Cooperation Agency, etc. It is also supported by local governments, relevant institutions and experts.

Institutional arrangements for reporting information on climate change response needs. China has not yet established a systematic needs assessment and information reporting system. This report has been prepared under the leadership of the Ministry of Ecology and Environment, with the involvement of relevant departments and experts in collecting and reporting the relevant information. The information and data comes from relevant competent authorities and available specialized research.

Institutional arrangements for reporting information on support received for addressing climate change. China has not yet established a systematic information reporting system for the support received. The report drafting has been mainly organized by Ministry of Ecology and Environment, with the engagement of relevant departments, local authorities and experts in collecting and reporting the relevant information. The Ministry of Finance is responsible for managing the financial support received by China through multilateral channels. Finance support received through bilateral channels, as well as technology and capacity building support received through various channels, involves multiple ministries and local governments.

(iii) Challenges in Reporting on Finance, Technology and Capacity Building Support

The enhanced transparency framework under the Paris Agreement sets more detailed requirements for compiling information on finance, technology and capacity building for addressing climate change. China faces challenges in fully, effectively and adequately reporting its needs and support in finance, technology and capacity building. First, there is a lack of a clear definition for climate finance, and the results of finance needs assessment and finance support statistics vary greatly depending on the methodologies chosen. Second, the wide variety of technologies for addressing climate change makes it challenging to regularly and timely update the progress on technology research and development, needs, and support. Third, the broad scope and diverse forms of capacity building for addressing climate change makes it difficult to establish mechanisms for identifying and analyzing capacity building needs and support. Fourth, China has not yet established a regular working mechanism for assessing needs of finance, technology and capacity building for addressing climate change. Fifth, China has not yet established a regular statistics and reporting mechanism for finance, technology and capacity building support received for addressing climate change.

II. National Strategies and Priorities Related to Finance, Technology and Capacity Building

(i) National Strategies and Implementation Plans

Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy provides strategic guidance for China's arrangements related to finance, technology and capacity building for achieving carbon peaking and carbon neutrality. The National Climate Change Adaptation Strategy 2035 sets out the direction for finance, technology and capacity building in adaptation areas. The Working Guidance for Financial Support for Carbon Dioxide Peaking and Carbon Neutrality and the Guiding Opinions on Promoting Climate Change Investment and Financing clarify the key directions and areas of financial support for carbon peaking and carbon neutrality, as well as the implementation pathways to guide climate investment and financing. The Implementation Plan for Science and *Implementation Plan for Carbon Peak and Carbon Neutrality Supported by Science and Technology (2022-2030)* proposes the technological innovation actions and support measures to achieve the carbon peaking goal by 2030. The Work Plan for Strengthening the Construction of Higher Education Talent Development System for Carbon Peaking and Carbon Neutrality and the Implementation Plan for Green and Low-carbon Development of National Education System outline arrangements for capacity building related to climate change response.

(ii) Goals and Priorities

1. Finance

Financial support. The goal is to establish an initial fiscal and taxation policy framework that supports green and low-carbon development by 2025, to form a fiscal and taxation policy system for green and low-carbon development by 2030, and to establish a mature and robust financial support policy system for green and low-carbon development by 2060. The priorities include strengthening the guiding role of financial support, improving the market-driven and diversified investment mechanism, leveraging the incentive and restraint effects of tax policies, refining government green procurement policies, and strengthening international cooperation in addressing climate change.

Investment and financing. The goal is to establish a systematic framework by 2025 that includes local pilot projects, comprehensive demonstration, project development, institutional response, and extensive participation in climate investment and financing, to build a climate investment and financing cooperation platform with international influence and to significantly increase finance in the climate sector. The priorities include building a climate investment and financing policy system, improving the climate investment and financing standard system, encouraging and guiding private and foreign investment into the climate investment and financing sector, guiding and supporting local climate investment and financing practices, and deepening international cooperation in climate investment and financing. In order to expand the scale of climate adaptation finance, the priorities include guiding commercial financial institutions and multi-channel market resources to invest in climate adaptation projects, encouraging the development of innovative climate adaptation investment and financing products, securing multilateral and bilateral adaptation-specific loans and grants, and building an adaptation investment and financing support system.

2. Technology

Low-carbon technology. The goal is to achieve major breakthroughs in key low-carbon technologies across critical industries and sectors by 2025; by 2030, to further advance cutting-edge disruptive carbon-neutral technologies, develop a number of low-carbon technology solutions and demonstration projects with significant influence, and establish a more comprehensive green and low-carbon scientific and technological innovation system. The priorities include the action for science and technology support for green and low-carbon energy transition, the action for technological breakthroughs in low-carbon and zero-carbon industrial process reengineering, the action for advancing low-carbon and zero-carbon technologies for urban and rural construction and transportation, the action for advancing innovation in cutting-edge disruptive low-carbon technologies, the action for low-carbon and zero-carbon technology demonstration, the action for supporting decision-making in carbon peaking and carbon neutrality management, the action for enhancing synergies among innovation projects, bases and talents, the action for fostering green and low-carbon technology enterprises and services, and the action for boosting international technology innovation cooperation.

Adaptation technology. The priorities include basic scientific research on climate change and adaptation, research on standards for climate change adaptation, research and development of key technologies for climate change adaptation, establishment of platforms for the transformation of technological achievements in climate change adaptation, adaptation technology pre-research and reserves based on future long-term climate change scenarios, strengthening coordination and sharing of adaptation technology resources across key industries and regions, and enhancing international and regional exchange in climate change adaptation technologies.

3. Capacity Building

Talent support. The goal is to provide talent support and intellectual resources for achieving carbon peaking and carbon neutrality. This includes establishing at least 600 academic programs nationwide in green and low-carbon fields by 2025 and developing a series of relevant course materials and textbooks. The priorities include popularizing green and low-carbon education, building teaching staff teams, training urgently needed talents for carbon peaking, carbon neutrality, and climate change adaptation, leveraging industry-education integration for collaborative talent development, establishing a cross-disciplinary multi-level expert database on climate change adaptation, and promoting international exchange and cooperation.

Public participation. The priorities include enhancing publicity and education, promoting green, low-carbon and climate-adaptive lifestyles, and implementing demonstration projects for green and low-carbon social initiatives.

III. Underlying Concepts, Methodologies and Assumptions

Decision 18/CMA.1 adopted at the Conference of the Parties to the Paris Agreement identifies 13 conceptual and methodological elements to help understand the support needed and received for finance, technology and capacity building for addressing climate change. The relevant considerations in this report are set out below:

(1) Convert domestic currency into United States dollars: Unless otherwise specified, conversions are based on the 2020 average annual exchange rate of RMB to USD. For support provided in other currencies, conversions to USD are made using the 2020 average annual exchange rates.

(2) Estimate the amount of support needed: The total national climate finance needs are

derived from a review of literature. The specific support needed from certain sources are calculated by the respective data providers according to their own methodologies.

(3) Determine the reporting year or time frame: All support received in this report consists of newly implemented projects during the period from 2020 to 2022, and the time frame for support needed is from 2024 to 2030.

(4) Identify support as coming from specific sources: This report uses the concept of "climate-relevant finance", covering projects whose primary purpose is to address climate change, as well as projects with other primary purposes (such as food security, energy security, and public health) that contribute to climate change mitigation or adaptation and enhance capacity in addressing climate change. If a project is conducted under a "climate change" initiative, framework or bilateral declaration, the amount of "climate-relevant finance" shall be reported at 100% of the total amount; if not, it shall be reported at 50% of the total amount. If the original data source specifies a particular proportion of the amount of climate change-related funds, that specified proportion is used for statistics purposes. If the competent authority of addressing climate change, finance receiving entities and finance implementing entities determine that the corresponding project support is unrelated to addressing climate change , it will not be included in the statistical report.

(5) Determine support as committed, received or needed: Committed support refers to support for which memorandums of understanding, cooperation agreements or contracts have been signed but have not yet been implemented or finance not yet disbursed during the reporting period. Received support includes finance or technology that has been fully or partially delivered, or capacity-building projects that have commenced. Needed support refers to assessed needs that have not yet received any support commitments.

(6) Identify and report status of the supported activity (planned, ongoing or completed): To avoid duplication of information with subsequent biennial transparency reports, this report only includes newly implemented support projects within the reporting period (2020-2022) and excludes projects planned for cooperation with support providers but not yet signed. Ongoing support refers to those projects that have commenced but have not been completed within the reporting period, while completed support refers to those projects that have commenced and have been completed within the reporting period.

(7) Identify and report the channel (bilateral, regional or multilateral): Bilateral channels refer to projects where one party is China and the other is another country or a regional alliance of countries as a whole; regional channels refer to projects where one party is China and the other is a country within a region, or where one party is a region that includes China and the other is a country or region; multilateral channels refer to projects where one party is China and the other is a multilateral institution or mechanism.

(8) Identify and report the type of support (mitigation, adaptation or cross-cutting):

Mitigation projects refer to projects primarily aimed at reducing GHG emissions or increasing removals under the UNFCCC framework. These include renewable energy (such as wind power generation, solar power generation and heat utilization, hydropower, biomass power generation, geothermal power generation and heat utilization, and ocean power generation), nuclear power, industrial energy conservation and efficiency improvement, building energy conservation and efficiency improvement, energy conservation and efficiency improvement in transportation, energy conservation and efficiency improvement in urban infrastructure, electric vehicles, ecological agriculture, emission reduction technologies and projects in industrial processes and agricultural planting and breeding, greenhouse gas reduction in waste and sewage treatment, afforestation, carbon capture, utilization and storage (CCUS), etc. Adaptation projects refer to projects primarily aimed at adapting to climate change and its adverse effects, encompassing climate change impact, vulnerability and risk assessments, adaptation planning, mitigation of adverse climate change impacts, post-disaster recovery and resilience enhancement, adaptation monitoring and evaluation, etc. These mainly include meteorological observation and monitoring, drought and flood prevention, coastal protection against tides, breeding crops resistant to drought and temperature variations, water-saving agriculture, safe drinking water in arid regions, comprehensive and efficient utilization of water resources, ecological restoration, health response systems for populations affected by heatwaves and severe cold, meteorological disaster emergency response systems, etc. Projects that serve both mitigation and adaptation purposes are classified as cross-cutting types.

(9) Identify and report the financial instrument (grant, concessional loan, non-concessional loan, equity, guarantee or other): This report only includes projects supported by grants and concessional loans, determined in accordance with general financial sector guidelines.

(10) Identify and report sectors and subsectors: According to Decision 18/CMA.1 adopted at the Conference of the Parties to the Paris Agreement, sectors in this report include energy, transportation, industry, agriculture, forestry and grassland, water resources, health, and others; subsectors are specific fields classified under these sectors, such as renewable energy, energy conservation, CCUS, and low-carbon transportation, as appropriate. Actions that encompass multiple sectors are classified as cross-cutting sectors, i.e. "multi-sector".

(11) Report on the use, impact and estimated results of the support needed and received: Where the project cooperation agreements include relevant indicators and actual effectiveness assessments, this report is based on the information provided by the project. Beyond these, due to limited capacity, this report does not assess the use, impact and estimated results of the support received.

(12) Identify and report support as contributing to technology development and transfer and capacity-building: Projects that assist China in conducting technology R&D, or involve technology transfer from developed countries to Chinese implementing entities, are considered to have attributes that support technology development and transfer.

Projects focused on climate change education and training, preparation and use of capacity-building materials, enhancement of China's climate change education and publicity capabilities, or increasing public awareness are considered to have attributes that support capacity building.

(13) Avoid double counting in reporting information on support needed and received for the implementation of Article 13 of the Paris Agreement and transparency-related activities, including for transparency-related capacity-building, when reporting such information separately from other information on support needed and received: To avoid double counting, this report includes such information only in Tables 4-7 and 4-8 and does not include it in other tables or in the total statistics for mitigation, adaptation and other capacity-building support.

Chapter 2 Financial Needs and Support Received for Addressing Climate Change

I. Financial Needs for Addressing Climate Change

(i) Financial Support needed by China to Achieve its Nationally Determined Contributions and the Long-term Goals of the Paris Agreement

The IPCC AR6 Synthesis Report highlights that climate action in developing countries is severely constrained due to inadequate climate finance input, especially for adaptation finance. As a developing country, China needs to continually strengthen its efforts in climate change mitigation and adaptation to fulfill its nationally determined contributions. Continuous, steady and large-scale financial input for addressing climate change is essential for advancing climate change mitigation and adaptation. China not only needs to fully mobilize its own public and private investment, but also needs to seek international financial support.

(ii) Scale of Financial Needs for Addressing Climate Change

The Fourth National Communication on Climate Change of the People's Republic of China, submitted in December 2023, indicates that China's annual average financial need for mitigation actions is approximately RMB 2 trillion from 2021 to 2030. To achieve the carbon neutrality goal, China is further intensifying its mitigation efforts, with an annual average financial need of about RMB 6.5 trillion for mitigation actions from 2021 to 2060. Additionally, the annual average financial need for climate change adaptation is about RMB 1.6 trillion from 2021 to 2060. Considering both mitigation and adaptation actions, China's total financial need from the reporting year (2024) to 2030 is approximately RMB 25.2 trillion, with an annual average of about RMB 3.6 trillion. The total financial need from the 2031 to 2060 is approximately RMB 243 trillion, with an annual average of about RMB 8.1 trillion.

(iii) Focal Areas of Financial Needs for Addressing Climate Change

The period before 2030 is critical for China to achieve its carbon peaking goal. China will accelerate the implementation of key carbon peaking tasks in the whole process and across all aspects of economic and social development. These tasks include actions for green and low-carbon energy transition, energy conservation, carbon emission reduction and efficiency improvement, carbon peaking in the industrial sector, carbon peaking in urban and rural construction, green and low-carbon transportation, carbon emission reduction through a circular economy, green and low-carbon technological innovation, enhancing carbon sink capacity, nationwide green and low-carbon initiatives, and regional phased and orderly carbon peaking actions. During the same period, China will carry out comprehensive actions for climate change adaptation across various sectors and regions. This includes organizing special initiatives to strengthen climate change monitoring, early warning, and risk management, improving climate change adaptation of natural ecosystems, enhancing climate change adaptation of socioeconomic systems, and establishing a regional framework for climate change adaptation.

Based on the current priorities for the mitigation and adaptation areas, some financial requirements are listed in Table 4-1.

II. Climate Finance Support Received by China

(i) Overview of Climate Financial Support Received by China

From 2020 to 2022, China received a total of US$2.62 billion in international finance through various channels, including the multilateral finance mechanism under the UNFCCC, multilateral development institutions and bilateral cooperation mechanisms, with an annual per capita support amount of only US$0.62, equivalent to 0.6% of China's own financial input in addressing climate change. The details of specific finance support projects are set forth in Table 4-2.

Classification by channels. China received US$141 million from the finance mechanism under the UNFCCC, US$407 million from bilateral channels with developed countries, and US$2.08 billion from multilateral development institutions. Multilateral development institutions served as the primary channel for China to receive the climate finance support during the reporting period.

Classification by financial instrument. US$51 million was in the form of grants and US$2.57 billion in the form concessional loans. Concessional loans constituted the vast majority of climate finance support received by China during the reporting period.

Classification by types of support. Finance support for mitigation, adaptation and cross-cutting sectors amounted to US$556 million , US$529 million and US$1.54 billion, respectively. Among these, the post-disaster recovery and reconstruction project for the severe rainstorm and flooding in Zhengzhou, Henan, received climate adaptation finance of US$528 million, while other adaptation projects received only US$937,000. Projects with both mitigation and adaptation objectives were the primary type of climate finance support received by China during the reporting period.

(ii) Climate Finance Support Received by China through Different Channels

Finance mechanism under the UNFCCC. During the reporting period, China received a total finance of US$141 million through the finance mechanism under the UNFCCC. This included grants of US$40.92 million from the Global Environment Facility (GEF) and concessional loans of US$100 million from the Green Climate Fund (GCF). As mentioned above, to avoid double counting, these statistics exclude projects related to transparency compliance. Among these projects, finance for mitigation and cross-cutting sectors accounted for 87.9% and 12.1%, respectively, with no projects specifically targeted at adaptation. These funds primarily supported actions in sectors such as energy, agriculture and industry, as well as multi-sectoral actions for biodiversity conservation and synergy in addressing climate change.

Multilateral development banks. According to incomplete statistics, China received grants worth US$9.13 million and concessional loans worth US$2.07 billion from multilateral development banks during the reporting period. These funds mainly supported fields such as agriculture, transportation, water resources and sanitation, as well as multi-sectoral actions. The Asian Development Bank (ADB) offered grants worth US$5.99 million and concessional loans worth US$594 million, which funded actions in transportation, agriculture, industry, urban and rural planning and development, climate financing, ecological protection, and disaster management; the World Bank (WB) offered grants worth US$3.14 million and concessional loans worth US$225 million, which funded agricultural management actions; the Asian Infrastructure Investment Bank (AIIB) offered concessional loans worth US$687 million to fund transportation and disaster risk management actions; the New Development Bank (NDB) offered concessional loans worth US$193 million to fund low-carbon transportation actions; the European Investment Bank (EIB) offered concessional loans worth US$367 million.

Bilateral channels. According to incomplete statistics, China received grants worth US$1.24 million and concessional loans worth US$406 million through bilateral channels during the reporting period. These funds supported climate financing, ecological protection, near-zero emission buildings, and multi-sectoral actions.

III. Challenges in Receiving Climate Finance Support

Developed countries are relatively reluctant to fund China to tackle climate change. In recent years, most of the climate finance support provided by developed countries to China has been in the form of loans. For grant projects, China often does not have control over the funds, with project operation and fund disbursement typically led by foreign institutions. As mentioned above, China is still in a stage of low per capita income and uneven development. In pursuing its carbon peaking and carbon neutrality goals, China must simultaneously address multiple challenges, including developing its economy, improving people's livelihoods and protecting its ecological environment. It still faces a significant financial gap for addressing climate change and requires support from the international community.

The concept of climate finance has become increasingly generalized, and developed countries emphasize global climate investment and financing, while downplaying their obligations to provide climate finance support. Developed countries often emphasize that the scale of worldwide climate investment and financing had hit US$1 trillion, and global capital should be fully mobilized. They try to confound their international obligations to provide climate finance to developing countries with the commercial behaviors in global investment and financing. This can prejudice the lawful rights stipulated in the UNFCCC and its Paris Agreement of developing countries including China.

Chapter 3 Technology Development and Transfer Needs and Support Received for Addressing Climate Change

I. China's Technology Needs for Addressing Climate Change

(i) Technology Development and Transfer Needs for Climate Change Mitigation

China is accelerating its transition from a coal-dominated energy structure to a green and low-carbon energy structure by vigorously deploying innovation and promotion of non-fossil energy technologies. While certain progress and experience have been gained in developing climate change mitigation technologies, there is still a need to strengthen technology innovation deployment and increase support to meet the vision for carbon peaking and carbon neutrality. In the energy sector, key technology needs to include new solar photovoltaic systems, deep-sea and ultra-large offshore wind power, ocean power generation, efficient biomass conversion and utilization, advanced nuclear energy, new energy storage, hydrogen energy, and advanced smart grids. In the industrial and other sectors, key technology needs to include low-carbon iron and steel smelting, low-carbon non-metallic mineral products, low-carbon chemicals, and new energy ships and aircraft. Additionally, carbon capture, utilization and storage (CCUS), negative emission technologies, technologies for reducing non-CO_2 greenhouse gases such as methane, fluorinated gases and nitrous oxide, and green hydrogen synthesis of ammonia under mild conditions are also priority areas for technology development and transfer support in China.

(ii) Technology Development and Transfer Needs for Climate Change Adaptation

China's vast territory and diverse climate make the cascading effects of climate change evident, leading to an even more urgent need for the development of climate adaptation technologies. Similar to other developing countries, China urgently needs to strengthen technology development and transfer support in areas such as the monitoring and early warning of multiple natural disasters and compound cascading disasters caused by climate change, adaptive decision-making and risk prevention, agricultural water-saving irrigation, crop breeding for stress tolerance and pest control, protection and restoration of sensitive ecosystems, integrated adaptation of marine and coastal zones, climate-resilient city construction, and human health effects and adaptation.

Some current technology needs are listed in Table 4-3.

II. Technology Support Received by China for Addressing Climate Change

(i) Technology Development and Transfer Support Received

From 2020 to 2022, China received support for several new technology development and transfer projects through channels such as the Global Environment Facility (GEF) and the

Green Climate Fund (GCF). In terms of content, project-related activities mainly focused on the feasibility study of technologies, capacity building, policy support and pilot demonstration, with a lack of substantive transfer targeting key technology needs.

Detailed technology support projects are listed in Table 4-4.

(ii) Typical Case Analysis

Box 4-1 China Renewable Energy Scale-up Program Phase II (CRESP II)

China Renewable Energy Scale-up Program Phase II (CRESP II), officially launched in 2013 and completed in 2022, is a phased project jointly implemented by the National Energy Administration, the Global Environment Facility (GEF), and the World Bank. Through a three-stage long-term cooperation plan, it aims at improving the economic efficiency of renewable energy development and utilization, accelerating the development of renewable energy power in China, and expediting the replacement of fossil fuels. In the context of the successful implementation and phased progress of CRESP I (2005-2012), China's renewable energy power development has initially established robust legal and regulatory measures and institutional arrangements. However, it still faces numerous technical and policy challenges, including the imbalance between renewable energy resource endowment and consumption load distribution, the mismatch between grid planning & construction and renewable energy development & utilization, and the need to improve new power system markets suitable for renewable energy power participation. To this end, CRESP II aims to overcome some of the key barriers to renewable energy development in China, accelerate large-scale development of renewable energy under a new investment landscape, control the costs of renewable energy power, enhance renewable energy grid connection capacity and reduce energy curtailment.

CRESP II received grants of US$27.28 million, which funded five types of activities, including renewable energy policy research, grid-connected consumption, technology development, pilot demonstration, and capacity building. In terms of renewable energy power technology development, key support was provided for the research on optimizing wind farm layout to reduce wake losses and maximize wind farm power output efficiency. For the grid connection scenarios of centralized renewable energy sources such as wind farms, the following activities were carried out: research on the integration of pumped storage and other energy storage technologies to address the intermittency and randomness of wind power output, enhance grid connection stability, and reduce curtailment rates; research on the layout of current collection lines in large wind farms to achieve global cost optimization in cross-regional line planning; design, development and demonstration of grid-friendly wind turbines with robust power control and fault management capabilities; research on large-scale grid connection simulation of wind power PV systems; support for international expert teams in providing training on solar thermal power generation engineering design to relevant institutions, as well as in the design optimization of solar thermal power stations and the research and development of key components and control systems. The project outcomes supported the formulation of national policies, such as the renewable energy development plan and the renewable energy power consumption guarantee mechanism. The optimization plans for the layout of large-scale onshore wind power bases have been applied to wind power base construction in Inner Mongolia, Qinghai, and other regions. Methods for coordinated development and planning of renewable energy and grid infrastructure in the northwest region have been promoted within the State Grid system, facilitating the large-scale consumption of renewable energy. The project also contributed to the development of multiple national technical standards for offshore wind turbines and the benchmarking with international engineering standards. It introduced planning, design and evaluation methods for DC grid integration systems suitable for the construction and development of offshore wind farms in China, and supported the construction of the national offshore wind turbine testing center. According to estimates, the project implementation supported an annual increase in wind power generation of 1,024 GWh, replacing the consumption of 3 million tons of standard coal and reducing carbon dioxide emissions by 9.16 million tons.

III. Challenges in Receiving Technology Support

Overall, the technology development and transfer support projects conducted by China have played a positive role in providing reference to excellent international practices, optimizing the domestic policy framework and technology promotion environment, enhancing domestic planning, design and manufacturing capabilities, and conducting capacity-building training for technical personnel. However, there was a lack of substantive transfer targeting China's key technology needs, resulting in limited improvement in the domestic technological innovation and development capacity. As a developing country, China actively participates in international cooperation on climate technology development and transfer. However, in recent years, like many other developing countries, China still faces various challenges in obtaining effective technology transfer and support.

First, policies in developed countries concerning supply chain security, technology export control and foreign investment security review have hindered the transfer of climate friendly technologies. In recent years, with the rise of anti-globalization and generalization of national security concepts, developed countries tend to prioritize ensuring domestic supply chain security and industrial advantages, and their initiative in transferring climate friendly technologies to foreign countries has weakened. They have formulated trade restrictions or technology blockade policies in some areas. Some developed countries, concerned about the acquisition of advanced technologies by developing countries, have intensified security review on foreign investment, therefore posing adverse impacts on the transfer of climate change response technologies to relevant industries (particularly to developing countries).

Second, barriers to technology flow of multinational companies have intensified. At present, most advanced climate technologies remain in the hands of private sectors in industrialized countries. In order to maximize profits and maintain technology monopoly advantages, the main foreign investment approach of multinational companies has evolved from joint venture towards majority shareholding and sole proprietorship, or confine technology transfers to their overseas branches within the scope of property and control rights, the essence of which is to block the transfer of relevant technologies to obtain technology monopoly value and secure market advantages in host countries.

Third, the current international mechanisms have failed to effectively support developing countries in acquiring climate technologies. As the implementing agency of the Technology Mechanism of the UNFCCC, the Climate Technology Centre and Network (CTCN) serves as a crucial channel for responding to technology requests from developing countries and providing technical assistance. However, it has long faced challenges due to insufficient finance for its operation. The limited personnel, resources and capabilities of Nationally Designated Entities (NDEs) in developing countries also pose significant constraints. The Clean Development Mechanism (CDM) projects under the Kyoto Protocol contributed to climate technology development and transfer to a certain extent. However, relying on CDM projects has limited the scope of technology transfer, causing a need for stronger measures or mechanisms to promote the transfer of relevant technologies to developing countries.

Fourth, there is a lack of mechanisms for sharing and matching technology supply and demand information. Developing countries such as China have identified key areas and priority technologies suited to their national circumstances through Technology Needs Assessment (TNA). However, due to the lack of effective platforms and mechanisms for sharing information about suitable advanced technology suppliers and relevant technical information, it is difficult to match technology supply with demand, thus hindering developing countries from acquiring climate technologies. The technology framework under the Paris Agreement calls for the Technology Mechanism to take action in identifying and developing approaches, tools and means for the assessment of the technologies that are ready to transfer, but no significant progress has been made.

Chapter 4 Capacity-Building Needs and Support Received for Addressing Climate Change

I. China's Capacity-Building Needs for Addressing Climate Change

China will be in need of more capacity-building support in the following areas:

(i) Capacity Building for Foundational Support on Climate Change

Climate monitoring, evaluation and early warning system. Reinforce the support of new-generation information technology in climate change monitoring, impact assessment and evaluation, establishing a climate change monitoring and evaluation system in a dynamic and systematic manner; conduct climate feasibility studies in national territorial spatial planning and strengthen early warning and risk management of extreme climate events.

Greenhouse gas accounting system. Improve the verification standards for carbon emission accounting reports for regions, industries, enterprises and products, and establish a unified and standardized carbon accounting system; establish a monitoring and accounting system for ecosystem carbon sinks; strengthen capacity building in carbon emission statistics and accounting, and build a carbon emission database, a national GHG emission factor database, and a carbon emission monitoring and management platform to enhance the level of information-based measurement.

(ii) Capacity building for institutional management for addressing climate change

Climate action coordination and collaboration mechanism. Establish and improve coordination and information sharing mechanisms for addressing climate change, and build a collaborative innovation work model featuring multi-sectoral coordination, multi-subject coordination, and mass participation.

Management capacity for addressing climate change. Encourage local governments, enterprises, social organizations and research institutions to integrate climate change considerations into their organizational structures, business areas and work processes, thereby enhancing their comprehensive decision-making and management capabilities in addressing climate change.

(iii) Capacity Building for Publicity and Education on Climate Change

Talent development. Strengthen climate change education in schools, improve the climate change-related academic and professional systems in higher education institutions, and cultivate innovative talents for addressing climate change.

Capacity training. Strengthen climate-related training for cadres and skills training for professionals, and expand continuing education channels for addressing climate change.

Publicity. Conduct science popularization activities on green, low-carbon, and climate-adaptive measures, innovate climate change publicity means through multimedia and new media channels, and develop public practice projects on addressing climate change.

Some of the current capacity-building needs are listed in Table 4-5.

II. Capacity-Building Support Received by China for Addressing Climate Change

(i) Capacity-Building Support Received by China for Addressing Climate Change

From 2020 to 2022, the capacity-building support received by China focused on improvements in transparency compliance, enhancement in climate policy formulation capacity, talent development and cooperation. Projects related to capacity-building support are all included in "Table 4-2 Financial Support Received by China for Addressing Climate Change". According to the reporting guidelines, some typical capacity-building support projects are listed in Table 4-6.

Through multilateral channels and with the support from GEF, China has successively launched the Capacity Building for Enhanced Transparency Phase I and the Capacity-building Project for the Preparation of the Fourth National Communication and the Biennial Update Reports on Climate Change, as detailed in Chapter 5 of this section. With the support from the finance mechanism under the UNFCCC and multilateral development banks, China has carried out capacity-building activities across key sectors such as transportation, industry, agriculture and forestry. These activities include improving the climate policy framework, organizing pilot demonstration and innovation, and promoting the establishment of collaborative mechanisms.

The capacity-building support received by China from bilateral channels primarily consists of research cooperation and specialized training. Some developed countries have signed memoranda of understanding with the Chinese government (including local governments), universities and research institutions to establish joint research centers and scientific cooperation projects, and carry out specialized training on capacity building for addressing climate change, covering topics such as synergy between pollution control and carbon reduction, near-zero emission buildings, and climate prediction models. Capacity building takes the form of providing analytical tools, sharing successful experiences, and exchanging expertise.

(ii) Typical Case Analysis

Box 4-2 EU-China Emissions Trading System (ETS) Project

China and the EU have engaged in close cooperation on carbon market capacity building for many years. From 2014 to 2017, China and the EU completed the EU-China Carbon Trading Capacity Building Project. In 2017, they launched the EU-China ETS Project, which has been extended into its second phase from 2021 to the present. The EU-China ETS Project, led by the European Commission's Directorate-General for Climate Action and the Ministry of Ecology and Environment of the People's Republic of China, aims to continue supporting China in building a national carbon market through capacity-building activities.

The capacity-building activities of this project include: regularly organizing carbon market policy dialogues to enhance the understanding of Chinese policymakers and stakeholders on how carbon markets support the implementation of the Paris Agreement goals; conducting capacity training for China's carbon market authorities and relevant enterprises to strengthen China's ability to operate its national carbon market; providing practical recommendations to China's carbon market authorities through joint research, further supporting the development of China's carbon market and expanding new areas of EU-China cooperation on carbon market-related topics.

From 2020 to 2022, a total of 44 carbon market capacity-building training sessions have been conducted across 18 provinces (autonomous regions and municipalities), including Guangdong, Hainan, Ningxia, Jiangsu and Chongqing, with nearly 6,200 participants comprising local ecological and environmental officials and representatives from key emitting enterprises. These training sessions further enhanced local departments' and enterprises' familiarity with carbon market construction and helped accumulate knowledge and experience related to regional low-carbon development. The project also launched online training for the power industry. The first training session introduced the latest policy requirements, advanced peer experience and case studies to 139 representatives from various power companies, to meet the need of power companies for improving their carbon market compliance capabilities. The project included several joint studies, including study on information disclosure for national carbon market regulation, industry benchmark study, and study on allocation methodologies for the national carbon market quotas for promoting the achievement of carbon peaking and carbon neutrality goals. It organized multiple joint technical seminars covering topics such as carbon market launch preparations and risk control, key issues in the construction and development of China's carbon market, and emission factor values for enterprise GHG emission accounting. The project also supported the third EU-China Ministerial Carbon Emissions Trading Policy Dialogue, where both sides exchanged views on the latest progress in carbon emissions trading and future EU-China cooperation in this area.

Overall, the EU-China ETS Project has achieved remarkable results in advancing the construction of China's national carbon market. It has enhanced the understanding and participation of Chinese government authorities at various levels and key emitting enterprises regarding carbon market operation, provided technical research support for the design of China's carbon market, and laid a solid foundation for the conti nued deepening of EU-China cooperation in carbon markets.

III. Problems and Challenges

The effectiveness of capacity-building support requires a more systematic and comprehensive evaluation. Compared with financial and technical support, most capacity-building efforts lack evaluation methods to measure their effectiveness, making it difficult to identify areas and methods for improvement. This includes areas such as enhancing compliance capacity, refining policy development, establishing coordination mechanisms, and raising public awareness.

There is a lack of mechanisms for sharing and matching information on the supply and demand of capacity-building support. Although developing countries such as China have identified their capacity-building needs for addressing climate change through Nationally Determined Contributions, National Communications, Biennial Update Reports, Biennial Transparency Reports, Adaptation Communication, National Adaptation Plans, and Technology Needs Assessments, a comprehensive, transparent and open information platform for capacity-building resource supply and a matching mechanism have yet to be established. As a result, developing countries face difficulties in acquiring timely and effective capacity-building support, including climate finance support and technology support related to capacity-building.

Chapter 5 Needs and Support Received for Enhancing Transparency in Compliance Efforts

I. China's Needs for Enhancing Transparency in Compliance Efforts

The Chinese government attaches great importance to compliance under the UNFCCC. The Ministry of Ecology and Environment has gradually established a stable technical support team for compliance under the UNFCCC and organized experts involved in the negotiation of transparency compliance rules to conduct multiple capacity-building training sessions and seminars targeting relevant industry authorities and compliance report authors. However, in terms of implementing the new requirements of the "modalities, procedures and guidelines" for the enhanced transparency framework under the Paris Agreement, China still faces the following difficulties and challenges in compliance.

In terms of inventory preparation, it is necessary to further establish and improve the data collection and statistics mechanism, strengthen the capacity for measurement and analysis of localized GHG emission/removal factors, develop and improve the database management platform, and enhance data quality control and assurance functions of the database.

In terms of reporting progress in nationally determined contributions and mitigation effectiveness evaluation actions, it is necessary to research and develop methodologies for rapid carbon emissions accounting and forecasting, create methodologies for disaggregating emission reductions to avoid double counting of mitigation effects, improve the capacity to identify and apply methodologies for quantifying effectiveness, enhance the capacity to evaluate the implementation effect of the "1+N" policy system for carbon peaking and carbon neutrality, and strengthen the assessment of the synergies of NDCs.

In terms of adaptation, it is necessary to research and establish a reporting mechanism for climate change impacts and adaptation, enhance the capacity to analyze the climate change characteristics and develop future climate change scenarios, improve the capacity to analyze climate change impacts, risks and vulnerabilities, strengthen the capacity to identify climate change adaptation goals, priorities, and the challenges or barriers faced, and improve the capacity to monitor, evaluate and report the progress on adaptation policies.

In terms of reporting the finance, technology and capacity-building support needed and received, it is necessary to develop cost-benefit analysis methodologies for calculating the needs of each sector and/or each type of mitigation action, explore the establishment of a bottom-up centralized statistical mechanism and data reporting platform for receiving information on the finance, technology and capacity-building support activities.

Based on the above needs, preliminary analysis indicates that from 2024 to 2030, China's financial need to enhance compliance transparency could reach tens of millions of US dollars annually. Some of the financial needs are listed in Table 4-7.

For example, in the measurement and analysis of the national GHG inventory as well as the development, construction, operation and maintenance of the database system, an average annual expenditure of approximately US$18 million and US$0.9 million, respectively, will be required over the next five years. The specific calculation details are provided in Box 4-3.

Box 4-3 Finance, Technology and Capacity-building Needs for GHG Emission Factor Measurement and Database Construction

01 Measurement and Analysis of National GHG Inventory Factors

Based on the specific requirements for preparing an inventory covering seven types of greenhouse gases from five major sectors - energy, industrial processes, agriculture, land use, land-use change and forestry (LULUCF), and waste, activities include matching with relevant activity level data, factor investigation, monitoring, measurement and analysis. The budget amounts for these activities are US$5.5 million/year, US$2.5 million/year, US$4.5 million/year, US$3 million/year and US$2.5 million/year, respectively, totaling US$18 million/year. In this process, there is also a need for technology and capacity-building support for the measurement and analysis of emission factors.

02 Development, Construction, Operation and Maintenance of Database System

A high-quality compliance-related database will encompass core modules covering the national GHG inventory, NDC progress and related policy measures, climate change adaptation policies and vulnerability assessments, finance, technology and capacity-building support, as well as support modules for international expert panel review and multilateral review processes. The development activities will include prototype design, interaction design, system design, system R&D, system testing, acceptance and launch, requiring a total budget of US$2 million. Subsequent system deployment and continuous operation and maintenance are estimated at US$500,000/year. In this process, there is also a need for technology and capacity-building support in areas such as database development design concepts and module configuration.

Although China received funding of US$250,000 from GEF during the actual preparation process, estimates indicate that fully and effectively completing the 1BTR to a high standard would cost over US$2 million, as detailed in Box 4-4.

Box 4-4 Funding, Technology and Capacity-building Needs for High-quality Compliance

01 National GHG Inventory

To complete this part of the compliance report, the following activities are required: conduct key category analysis to determine the methodological tiers for GHG inventory preparation; summarize and sort out official basic statistics, facility-level data from national carbon market enterprises, and relevant information of industry associations; invite relevant authorities and industry associations to perform quality control on activity level data through peer review; conduct measurement of emission factors and related parameters for the national GHG inventory; complete national GHG inventory tables for each sector according to the common reporting format, using tools issued by the UNFCCC Secretariat ; implement quality assurance/quality control of inventory data; perform uncertainty analysis on the national GHG inventory results and propose improvement plans for inventory preparation; conduct capacity-building training for the inventory preparation team.

The above activities are estimated to cost at least US$800,000.

02 NDC Mitigation Progress

To complete this part of the compliance report, it is necessary to establish a reporting mechanism for NDC mitigation-related information, continuously enhance the capacity to track NDC-related information, improve the capacity to evaluate the implementation effect of the "1+N" policy system for carbon peaking and carbon neutrality, strengthen the capacity to manage tracking data for climate change mitigation policies and actions, enhance the assessment of the synergies of NDCs, and summarize the relevant information.

The above activities are estimated to cost at least US$400,000.

03 Climate Change Impacts and Adaptation

To complete this part of the compliance report, the following activities are required: analyze the spatio-temporal evolution of major extreme climate events and natural disasters in China, develop downscaling techniques suitable for the regional scale of China, and conduct quantitative modeling studies on the relationship between disaster-causing meteorological conditions and disaster losses; assess the impacts of observed climate change on natural ecosystems, socio-economic systems, and sensitive or vulnerable regions; conduct climate change impact and risk assessments for key sectors and regions; develop methodologies for monitoring and evaluation of climate change adaptation policies and actions; establish a provincial-level evaluation index system for climate change adaptation; collect and sort out typical cases of nature-based solutions for climate change adaptation from both domestic and international sources, and track and assess the progress of international climate change adaptation actions.

The above activities are estimated to cost at least US$300,000.

04 Finance, Technology and Capacity-building Support Needed and Received

To complete this part of the compliance report, the following activities are required: conduct an analysis of priorities for funding, technology and capacity-building for addressing climate change; organize research and analysis on institutional arrangements and challenges for identifying, tracking and reporting information on funding, technology and capacity-building support; develop a foundational methodological guide on the support needed, received and provided for addressing climate change. The focus should be on refining the granularity of information on funding, technology and capacity-building support for addressing climate change, and organizing various special assessments of information related to finance, technology and capacity-building support for addressing climate change as required by the implementation rules of the Paris Agreement, including finance needs assessment, technology needs assessment, capacity-building needs assessment, assessment of existing support, and assessment of support provided externally.

The above activities are estimated to cost at least US$250,000.

05 Supporting the Hong Kong Special Administrative Region and the Macao Special Administrative Region to Prepare GHG Inventories and Complete Relevant Parts of the Compliance Report

To complete this part of the compliance report, it is necessary to organize experts in relevant fields to carry out capacity-building activities in the Hong Kong Special Administrative Region (HKSAR) and the Macao Special Administrative Region (MSAR), with the purpose of enhancing the ability of the government staff and their support teams to prepare inventories in accordance with the 2006 IPCC Guidelines and to compile compliance reports in accordance with the implementation rules of the Paris Agreement.

The above activities are estimated to cost at least US$50,000.

06 Compiling and Translating the Compliance Report, and Undergoing International Technical Expert Review and Multilateral Review

Compile and translate the compliance report; undergo the international technical expert review organized by the UNFCCC Secretariat and the facilitative multilateral review at the sessions of the subsidiary bodies to the Parties of the UNFCCC; continuously optimize and improve the mechanisms for preparing climate change compliance reports to meet the requirements of the implementation rules of the Paris Agreement; conduct capacity-building for relevant departments involved in compliance report preparation to enhance their preparation capabilities.

The above activities are estimated to cost at least US$200,000.

II. Support Received by China for Enhancing Transparency in Compliance Efforts

(i) Support Provided by the UNFCCC Mechanism

In accordance with decisions adopted at the Conference of the Parties to the UNFCCC, GEF has provided China with finance support totaling approximately US$6.466 million for the projects "Enabling China to Prepare its Fourth National Communication and Biennial Update Report on Climate Change" "China Capacity Building for Enhanced Transparency Phase I" and "Enabling China to Prepare Its First Biennial Transparency Reports on Climate Change under UNFCCC". The project "Enabling China to Prepare its Fourth National Communication and Biennial Update Report on Climate Change" directly supports China in completing its Fourth National Communication, Third Biennial Update Report, and Fourth Biennial Update Report. The project "China Capacity Building for Enhanced Transparency Phase I" focuses on the enhanced transparency framework requirements of the Paris Agreement, and conducts in-depth capacity enhancement research and design activities at the national, local, enterprise, and platform levels, covering transparency-related methodology research, institutional design, and data platforms.

The Consultative Group of Experts (CGE) under the UNFCCC and its Paris Agreement, the UNFCCC Secretariat, UNDP, UNEP, and other organizations have also provided a range of capacity-building support for China's transparency compliance efforts, including online training on enhanced transparency, national GHG inventory preparation, and workshops on topics such as data collection for national GHG inventory preparation, uncertainty analysis methods, and tracking of NDC targets.

(ii) Support Provided by Developed Countries

Some developed countries have provided finance and capacity-building support to China's transparency compliance support team, including supporting China in conducting a transparency compliance gap analysis, identifying difficulties and challenges in the transition from the 1996 IPCC Guidelines to the 2006 IPCC Guidelines, and improving data collection mechanisms; supporting China's participation in transparency compliance capacity-building training seminars, facilitating full communication and exchange with developed countries and other developing countries to learn about good international experiences and practices.

China looks forward to receiving further finance, technology and capacity-building support in the preparation of future compliance reports. This will help China gradually establish a more complete transparency compliance model and continuously enhance its compliance capabilities.

(iii) Others

China's compliance report preparation team has also participated in the biennial transparency report training and exchange sessions organized by Azerbaijan, the Partnership on Transparency in the Paris Agreement (PATPA), the NDC Partnership, and some developing countries, and has received capacity-building support from the Initiative for Climate Action Transparency (ICAT).

Table 4-1 Financial Support needed by China to Address Climate Change[43]

Sector	Subsector	Title of activity, programme, project or other	Programme/ project description	Estimated amount (Domestic currency)	Estimated amount (climate-specific) (Domestic currency)	Expected time frame	Expected financial instrument	Type of support	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Expected use, impact and estimated results
Energy	Renewable energy and electricity	Action for green and low-carbon energy transition	Promote nationwide renewable energy deployment. Promote the substitution, transformation and upgrading of coal consumption, vigorously develop new energy, develop hydropower according to local conditions, develop nuclear power in an active, safe and orderly manner, rationally regulate oil and gas consumption, and accelerate the construction of a new power system.	Over 6 trillion	Over 6 trillion	2024-2030	Grant and concessional loan	Mitigation	NA[44]	NA	Support the development of renewable energy and the green and low-carbon energy transition
Energy	Energy conservation	Action for energy conservation, carbon emission reduction and efficiency improvement	Comprehensively improve energy conservation management capabilities, implement key projects for energy conservation and carbon emission reduction, promote energy conservation and efficiency improvement in key energy-consuming equipment, and strengthen energy conservation and carbon emission reduction in new infrastructure.	781.5 billion	781.5 billion	2024-2030	Grant and concessional loan	Mitigation	NA	NA	Support energy conservation and carbon emission reduction
Industry	Low-carbon industry	Action for carbon peaking in the industrial sector	Promote energy conservation and efficiency improvement in key energy-consuming equipment, and advance carbon peaking in the steel industry, non-ferrous metals industry and non-metallic minerals industry.	355.6 billion	355.6 billion	2024-2030	Grant and concessional loan	Mitigation	NA	NA	Support carbon peaking in the industrial sector
Construction	Urban and rural construction	Action for carbon peaking in urban and rural construction	Promote the green and low-carbon transformation in urban and rural construction, accelerate the improvement of building energy efficiency, accelerate the optimization of the energy structure in buildings, and advance the low-carbon transformation in rural construction and energy consumption.	647.0 billion	647.0 billion	2024-2030	Grant and concessional loan	Mitigation	NA	NA	Support carbon peaking in urban and rural construction
Transport	Low-carbon transportation	Action for green and low-carbon transportation	Promote the low-carbon transformation of transportation vehicles and equipment, build a green and efficient transportation system, and accelerate the construction of green transportation infrastructure.	822.7 billion	822.7 billion	2024-2030	Grant and concessional loan	Mitigation	NA	NA	Support low-carbon transportation

[43] Calculations conducted by relevant research institutions.
[44] "NA" indicates that the technology needs and capacity building needs will be respectively reported in Table-3 and Table-5, and will not be presented here.

Sector	Subsector	Title of activity, programme, project or other	Programme/ project description	Estimated amount (Domestic currency)	Estimated amount (climate-specific) (Domestic currency)	Expected time frame	Expected financial instrument	Type of support	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Expected use, impact and estimated results
Multi-sector	Circular economy	Action for carbon emission reduction through a circular economy	Promote the circular development of industrial parks, strengthen the comprehensive utilization of bulk solid waste, improve the resource recycling system, and vigorously advance the reduction and recycling of household waste.	38.2 billion	38.2 billion	2024-2030	Grant and concessional loan	Mitigation	NA	NA	Develop circular economy
Multi-sector	Low-carbon technologies	Action for green and low-carbon technological innovation	Improve innovation systems and mechanisms, strengthen innovation capacity building and talent development, enhance basic applied research, and accelerate the R&D and promotion of advanced applicable technologies.	827.8 billion	827.8 billion	2024-2030	Grant	Cross-cutting	NA	NA	Develop low-carbon technologies
Multi-sector	Carbon sink	Action for enhancing carbon sink capacity	Reinforce the carbon fixation function of ecosystems, enhance carbon sink capacity of ecosystems, strengthen foundational support for ecosystem carbon sinks, and promote emission reduction and carbon fixation in agriculture and rural areas.	895.2 billion	895.2 billion	2024-2030	Grant	Mitigation	NA	NA	Increase carbon sinks
Multi-sector	Public education	Nationwide green and low-carbon initiatives	Strengthen ecological civilization publicity and education, promote green and low-carbon lifestyles, guide enterprises in fulfilling social responsibilities, and enhance training for leading cadres.	71.1 billion	71.1 billion	2024-2030	Grant	Cross-cutting	NA	NA	Empower the public to to address climate change
Multi-sector	Regional transition	Regional phased and orderly carbon peaking actions	Set orderly carbon peaking targets in a scientific and reasonable manner, promote green and low-carbon development according to local conditions, coordinate at multiple levels to develop regional carbon peaking plans, and organize carbon peaking pilot projects.	901.1 billion	901.1 billion	2024-2030	Grant and concessional loan	Mitigation	NA	NA	Support regional carbon peaking
Multi-sector	Meteorological observation	Climate and climate change observation network	Establish a well-structured, rationally distributed, fully functional, professionally standardized, scientifically managed, stable and reliable observation network for reference radiation observation, atmospheric background observation, stereoscopic ozone observation, greenhouse gas and carbon monitoring, and cryosphere and ecosystem observation on the Qinghai-Tibet Plateau. Strengthen the construction and protection of meteorological observation environment.	250.6 billion	250.6 billion	2024-2030	Grant	Adaptation	NA	NA	Enhance meteorological observation capabilities

Sector	Subsector	Title of activity, programme, project or other	Programme/ project description	Estimated amount (Domestic currency)	Estimated amount (climate-specific) (Domestic currency)	Expected time frame	Expected financial instrument	Type of support	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Expected use, impact and estimated results
Multi-sector	Ecological protection and restoration	Key projects for marine and coastal ecosystem conservation; technologies for ecosystem protection and restoration in climate-sensitive areas	Promote comprehensive ecological environment management projects for bays, consolidate and deepen the achievements in the comprehensive management of the Bohai Sea, and implement comprehensive management actions in the adjacent sea areas of the Yangtze River Estuary-Hangzhou Bay and Pearl River Estuary; coastal ecosystem protection and restoration projects: guided by the restoration of coastal ecosystem structure and the enhancement of service functions, while also strengthening the adaptive capacity of coastal ecosystems to climate change; advance the improvement of resilience and adaptability of ecosystems related to forests, grasslands, wetlands, deserts, oceans, protected natural areas and species, and implement the Three-North Shelterbelt Forest Program in arid and semi-arid regions, and forest management actions in the Yangtze River Basin and its south, as well as in traditional forest areas in Northeast and Southwest China.	77.8 billion	77.8 billion	2024-2030	Grant	Adaptation	NA	NA	Support adaptive capacity of oceans and coastal zones; enhance climate resilience of ecosystems in climate-sensitive areas
Agriculture	Climate-adaptive agriculture	Special action for climate change adaptation in agriculture and food systems	Carry out demonstration of climate change adaptation technologies in agriculture, pilot demonstration of climate-smart agriculture, and certification of climate-friendly low-carbon agricultural products.	763.3 billion	763.3 billion	2024-2030	Grant and concessional loan	Adaptation	NA	NA	Support climate change adaptation in agriculture
Multi-sector	Public health	Special action for health adaptation to climate change	Conduct specialized research on health adaptation to climate change, develop guidelines, standards and adaptation implementation plans for health risk assessment of climate change and extreme weather-climate events, and carry out demonstration projects for health adaptation actions in response to climate change and extreme weather-climate events.	148.7 billion	148.7 billion	2024-2030	Grant	Adaptation	NA	NA	Support climate change adaptation in the health sector

Sector	Subsector	Title of activity, programme, project or other	Programme/ project description	Estimated amount (Domestic currency)	Estimated amount (climate-specific) (Domestic currency)	Expected time frame	Expected financial instrument	Type of support	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Expected use, impact and estimated results
Multi-sector	Urban construction	Special action for urban adaptation to climate change	Promote infrastructure connectivity across urban clusters and metropolitan areas, mutual recognition and sharing of public services, joint protection and governance of the ecological environment, and coordinated prevention and control of climate risks; advance pilot projects for climate-adaptive cities, strengthen flood control and drainage in key flood control cities and cities along major rivers, and address infrastructure shortcomings in county towns, county-level cities and large towns; promote research on the mitigation and adaptation of urban ecosystems to climate change.	689.7 billion	689.7 billion	2024-2030	Grant	Adaptation	NA	NA	Support urban adaptation to climate change

Table 4-2 Financial Support Received by China for Addressing Climate Change

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
1	Green Climate Fund - Shandong Green Development Fund Project	The project aims to establish a transformative green financing mechanism that combines funds from international financial institutions with private, institutional and commercial funds as well as local government funds to jointly finance relevant projects in Shandong Province. The project is financed by loans from four international organizations, including a US$100 million loan from the Green Climate Fund.	Multilateral	MOF	Shandong Green Capital Investment Group Co., Ltd.	100,000,000	2020-2026	Concessional loan	Received (in part)	Mitigation	Multi-sector	Climate financing	No	Yes	Ongoing
2	World Bank - Hubei Smart and Sustainable Agriculture Project	The project aims to promote environmentally sustainable and climate-smart agriculture and improve the quality and safety of agricultural products. The project consists of three components: first, agricultural practice demonstration and replication; second, demonstration and replication of smart sustainable agricultural practices; third, project and knowledge management.	Multilateral	MOF	Hubei Provincial Department of Agriculture and Rural Affairs	75,000,000	2021-2025	Concessional loan	Received (in part)	Cross-cutting	Agriculture	Agricultural management	Yes	Yes	Ongoing
3	World Bank - Henan Green Agriculture Fund Project - Loan	The project aims to validate the feasibility of green agriculture investment, improve the green agriculture standard system, and promote the innovation and application of green agriculture standards and technologies.	Multilateral	MOF	Henan Agri-Investment Fund Management Company	150,000,000	2020-2026	Concessional loan	Received (in part)	Cross-cutting	Agriculture	Agricultural management	No	Yes	Ongoings
4	New Development Bank - Anhui Province Roads Development Project	The project includes: "Green" Roads Development in Anhui Province, mainly including construction/upgrading of six road sections in five municipalities in Anhui Province. Total mileage for construction and upgrading is about 196 km; Pilot of Technologies for	Multilateral	MOF	Anhui Provincial Department of Transport	193,203,773	2022-2026	Concessional loan	Received (in part)	Cross-cutting	Transport	Low-carbon transportation	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
		Sustainable Road Development; capacity building to support project preparation, implementation, management and operation.													
5	European Investment Bank - Imar Tongliao Sand Dunes Shelterbelt Forest	The project aims to finance the implementation of a comprehensive investment plan for desertification prevention and control through the implementation of an afforestation and sustainable forestry management program in the Horqin Sandy Land in Tongliao City, Inner Mongolia Autonomous Region. The project covers a total area of approximately 138,000 hectares.	Multilateral	MOF	Tongliao Municipal People's Government, Inner Mongolia	366,510,000	2020-2025	Concessional loan	Committed	Cross-cutting	Forestry and grassland	Sandy land management	No	No	Ongoing
6	Asian Infrastructure Investment Bank - Liaoning Green Smart Public Transport Demonstration Project	The project aims to improve the quality and efficiency of public transportation service and urban environment by replacing conventional fossil-fueled buses with battery electric buses (BEBs) and applying digital technology to public transport management systems in five small and medium cities of Liaoning Province.	Multilateral	MOF	Public Transport Companies of Jinzhou, Yingkou, Fuxin, Panjin, and Huludao Municipalities, Liaoning Province	158,821,000	2021-2026	Concessional loan	Received (in part)	Mitigation	Transport	Low-carbon transportation	No	Yes	Ongoing
7	Asian Infrastructure Investment Bank - Henan Flood Emergency Rehabilitation and Recovery Project	The project objectives are (1) to support the post-disaster rehabilitation and recovery in the municipalities of Zhengzhou, Xinxiang, and Jiaozuo of Henan Province, and (2) to strengthen the capacity of the three municipalities in integrated flood risk management and flood emergency response.	Multilateral	MOF	Zhengzhou (Water Resources Bureau, Urban Construction Bureau, Highway Development Center), Dengfeng (Water	528,385,250	2021-2026	Concessional loan	Received (in part)	Adaptation	Multi-sector	Water Resources, transportation, municipal administration, and emergency management	Yes	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
					Resources Bureau), Xinxiang (Transport Bureau, Housing and Urban-Rural Development Bureau, Emergency Management Bureau), Weihui (Water Resources Bureau), Jiaozuo (Water Resources Bureau, Housing and Urban-Rural Development Bureau, Emergency Management Bureau, Agriculture and Rural Affairs Bureau of Macun District, Water Resources Bureau of Xiuwu County)										

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
8	Asian Development Bank - Jilin Yanji Low-Carbon Climate-Resilient Healthy City Project	The project aims to improve urban livability of medium-sized cities by providing integrated solutions, contribute to regional public health, enhanced air and water quality, and revitalize economically struggling areas in Northeast China.	Multilateral	MOF	Yanji Municipal People's Government, Jilin Province	38,280,000	2020-2027	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Urban and rural planning and construction	No	Yes	Ongoing
9	Asian Development Bank - Henan Dengzhou Integrated River Restoration and Ecological Protection Project	The project will implement integrated water resource management, focusing on upstream-downstream linkages and urban-rural integration. It aims to improve the urban and rural water infrastructure in Dengzhou Municipality, restore the ecological regions of the Hanjiang River, and enhance water resource management capacity.	Multilateral	MOF	Dengzhou Environmental Protection Bureau, Water Resources Bureau, Urban-Rural Integrated Development Pilot Zone Management Committee, and Dengzhou Project Office	22,080,000	2020-2026	Concessional loan	Received (in part)	Cross-cutting	Water and sanitation	Water resource management	No	Yes	Ongoing
10	Asian Development Bank - Anhui Huangshan Xin'an River Ecological Protection and Green Development Project	The project will promote ecological protection and green development by: establishing and applying international best practices in the management of point source water pollution in urban areas; introducing new financing mechanisms to improve the management of agriculture-based non-point source water pollution; promoting green development in rural areas through piloting small and medium-sized green businesses.	Multilateral	MOF	Anhui Provincial Finance Department, Huangshan Municipal People's Government	15,510,000	2020-2026	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Ecological protection; climate financing; urban and rural planning and construction	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
11	Asian Development Bank - Air Pollution Control Financing Support in the Beijing-Tianjin-Hebei Region (Bank of Xingtai Green Finance Development Project)	The project aims to promote industrial transformation and green development in Hebei Province while expanding the scale of green finance provided by urban and rural commercial banks in Hebei Province.	Multilateral	MOF	Bank of Xingtai, Hebei Province	63,000,000	2020-2027	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Climate financing	No	Yes	Ongoing
12	Asian Development Bank - Xiangtan Low-Carbon Transformation Sector Development Program	This project aims to achieve Xiangtan Municipality's carbon peaking target by 2028 and facilitate the implementation of its low-carbon support systems.	Multilateral	MOF	Hunan Provincial Department of Finance, Xiangtan Municipal People's Government	12,100,000	2020-2026	Concessional loan	Received (in part)	Mitigation	Multi-sector	Low-carbon planning	No	Yes	Ongoing
13	Asian Development Bank - Shaanxi Green Smart Transport and Logistics Management Demonstration Project	The project aims to strengthen green economic development in Shaanxi Province and improve low-carbon, efficient and environmentally friendly logistics services in the province.	Multilateral	MOF	Shaanxi Provincial Department of Finance, Foreign Capital Utilization Center of Shaanxi Provincial Department of Transportation	133,660,000	2021-2027	Concessional loan	Received (in part)	Cross-cutting	Transport	Low-carbon transportation	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
14	Asian Development Bank - Hunan Miluo River Disaster Risk Management and Comprehensive Environment Improvement Project	The project aims to improve rural revitalization and the environment in Pingjiang County, Hunan. The innovative design integrates nature-based solutions to address climate change and ecological pressures, which can be replicated in other areas of the Yangtze River Economic Belt and across other provinces in China, providing a reference for ADB member countries facing similar challenges.	Multilateral	MOF	Pingjiang County Government	8,940,000	2021—2027	Concessional Loan	Received (in part)	Cross-cutting	Multi-sector	Disaster risk management	No	Yes	Ongoing
15	Asian Development Bank - Jiangxi Ganzhou Rural Vitalization and Comprehensive Environment Improvement Project	The project will promote rural revitalization and ecological protection in Ganzhou City, Jiangxi Province, by: enhancing regional and local ecological and environmental management capacities; promoting rural transformation and the transition toward green development in the region; developing rural environmental infrastructure to address environmental degradation caused by economic development; improving ecosystem protection in the region to enhance the living environment.	Multilateral	MOF	Jiangxi Provincial People's Government, Ganzhou Municipal People's Government, and its subordinate Development and Reform Commission and Finance Bureau	79,940,000	2021-2028	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Ecological protection; urban and rural planning and construction	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
16	Asian Development Bank - Henan Xichuan Integrated Ecological Protection and Environmental Improvement Project	The project will promote environmental improvement and green development in ecologically sensitive rural areas by: strengthening capacity-building of the Xichuan County Government in environmental planning and management; facilitating soil and water conservation efforts through advanced technologies, including remote sensing, intelligent drip irrigation, and landscape-based rainwater runoff collection; improving rural waste management and integrated urban-rural water supply systems.	Multilateral	MOF	People's Government of Xichuan County, Henan Province	18,290,000	2021-2027	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Ecological protection; urban and rural planning and construction	No	Yes	Ongoing
17	Asian Development Bank - Hunan Xiangxi Rural Environmental Improvement and Green Development Project	The project will demonstrate environmental improvement and green development in rural areas by: improving rural waste and sanitation management facilities and services with innovative technologies and arrangements; developing local featured agricultural and forestry products; adding values to agricultural and forestry products through improvement of value chains and integration with tourism. The project aims to play a demonstrative role for rural vitalization; promote the provision of regional public goods by reversing the negative impacts of pollution; reduce the risk of future epidemics; promote recovery from COVID-19 through inclusive rural economic development.	Multilateral	MOF	People's Government of Xiangxi Tujia and Miao Autonomous Prefecture, Hunan Province, and 8 project counties and cities	26,851,000	2021-2027	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Ecological protection; urban and rural planning	No	Yes	Ongoing
18	Asian Development Bank - Fujian Xianyou Mulan River Basin	This project aims to assist Xianyou County in Putian City, Fujian Province of the PRC in developing an integrated solution to address climate change and environmental management, improving	Multilateral	MOF	Fujian Provincial People's Government,	14,000,000	2022-2029	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Ecological protection	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	Integrated Ecological Improvement and Environmental Management Project	flood control, ecological restoration, and water quality of the Mulan River.			Putian Municipal People's Government, People's Government of Xianyou County										
19	Asian Development Bank - Shandong West Jining Water Supply and Drainage Integration Program	The project aims to address the water sector needs and development constraints of Jiaxiang County, Jining City, Shandong Province, by: addressing the policy and institutional gaps; integrating water supply and sewerage services; improving public health and environmental quality of water supply and drainage systems; enhancing institutional and program management capacity under an integrated long-term approach.	Multilateral	MOF	Shandong Provincial People's Government, People's Government of Jiaxiang County	5,030,000	2022-2028	Concessional loan	Received (in part)	Cross-cutting	Water resources and sanitation	Water resource management	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
20	Asian Development Bank - Gansu Environmentally Sustainable Rural Vitalization and Development Project	The project aims to support innovative, low-carbon and environmentally sustainable rural development models in Gansu Province. The project will explore a carbon credit scheme and new practices to sustain and propagate the low-carbon interventions, strengthen governments' institutional capacity for green governance and private sector engagement, and diversify employment opportunities beyond agriculture.	Multilateral	MOF	Gansu Provincial People's Government; People's Governments of Ganzhou District, Zhangye, Yongchang County, Jinchang, Pingchuan District, Baiyin, and Lintao County, Dingxi; Tianshui Economy Development Investment & Financing Group Co., Ltd.	75,000,000	2022-2029	Concessional loan	Committed	Cross-cutting	Multi-sector	Urban and rural planning and construction	No	Yes	Ongoing
21	Asian Development Bank - Heilongjiang Green Transformation Demonstration Project and Program	This project will assist Heilongjiang Province in implementing its strategies and action plans to develop green and exemplary supply chains and promote sustainable, resilient and inclusive development.	Multilateral	MOF	Heilongjiang Development and Reform Commission	21,859,706	2022-2029	Concessional loan	Received (in part)	Mitigation	Multi-sector	Industrial transition and upgrading	No	Yes	Ongoing
22	Asian Development Bank - Silk Road Ecological	The project is part of the Yellow River Ecological Corridor Program. This Program was shaped by Asian Development Bank's support to the	Multilateral	MOF	National Forestry and Grassland Administratio	59,761,000	2022-2029	Concessional loan	Committed	Cross-cutting	Multi-sector	Ecological protection	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	Rehabilitation and Protection Project (Qinghai)	Yangtze River Economic Belt Program, aiming to support ecosystem restoration, environmental protection and water resource management. The relevant experiences can be replicated in other regions of China and other developing member countries.			n, Qinghai Provincial Forestry and Grassland Bureau, Gansu Provincial Forestry and Grassland Bureau, Shaanxi Provincial Forestry and Grassland Bureau										
23	France - Shandong Green Development Fund Project	The project aims to establish a transformative green financing mechanism that combines funds from international financial institutions with private, institutional and commercial funds as well as local government funds to jointly finance relevant projects in Shandong Province. The project is financed by loans from four international organizations, including the French Development Agency.	Bilateral	MOF	Shandong Green Capital Investment Group Co., Ltd.	85,519,000	2020-2026	Concessional loan	Received (in part)	Mitigation	Multi-sector	Climate financing	No	No	Ongoing
24	Germany - Shandong Green Development Fund Project	The project aims to establish a transformative green financing mechanism that combines funds from international financial institutions with private, institutional and commercial funds as well as local government funds to jointly finance climate projects in Shandong Province and support the provincial government's policies aimed at economic decarbonization.	Bilateral	MOF	Shandong Green Capital Investment Group Co., Ltd.	122,170,000	2020-2026	Concessional loan	Received (in part)	Mitigation	Multi-sector	Climate financing	No	No	Ongoing
25	Germany - Shaanxi	The project is co-financed by a World Bank loan and a KfW Promotional	Bilateral	MOF	Shaanxi Provincial	27,213,368	2020-2025	Concessional loan	Received (in part)	Mitigation	Multi-sector	Urban-rural development	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	Sustainable Towns Development Project	Loan, with the KfW Promotional Loan amounting to EUR 44.55 million (approximately US$50 million). The project, co-financed by a World Bank loan and a KfW Promotional Loan, aims to establish a coordinated development platform for the Hanjiang River Ecological Economic Belt in three southern cities of Shaanxi Province, improve the flood warning and water quality monitoring systems in the Hanjiang River Basin and build resilient towns in six counties/districts along the river.			Foreign Loan Project Office							planning			
26	Germany - Protection and Resource Recycling Project of Zhoujiaba Ecological Wetland Project	The project, financed by a KfW Promotional Loan amounting to EUR 40 million, includes the following components: 1. Upgrading and reconstruction of the wastewater treatment plant and waste recycling subproject. 2. Zero-carbon center demonstration subproject. 3. 2# gate and ecological embankment water conservancy subproject. 4. Zhoujiaba ecological wetland protection and restoration subproject.	Bilateral	MOF	Sichuan Southwest Development Holding Group Co., Ltd.	24,434,000	2020-2025	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Ecological protection; climate financing; urban and rural planning and construction	No	Yes	Ongoing
27	Germany - Anhui Huangshan Xin'an River Ecological Protection and Green Development Project	The project is co-financed by ADB and KfW. KfW provided a loan of EUR 50 million. The project aims to manage point-source water pollution, improve the management of agriculture-based non-point source water pollution, and promote green development in rural areas. The project is envisaged to play a demonstrative role in the Yangtze River Economic Belt and other similar areas.	Bilateral	MOF	Anhui Provincial Finance Department, Huangshan Municipal People's Government	30,542,500	2020-2027	Concessional loan	Committed	Cross-cutting	Multi-sector	Ecological protection	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
28	Germany - Comprehensive Ecological Management in Baishui County, Shaanxi Province	The project includes the following components: environmental project construction, including forest restoration, endangered species protection and construction of educational exhibition halls; infrastructure development, including road improvement, construction of management stations and other supporting facilities; capacity building, including the establishment of forest fire prevention systems and related training.	Bilateral	MOF	Shaanxi Provincial Forestry Bureau, Baishui County Forestry Bureau	42,759,500	2020-2028	Concessional loan	Committed	Cross-cutting	Multi-sector	Ecological protection	No	Yes	Ongoing
29	Germany - Miluo River Disaster Risk Management and Comprehensive Environmental Improvement Project	The project is part of the Yellow River Ecological Corridor Program, shaped by Asian Development Bank's support to the Yangtze River Economic Belt Program focusing on ecosystem restoration, environmental protection and water resource management. It is intended to be replicable in other regions of China and other developing member countries.	Bilateral	MOF	Pingjiang County People's Government	73,302,000	2021-2027	Concessional loan	Received (in part)	Cross-cutting	Multi-sector	Disaster risk management; environmental protection	No	Yes	Ongoing
30	Global Environment Facility - Enabling Zero Carbon Energy in Rural Towns and Villages in China (EZCERTV) Project	Through the development of rural renewable energy such as biomass and solar energy, as well as the adoption of advanced energy-saving, storage and substitution technologies, this project aims to realize the substitution of renewable energy for traditional fossil fuels, accelerate the zero-carbon transition in rural China, and contribute to mitigating climate change and achieving the United Nations 2030 Sustainable Development Goals.	Multilateral	MOF	Ministry of Agriculture and Rural Affairs	8,932,420	2022-2027	Grant	Received (in part)	Mitigation	Energy	Low-carbon energy	Yes	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
31	Global Environment Facility - Innovative transformation of China's food production systems and agroecological landscapes	Through activities such as agricultural ecosystem landscape planning, sustainable climate-smart agricultural production, and ecological value assessment of agricultural products, this project aims to promote the innovative transformation of China's agricultural landscapes and agri-food value chains toward environmental and ecological sustainability, and support the United Nations 2030 Sustainable Development Goals, rural revitalization, and climate adaptation.	Multilateral	MOF	Ministry of Agriculture and Rural Affairs	3,589,725	2021-2026	Grant	Received (in part)	Cross-cutting	Agriculture	Agricultural transition	Yes	Yes	Ongoing
32	Global Environment Facility - Facilitating Cleaner and Energy Efficient Phosphate Chemicals Industry in China (PhosChemEE) Project - MIIT	The project aims to improve the policy system, standard system and finance system for the green and low-carbon development of the phosphorus chemical industry chain, promote technological innovation and industrial application in the phosphorus chemical industry, establish a replicable and scalable benchmark for phosphorus chemical production, build a green manufacturing system across the entire phosphorus chemical industry chain, and promote the energy-saving and green low-carbon transformation across the entire phosphorus chemical industry chain in China.	Multilateral	MOF	Ministry of Industry and Information Technology	5,596,528	2022-2027	Grant	Received (in part)	Mitigation	Industry	Low-carbon chemical industry	No	Yes	Ongoing
33	Global Environment Facility - Facilitating Cleaner and Energy Efficient Phosphate Chemicals Industry in	The project aims to improve the policy system, standard system and finance system for the green and low-carbon development of the phosphorus chemical industry chain, promote technological innovation and industrial application in the phosphorus chemical industry, establish a replicable and scalable benchmark for phosphorus	Multilateral	MOF	Ministry of Natural Resources	9,343,379	2022-2027	Grant	Received (in part)	Mitigation	Industry	Low-carbon chemical industry	No	No	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	China (PhosChemEE) Project - MNR	chemical production, build a green manufacturing system across the entire phosphorus chemical industry chain, and promote the energy-saving and green low-carbon transformation across the entire phosphorus chemical industry chain in China.													
34	Global Environment Facility - Green and Carbon Neutral Cities	The project aims to integrate biodiversity conservation in participating cities' urban development and establish their pathway to carbon neutrality.	Multilateral	MOF	China Center for Urban Development, NDRC, Chongqing, Chengdu, and Ningbo Municipal Governments	13,454,525	2022-2027	Grant	Received (in part)	Cross-cutting	Multi-sector	Biodiversity conservation	No	Yes	Ongoing
35	World Bank - Hubei Smart and Sustainable Agriculture Project - Grant	The project aims to promote environmentally sustainable and climate-smart agriculture and improve the quality and safety of agricultural products. The project consists of three components: first, agricultural practice demonstration and replication; second, demonstration and replication of smart sustainable agricultural practices; third, project and knowledge management.	Multilateral	MOF	Hubei Provincial Department of Agriculture and Rural Affairs	3,141,009	2021-2025	Grant	Received (in part)	Cross-cutting	Agriculture	Agricultural management	Yes	Yes	Ongoing
36	Asian Development Bank - Climate Change Financing Acceleration Platform	The project will promote and increase the participation of private capital in climate financing in the People's Republic of China. It will address the information and resource asymmetry in climate change mitigation investment to improve access to finance, the carbon market, and technological tools among financial investors, technology providers, and policy makers. This will support evidence-based and strategically	Multilateral	MOF	Department of Climate Change, Ministry of Ecology and Environment	895,670	2020-2023	Grant	Received	Mitigation	Multi-sector	Climate financing	Yes	Yes	Completed

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
		sound investment that would drive the PRC's economy toward the higher end of the value chain and generate sustainable greenhouse gas emissions reduction impacts.													
37	Asian Development Bank - Strengthening Capacity, Institutions, and Policies for Enabling High-Quality Green Development in the Yellow River Ecological Corridor - Improving Policies and Planning for Nature-Positive Development in the Huangshui River Source Area (Subproject 8)	This subproject under 'Strengthening Capacity, Institutions, and Policies for Enabling High-Quality Green Development in the Yellow River Ecological Corridor Project' aims to develop pilot activities in the Haiyan County within the source area of the Huangshui River, a major tributary of the Yellow River, and to improve ecological protection and green development management in Haiyan County.	Multilateral	MOF	People's Government of Haiyan County, Qinghai Province	258,000	2020-2022	Grant	Received	Cross-cutting	Multi-sector	Ecological protection	No	Yes	Ongoing
38	Asian Development Bank - Integrated Framework for Cost-Effective Disaster Risk Management	The project will provide policy recommendations and technical guidance for disaster risk management (DRM) based on natural hazard characteristics, exposure, and physical and socioeconomic vulnerabilities. It will foster regional partnerships among the PRC and neighboring countries on improving disaster preparedness and resilience.	Multilateral	MOF	Flood Control, Drought Relief and Disaster Mitigation Research Center of the Ministry of Water Resources, Department of	170,000	2021-2023	Grant	Received	Adaptation	Multi-sector	Disaster risk management	No	No	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
					Energy Conservation and Technology of the Ministry of Housing and Urban-Rural Development, Department of International Cooperation and Rescue of the Ministry of Emergency Management, Guangxi Development and Reform Commission										
39	Asian Development Bank - Scaling Up Climate Financing and Carbon Neutrality in Hainan	The project will help develop a roadmap for creating enabling policies and regulations, financial, and institutional mechanisms for scaling up climate finance; strengthen capacity for project development and investment opportunities in low carbon, climate resilient infrastructure; and identify pilot climate finance project on low-carbon technologies.	Multilateral	MOF	Hainan Department of Ecology and Environment	100,000	2021-2024	Grant	Received (in part)	Mitigation	Multi-sector	Climate financing	No	Yes	Ongoing
40	Asian Development Bank - Research on Addressing Climate Change in Ningxia through the Use	The project will analyze measures to reduce Ningxia's contribution to China's carbon emissions and mitigate the impacts of climate change.	Multilateral	MOF	Department of Science and Technology of Ningxia Hui Autonomous Region	200,000	2021-2024	Grant	Received (in part)	Cross-cutting	Multi-sector	Multi-sector	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	of Science and Technology														
41	Asian Development Bank - Research for Demonstration of Carbon Capture, Utilization and Storage Technologies in Industrial Sectors of Yunnan Province	The project aims to assist Kunming Iron & Steel Co., Ltd. in conducting pre-feasibility case study on the demonstration of carbon sequestration technologies, and enhance the capacity on CCUS technology of the Yunnan provincial government, the Kunming Iron & Steel Co., Ltd., academia and private sector.	Multilateral	MOF	Department of Ecology and Environment of Yunnan Province, Kunming Iron & Steel Co., Ltd.	300,000	2022-2023	Grant	Received (in part)	Mitigation	Industry	Carbon sequestration technology	Yes	Yes	Ongoing
42	Asian Development Bank - Study on the Development of Green Ports and Shipping	The project will support the green development of China's ports and shipping by providing international case studies of best practices, policy recommendations, investment roadmaps and knowledge-sharing activities.	Multilateral	MOF	Water Transport Bureau of the Ministry of Transport	300,000	2022-2023	Grant	Received (in part)	Mitigation	Transport	Water transport	No	Yes	Ongoing
43	Asian Development Bank - Strengthening Capacity, Institutions, and Policies for Enabling High-Quality Green Development in the Yellow River Ecological Corridor - Subproject 13:	This subproject includes: improving strategic planning, enhancing policy coordination and management actions to improve basin resilience in line with national adaptation goals; applying best practices and scientific approaches to assess climate risks and select adaptation measures to strengthen basin resilience; enhancing the capacity of government agencies to conduct climate risk assessment and analysis.	Multilateral	MOF	Department of Climate Change and Department of International Cooperation, Ministry of Ecology and Environment	417,000	2022-2025	Grant	Received (in part)	Adaptation	Multi-sector	Ecological protection; adaptation planning	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	Building Climate Resilience through Adaptation Planning in the Yellow River Basin														
44	Asian Development Bank - Research on Methane Emission Reduction in Agriculture	The project will identify the priority actions to be undertaken by the government of the PRC to reduce methane emissions from agriculture.	Multilateral	MOF	Department of Science, Technology and Education of the Ministry of Agriculture and Rural Affairs	300,000	2022-2024	Grant	Received (in part)	Mitigation	Agriculture	Low-carbon agriculture	No	Yes	Ongoing
45	Asian Development Bank - Policy Research and Pilot Demonstration of Green and Low-Carbon Rural Houses	The project will provide policy recommendations and technical guidance for promoting energy efficiency and reducing carbon emissions from rural residential buildings in the northern region through: research on green and low-carbon rural houses; pilot demonstration of green and low-carbon rural houses in the northern region; provision of evidence-based feasible measures and policy recommendations.	Multilateral	MOF	Department of Village and Township Construction of the Ministry of Housing and Urban-Rural Development, and the Center for Technology and Industrialization Development of the Ministry of Housing and Urban-Rural	1,000,000	2022-2024	Grant	Received (in part)	Mitigation	Multi-sector	Urban and rural planning and construction	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
					Development										
46	Asian Development Bank - Development of Disaster Risk Finance Framework for the Yangtze River Basin Flood Risk Management	The project aims to help the Changjiang Water Resources Commission (CWRC) of the Ministry of Water Resources of the People's Republic of China develop a comprehensive disaster risk finance framework to support integrated flood risk management for the Yangtze River Basin.	Multilateral	MOF	Bureau of International Cooperation and Science & Technology of the Changjiang Water Resources Commission of the Ministry of Water Resources	250,000	2022-2026	Grant	Committed	Adaptation	Multi-sector	Disaster management	No	Yes	Ongoing
47	Asian Development Bank - Supporting Climate Resilience and Ecological Sustainability	The project aims to support a range of innovative projects in China during 2024-2025, provide comprehensive project preparation and implementation startup support for subsequent projects, including project due diligence, capacity development, policy recommendations, and other relevant assistance, to addresses environmental and climate change challenges. The project proposals comprise (1) Hainan Disaster Risk Financing and Resilience Project, (2) Industrial Park Decarbonization Project, (3) Shandong Qixia Ecological Conservation Demonstration Project, and (4) Hunan Dongting Lake Wetland Ecological Restoration and Sustainable Development Project.	Multilateral	MOF	Hainan Department of Ecology and Environment, Shandong Department of Ecology and Environment, and Hunan Department of Ecology and Environment	500,000	2022-2025	Grant	Received (in part)	Cross-cutting	Multi-sector	Disaster management; ecological protection	No	Yes	Ongoing
48	Asian Development Bank - Preparing Low-	The project aims to support the preparatory work and due diligence of three projects, including: (1) Ningbo Green and Low-carbon Development	Multilateral	MOF	Ningbo Municipal Development and Reform	1,200,000	2022-2026	Grant	Received (in part)	Mitigation	Multi-sector	Low-carbon planning	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	carbon Development Projects	Project, (2) Shaanxi Low-carbon and Integrated Urban-Rural Sustainable Development Program, and (3) Chongqing Nature-based, Green, Low-carbon, and High-quality Urban Development Demonstration.			Commission of Zhejiang Province, Shaanxi Provincial Department of Housing and Urban-Rural Development, Chongqing High-Tech Development and Construction Investment Group Co., Ltd.										
49	Asian Development Bank - Formulation of China's 2035 National Climate Change Adaptation Strategy	The project primarily supports the formulation of the 2035 Climate Change Adaptation Strategy.	Multilateral	MOF	Department of Climate Change, Ministry of Ecology and Environment	100,000	2020-2022	Grant	Received	Adaptation	Multi-sector	Adaptation planning	No	No	Completed
50	Germany - Sino-German Cooperation on Climate Change - NDC Implementation	The project mainly supports the Ministry of Ecology and Environment in implementing the Nationally Determined Contribution (NDC) during the "14th Five-Year Plan" period and advancing more ambitious NDC implementation during the "15th Five-Year Plan" period.	Bilateral	MEE	National Center for Climate Change Strategy and International Cooperation	674,251	2021-2024	Grant	Received (in part)	Cross-cutting	Multi-sector	Climate policy	No	Yes	Ongoing
51	Switzerland -	The project aims to draw on	Bilateral	MOHUR	China	564,065	2021-	Grant	Received	Mitigation	Constructio	Low-carbon	No	Yes	Ongoing

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entity	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Subsector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
	Chinese Zero Emission Buildings with Swiss Know-how Project (ZEB CHINA)	Switzerland's accumulated experience in the field of zero-carbon buildings by transferring advanced technologies and experience to China through the development of standards for zero-energy buildings and zero-carbon buildings, demonstration projects, and capacity-building initiatives, ultimately reducing GHG emissions from the building sector.		D	Academy of Building Research		2025		(in part)		n	building			

Table 4-3 Technology Development and Transfer Support Needed by China to Address Climate Change

No.	Sector	Sub-sector	Title of activity, programme, project or other	Programme/project description	Type of support	Type of technology	Expected time frame	Expected use, impact and estimated results
1	Energy	Electricity	New-type energy storage technology	New-type energy storage technologies can help improve the regulation capacity, comprehensive efficiency and safety guarantee capability of power systems, increase the share of renewable energy and cater to needs of different application scenarios.	Mitigation	Compressed air energy storage, flywheel energy storage, flow batteries, sodium-ion batteries, superconducting energy storage, lithium-ion battery storage, gravity energy storage, and key components and materials for fuel cells.	2024-2030	Achieve significant reduction in energy storage costs and large-scale deployment of storage technologies to support the healthy development of high-proportion renewable energy power systems.
2	Energy	Cross-cutting	Hydrogen technology	Leveraging hydrogen's large-scale and long duration advantage in energy storage can help optimize the allocation of heterogeneous energy across regions and seasons, and facilitate the integration of hydrogen, electricity, and thermal energy systems to establish a clean energy supply system composed	Mitigation	Hydrogen production technologies, including alkaline, proton exchange membrane, anionic membrane, and solid oxide electrolysis water hydrogen production technologies; hydrogen storage and transport technologies, including high-pressure gaseous hydrogen storage and transport, cryogenic liquid hydrogen storage	2024-2030	Achieve large-scale, low-cost, safe and efficient hydrogen production and utilization, as well as coupled development with electrical, transport and industrial systems.

				of diversified and complementary units. It may also support green development in end-use sectors such as transportation and industry by using hydrogen as an alternative fuel.		and transport, solid-state hydrogen storage and transport, and pure hydrogen/natural gas-blended hydrogen pipeline transport technologies and supporting facilities; fuel cell technologies and equipment, including proton exchange membrane fuel cells, solid oxide fuel cells, and molten carbonate fuel cells; hydrogen gas turbine technologies and related key components and materials.		
3	Energy	Electricity	New-type solar PV technology	Low-cost, efficient and stable solar PV technologies are utilized to support the high-quality development and utilization of solar energy.	Mitigation	New solar cell technologies, including multi-junction solar cells, organic solar cells, perovskite solar cells, dye-sensitized solar cells, and inorganic solar cells (copper-zinc-tin-sulfur-selenium).	2024-2030	Low-cost solar PV technology will be used more efficiently and better integrate with buildings and other systems.
4	Energy	Electricity	Deep-sea and ultra-large offshore wind power technologies	Develop low-cost and highly efficient wind power in deep sea areas and ultra-large offshore wind power technologies to facilitate the development and utilization of wind power with a high quality.	Mitigation	Technologies mainly include overall design, critical components manufacture and integration for ultra-high-power offshore wind turbines, and integrated design and construction of floating wind turbine foundation in deep-sea, far-offshore areas, etc.	2024-2030	Achieve low-cost, high-efficiency, and safe utilization of offshore wind power technology.
5	Energy	Electricity	Ocean power generation technology	Develop efficient ocean energy capture and conversion technologies to achieve efficient, reliable power generation and comprehensive utilization of ocean energy.	Mitigation	Ocean power generation technologies include wave energy, tidal energy and ocean thermal energy technologies.	2024-2030	Ocean energy will be utilized in a low-cost and high-efficiency manner in light of local conditions.
6	Energy	Fuel	Technology of efficient conversion and utilization of biomass energy	Efficient and high-value biomass conversion and utilization technologies can help facilitate clean transition in the transportation sector and others.	Mitigation	Biomass depolymerization and conversion technology for producing bio-aviation fuel.	2024-2030	Biomass energy will be utilized at a low cost in the light of local conditions.
7	Energy	Cross-cutting	Advanced nuclear energy technology	In combination with the passive design concept, the development of next-generation advanced nuclear energy technologies can help improve inherent safety continuously.	Mitigation	Technologies such as floating reactor, mobile reactor, and advanced fast reactor.	2024-2030	Enhance stable base-load electricity supply and achieve safe, efficient and comprehensive utilization of nuclear energy.
8	Energy	Electricity	New smart grid	Develop new-type smart grid	Mitigation	Technologies such as high-precision	2024-2030	Achieve intelligent, stable and

			technology	technologies to sustain large-scale renewable energy and distributed power integration in a grid-friendly manner.		forecasting of new energy power output, multi-directional and automatic allocation, energy-borne information, grid self-healing automatic control, intelligent perception of grid disasters, and intelligent remote control and inspection of equipment.		flexible operation of the power grid.
9	Industry	Metallurgy	Low-carbon iron and steel production technology	Achieve emission reduction in iron and steel production through raw material substitution and process reengineering technologies, including hydrogen-rich direct reduction process.	Mitigation	Technologies such as oxygen/oxygen-rich blast furnace, hydrogen-rich blast furnace injection, hydrogen-rich direct reduction, hydrogen direct reduction, electrochemical iron making, mega-scale electric furnace efficient smelting, and carbon sequestration and chemical co-production from carbon-rich gases in steel plants.	2024-2030	Achieve low-carbon, high-quality production in the iron and steel industry.
10	Industry	non-metallic mineral products	Low-carbon non-metallic mineral products technology	Achieve emission reduction in the non-metallic minerals industry through fuel and raw material substitution and process reengineering technologies.	Mitigation	Technologies such as raw material substitution, biomass/refuse-derived fuel substitution, second-generation new dry-process kilns, new high-efficiency burners, advanced grate coolers, high-efficiency decomposition furnace preheating system, and carbon dioxide mineralization.	2024-2030	Achieve low-carbon, high-quality production in the cement industry.
11	Industry	Chemical industry	Low-carbon chemical technology	Achieve emission reduction in the chemical industry through fuel and raw material substitution and process reengineering technologies.	Mitigation	Molecular oil refining, heavy oil/low-quality oil processing for petrochemical emission reduction, and coal chemical emission reduction technologies such as new energy-coupled hydrogen production.	2024-2030	Achieve low-carbon, high-quality production in the chemical industry.
12	Transport	Water transport	New energy shipping technology	Achieve green and low-carbon development in transportation through the substitution of fossil fuels with clean energy.	Mitigation	Technologies for ships powered by fuels such as liquefied natural gas, biodiesel, biogas, hydrogen, ammonia, methanol, as well as electric ship technologies.	2024-2030	Achieve economically competitive, low-carbon and sustainable energy substitution for traditional diesel ships.
13	Transport	Aviation	New energy aviation technology	Achieve green and low-carbon development in transportation through the substitution of fossil fuels with clean energy.	Mitigation	New energy powered aero-engine technologies, such as by hydrogen energy and biofuel, as well as aerostructure optimization and energy saving technologies, such as wing design optimization.	2024-2030	Achieve economically competitive, green, low-carbon and sustainable energy substitution for traditional air transport.
14	Multi-	Carbon	CO_2 capture	Achieve emission control and reduction	Mitigation	High-efficiency, low-energy-consumption,	2024-2030	Support emission reduction in

	sector	managem ent	technology	in the power and industry sectors through next-generation high-efficiency, low-energy-consumption CO_2 capture technologies and equipment.		and low-cost pre- and post-combustion carbon capture technologies.		industries such as coal-fired power generation, steel, and cement.
15	Multi-sector	Carbon managem ent	CO_2 chemical utilization technology	Achieve high-value utilization of CO_2 through chemical utilization technologies.	Mitigation	Photoelectrocatalytic synthesis of high-value chemicals and fuels from carbon dioxide, hydrogenation of carbon dioxide to produce aviation fuel and methanol fuel, and carbon dioxide reduction coupled with Fischer-Tropsch synthesis.	2024-2030	Achieve raw material substitution and emission reduction and generate economic benefits.
16	Multi-sector	Carbon managem ent	CO_2 geological utilization and storage technologies	Achieve long-term safe storage of carbon dioxide through enhanced recovery and sequestration technologies.	Mitigation	Carbon dioxide-enhanced oil recovery, enhanced methane recovery, geothermal extraction, enhanced deep salt water extraction, and carbon dioxide monitoring.	2024-2030	Achieve long-term safe storage of carbon dioxide.
17	Multi-sector	Carbon managem ent	Negative emission technology	Develop negative emission technologies and conduct large-scale demonstration to significantly reduce the implementation cost of negative emission technology, enhance process efficiency, and establish the capability for promotion and application in suitable scenarios.	Mitigation	Direct air carbon capture coupled with carbon storage, biomass utilization coupled with carbon capture and storage, and enhanced rock weathering.	2024-2030	Establish an engineering technological process with negative carbon effects over the whole life cycle to reduce atmospheric carbon dioxide concentration and achieve long-term fixation.
18	Multi-sector	Emission control and reduction of non-CO_2 greenhous e gases	Methane reduction technology	Achieve methane emission control and reduction through methane reduction and utilization technologies.	Mitigation	Methane satellite monitoring, efficient development and intelligent extraction of coalbed methane, advanced flare extinguishing for oil and gas operations, resource-based and energy-based utilization of rice straw, breeding of high-yield and low-emission livestock and poultry varieties, methane emission reduction for landfills and wastewater treatment, and high-value conversion of methane into chemicals or fuels.	2024-2030	Support methane emission reduction in industries such as coal, oil and gas, agriculture, livestock, and waste management, achieving emission control, reduction and high-value utilization of methane.
19	Multi-sector	Emission control and reduction	Nitrous oxide reduction technology	Achieve emission control and reduction of nitrous oxide through reduction and utilization technologies.	Mitigation	Nitrous oxide adsorption, separation and enrichment; nitrous oxide catalytic purification; collaborative treatment of nitrous oxide and pollutants; recycling of	2024-2030	Achieve efficient treatment and utilization of nitrous oxide in chemical industries such as nitric acid, adipic acid and caprolactam

		of non-CO_2 greenhouse gases				nitrous oxide.		production, as well as in power plants and automobile exhaust.
20	Multi-sector	Emission control and reduction of non-CO_2 greenhouse gases	F-gas reduction technology	Achieve F-gas emission control and reduction through F-gas reduction technologies.	Mitigation	F-gas source control, hydrofluoroolefin substitution, F-gas catalytic purification, and recycling of F-gases.	2024-2030	Achieve reduction and efficient management of F-gas emissions.
21	Disaster prevention and control	Climate monitoring and disaster early warning	Technology of climate monitoring and natural disaster monitoring and early warning	Develop disaster monitoring and early warning technologies to reduce adverse impacts and risks caused by climate change.	Adaptation	Intelligent and precise monitoring of mutual feedback between atmosphere and multi-layers; climate system monitoring and analysis, accurate forecasting, as well as monitoring and early warning of extreme climate events, severe natural disasters, compound and concurrent natural hazards.	2024-2030	Enhance climate monitoring, disaster early warning and prevention capabilities.
22	Disaster prevention and control	Climate monitoring and disaster early warning	Technology of disaster scenario simulation and replay	Develop disaster scenario simulation and replay technologies to reinforce forecast and intervention of natural disasters triggered by climate change.	Adaptation	Catastrophe scenario construction, disaster chain analysis and proactive intervention, data analysis and data base construction, and digital twin technologies.	2024-2030	Improve disaster forecasting capabilities.
23	Disaster prevention and control	Climate monitoring and disaster early warning	Technology of risk assessment and comprehensive precaution	Develop risk assessment and comprehensive prevention technologies to enhance the comprehensive prevention and control of natural disasters caused by climate change.	Adaptation	Climate change impact and risk assessment in vulnerable sectors and key areas, critical risk threshold measurement, adaptation action effect evaluation, and disaster risk prevention, emergency response and comprehensive management. Technologies and equipment for disaster response, including disaster information acquisition, emergency command communication, special emergency transportation support, life search and rescue, emergency medical rescue, and epidemic prevention.	2024-2030	Improve risk assessment and comprehensive prevention capabilities for climate-related disasters.

24	Agriculture	Agricultural water resource utilization	Water-efficient agricultural irrigation technology	Develop technologies such as water-efficient agricultural irrigation, agronomic water saving, and rainwater collection to mitigate the adverse impacts of precipitation variation on agricultural production.	Adaptation	Water-efficient irrigation technologies such as sprinkler irrigation, drip irrigation, anti-seepage for low-pressure pipeline water transport channels, and subsurface irrigation; agronomic water saving technologies such as mulching for moisture conservation, tillage for moisture conservation, and water-fertilizer coupling; rainwater collection technologies such as rainwater runoff collection and ecological utilization.	2024-2030	Improve the recycling efficiency of agricultural water and ensure the agricultural water security.
25	Agriculture	Crop cultivation	Technology of crop stress-resistant breeding and pest control	Develop crop stress-resistant breeding and pest control technologies to enhance crop adaptability to the adverse impacts of climate change.	Adaptation	Technologies such as heat-resistant rice breeding, drought-resistant rice breeding, drought-resistant wheat and corn breeding, pest control, identification and cultivation of crop strains with stress-resistant traits against adverse impacts of climate change, including resistance to high and low temperature, drought, waterlogging, and salt.	2024-2030	Enhance crop adaptability to the adverse impacts of climate change and ensure crop production capacity.
26	Multi-sector	Ecosystems	Technology of Climate-sensitive ecosystem protection and restoration	Improve the adaptability of climate-sensitive ecosystems through ecosystem protection and restoration technologies.	Adaptation	Biodiversity conservation technologies such as restoring degraded grasslands and protecting wetlands in regions affected by climate warming and drying, as well as forest succession and the protection of rare animals and plants in areas experiencing drastic climate changes; technologies to enhance ecosystem service functions to strengthen the climate resilience of economic and social systems.	2024-2030	Enhance the climate resilience of ecosystems in climate-sensitive regions.
27	Multi-sector	Oceans and coastal zones	Technology of sea level and storm surge monitoring, and coastal zone protection	Achieve protection of marine ecosystems and coastal zone infrastructure through comprehensive adaptation technologies.	Adaptation	Sea level and storm surge monitoring, coastal zone protection, protection and restoration of tidal flats, mangroves, and coral reefs, saltwater intrusion and salinization coping, three-dimensional greening of marine eco-friendly shorelines, ecosystem restoration in coastal dike areas,	2024-2030	Enhance the climate resilience of coastal zones and related ecosystems.

						and functional zone planning.		
28	Multi-sector	Urban construction	Climate-resilient infrastructure technology	Develop urban rainwater-resilient technologies and systems to achieve a virtuous urban hydrological cycle, and improve the capacity of rainwater runoff penetration, storage, purification, utilization and discharge.	Adaptation	Integrate technologies of urban infrastructure development and rainwater treatment and the concepts of "smart city", "sponge city" and "resilient city" to achieve urban risk-resistant construction and enhance urban climate resilience.	2024-2030	Improve climate resilience for urban infrastructure.
29	Multi-sector	Human health	Technology of comprehensive adaptation of human health	Develop monitoring, early warning, and public health technologies to reduce the adverse impacts of climate change on human health.	Adaptation	Monitoring, early warning and risk assessment of human health impacts from extreme weather and climate events, assessment and prevention of vector-borne disease outbreaks under climate change conditions, response to heat stress (heatstroke, cardiovascular and cerebrovascular diseases) and disaster-related casualties, as well as human health adaptation to address the impacts of hidden hunger exacerbated by climate change. Technologies for risk assessment, forecasting and early warning of climate-sensitive diseases, appropriate technologies for categorized and graded protection, cost-benefit economic evaluation of health adaptation measures, intelligent application of big data, and climate change health data products and intelligent software products.	2024-2030	Reduce the adverse impacts of climate change on human health and enhance monitoring, early warning and proactive adaptation capabilities.

Table 4-4 Technology Development and Transfer Support Received by China to Address Climate Change

No.	Title of activity, programme, project or other	Programme/project description	Type of technolog	Time frame	Recipient entity	Implementing entitiy	Type of support	Sector	Subsector	Status of activity	Use, impact and estimated results
1.	Global Environment Facility - Enabling Zero Carbon Energy in Rural Towns and Villages in China (EZCERTV) Project	Through the development of rural renewable energy such as biomass and solar energy, as well as the adoption of advanced energy-saving, storage and substitution technologies, this project aims to realize the substitution of renewable energy for traditional fossil fuels, accelerate the zero-carbon transition in rural China, and contribute to mitigating climate change and achieving the United Nations 2030 Sustainable Development Goals.	Renewable energy developme nt and utilization	2022-2027	MOF	Ministry of Agriculture and Rural Affairs	Mitigati on	Energy	Low-carbon energy	Ongoing	A management organization, an expert team and a technical support team have been established to initiate the preparation of energy plans and programs for zero-carbon demonstration villages and towns. Renewable energy policies have been introduced, laying the foundation for the demonstration and promotion of zero-carbon village and town construction.
2.	Global Environment Facility - Innovative Transformation of China's Food Production Systems and Agroecological Landscapes	Through activities such as agricultural ecosystem landscape planning, sustainable climate-smart agricultural production, and ecological value assessment of agricultural products, this project aims to promote the innovative transformation of China's agricultural landscapes and agri-food value chains toward environmental and ecological sustainability, and support the United Nations 2030 Sustainable Development Goals, rural revitalization, and climate adaptation.	Carbon sequestratio n and sink enhanceme nt in agricultural systems	2021-2026	MOF	Ministry of Agriculture and Rural Affairs	Cross-cutting	Agricul ture	Agricultur al transforma tion	Ongoing	Through systematic efforts in the preparation of project area demonstration plans, technical demonstration application, knowledge management and publicity training, as well as project monitoring and evaluation, agricultural ecological landscape technologies have been integrated and developed, and an agricultural ecological project monitoring guide has been compiled, laying the foundation for an innovative transformation towards sustainable agricultural ecosystems.
3.	World Bank - Hubei Smart and	The project aims to promote environmentally sustainable and	Climate-smart	2021-2025	MOF	Hubei Provincial	Cross-cutting	Agricul ture	Agricultur al	Ongoing	The project has facilitated the sustainable development of

	Sustainable Agriculture Project	climate-smart agriculture and improve the quality and safety of agricultural products. The project consists of three components: first, agricultural practice demonstration and replication; second, demonstration and replication of smart sustainable agricultural practices; third, project and knowledge management.	agriculture			Department of Agriculture and Rural Affairs			transformation		agriculture, rural areas and farmers, soil and water conservation, climate change mitigation, and food security improvement in the target regions.
4.	World Bank - Hubei Smart and Sustainable Agriculture Project	The project aims to promote environmentally sustainable and climate-smart agriculture and improve the quality and safety of agricultural products. The project consists of three components: first, agricultural practice demonstration and replication; second, demonstration and replication of smart sustainable agricultural practices; third, project and knowledge management.	Climate-smart agriculture	2021-2025	MOF	Hubei Provincial Department of Agriculture and Rural Affairs	Cross-cutting	Agriculture	Agricultural transformation	Ongoing	The project has facilitated the sustainable development of agriculture, rural areas and farmers, soil and water conservation, climate change mitigation, and food security improvement in the target regions.
5.	Asian Infrastructure Investment Bank - Henan Flood Emergency Rehabilitation and Recovery Project	The project objectives are: 1. to support the post-disaster rehabilitation and recovery in the municipalities of Zhengzhou, Xinxiang, and Jiaozuo of Henan Province, and 2. to strengthen the capacity of the three municipalities in integrated flood risk management and flood emergency response.	Flood disaster risk management	2021-2026	MOF	Zhengzhou (Water Resources Bureau, Urban Construction Bureau, Highway Development Center), Dengfeng (Water Resources Bureau), Xinxiang (Transport Bureau, Housing and Urban-Rural Development	Adaptation	Multi-sector	Water conservancy, transportation, municipal administration, and emergency management	Ongoing	The implementation of the water conservancy works not only enhances local disaster prevention and mitigation capabilities by restoring damaged urban public transportation systems and rural roads, raising river flood control standards, restoring urban drainage systems and improving urban flood emergency systems, but also improves water quality and promotes ecological balance through river regulation.

						Bureau, Emergency Management Bureau), Weihui (Water Resources Bureau), Jiaozuo (Water Resources Bureau, Housing and Urban-Rural Development Bureau, Emergency Management Bureau, Agriculture and Rural Affairs Bureau of Macun District, Water Resources Bureau of Xiuwu County)					
6.	Asian Development Bank - Climate Change Financing Acceleration Platform	The project will promote and increase the participation of private capital in climate financing in the People's Republic of China. It will address the information and resource asymmetry in climate change mitigation investment to improve access to finance, the carbon market, and technological tools among financial investors, technology providers, and policy makers. This will support evidence-based and strategically sound investment that would drive the	Low-carbon technologies	2020-2023	MOF	Department of Climate Change, Ministry of Ecology and Environment	Mitigation	Multi-sector	Climate financing	Completed	Through the development of a climate investment and financing priority project standard (Standard I) and a high-quality carbon credit standard (Standard II), and the establishment of a climate investment and financing acceleration platform, the project will effectively connect low-carbon technology providers, developers and investors, driving more capital into the field of low-

		PRC's economy toward the higher end of the value chain and generate sustainable greenhouse gas emissions reduction impacts.									carbon technology innovation.
7.	Asian Development Bank - Research for Demonstration of Carbon Capture, Utilization and Storage Technologies in Industrial Sectors of Yunnan Province	The project aims to assist the Department of Ecology and Environment of Yunnan Province in developing recommended solutions and showcasing carbon sequestration technologies to achieve peak carbon emissions by 2030 and carbon neutrality by 2060. These solutions will be applicable to the steel industry and other carbon-intensive industries. The project will also conduct a preliminary feasibility case study on carbon sequestration technology demonstration for Kunming Iron & Steel Co., Ltd., and will enhance the capacity on CCUS technology of the Yunnan provincial government, the Kunming Iron & Steel Co., Ltd., academia and private sector.	Carbon capture, utilization and storage	2022-2023	MOF	Department of Ecology and Environment of Yunnan Province, Kunming Iron & Steel Co., Ltd.	Mitigation	Industry	Carbon sequestration technology	Ongoing	The project implementation has achieved the following outcomes: (1) Incorporating CCUS technology into the provincial government's carbon reduction development plan to promote early and scientific planning by government departments and enterprises in areas such as carbon capture, CCUS hubs, storage sites, and CO_2 utilization; (2) Incorporating CCUS technology into the investment plan of Kunming Iron & Steel Co., Ltd. to support the preliminary work of the CCUS demonstration, thereby positively contributing to the scheduled achievement of deep carbon reduction and carbon neutrality goals in the industrial sector; (3) The project has engaged three experts from Yunnan Province to provide leadership and guidance for future work in carbon peaking, carbon neutrality, and CCUS in the province.

Table 4-5 Capacity-Building Support Needed by China to Address Climate Change

Sector	Title of activity, programme, project or other	Programme/project description	Type of support	Expected time frame	Expected use, impact and estimated results
Multi-sector	Capacity Building for Climate Monitoring, Evaluation and Early Warning System	Reinforce the role of new-generation information technology in climate change monitoring, impact and evaluation to establish a climate change monitoring and evaluation system in a dynamic and holistic manner; conduct climate feasibility studies in national spatial planning and strengthen early warning and risk management of extreme climate events.	Adaptation	2024-2030	Develop an integrated numerical weather and climate forecasting system, and establish a climate change risk early warning platform and a meteorological disaster monitoring, forecasting and early warning system tailored to specific disaster types.
Multi-sector	Capacity Building for Greenhouse Gas Accounting System	Improve the verification standards for carbon emission accounting reports for regions, industries, enterprises and products, and establish a unified and standardized carbon accounting system; establish a monitoring and accounting system for ecosystem carbon sinks; strengthen capacity building in carbon emission statistics and accounting, and enhance the level of information-based measurement.	Mitigation	2024-2030	Organize a series of capacity-building training sessions on the development of carbon emission statistics and accounting methods at the national, regional, key industry, enterprise, and key product levels, and establish a GHG emission factor library, database, and monitoring management platform.
Multi-sector	Capacity Building for Climate Action Coordination and Collaboration Mechanism	Establish and improve coordination and information sharing mechanisms for addressing climate change, and build a collaborative innovation work model featuring multi-sectoral coordination, multi-subject coordination, and mass participation.	Cross-cutting	2024-2030	Coordinate and organize relevant departments to conduct planning coordination workshops and capacity-building training sessions at various levels and across different sectors.
Multi-sector	Enhancement of Multi-subject Management Capacity to Address Climate Change	Encourage local governments, enterprises, social organizations and research institutions to incorporate climate change considerations into their organizational structures, business areas and work processes, thereby enhancing their comprehensive decision-making and management capabilities in addressing climate change.	Cross-cutting	2024-2030	Conduct capacity-building training for local governments on climate change management, and organize seminars for enterprises, social organizations and research institutions on improving the comprehensive decision-making and management capabilities in addressing climate change.
Multi-sector	Talent Development to Address Climate Change	Strengthen climate change education in schools, improve the climate change-related academic and professional systems in higher education institutions, and cultivate innovative talents for addressing climate change.	Cross-cutting	2024-2030	Enhance the implementation of climate change education in schools, foster students' understanding of the concept of harmonious coexistence between humans and nature, and establish climate change-related academic disciplines and talent development programs.
Multi-sector	Knowledge Training to Address Climate Change	Expand continuing education channels for addressing climate change and strengthen the knowledge base and skill sets of management teams and professionals.	Cross-cutting	2024-2030	Organize climate change-related training for cadres and skills training for professionals.
Multi-sector	Publicity Promotion to Address Climate Change	Strengthen climate change science popularization and innovate publicity modes for raising public awareness on climate change.	Cross-cutting	2024-2030	Conduct diverse science popularization activities on green, low-carbon living and climate adaptation through multimedia and new media channels, and implement public practice projects on addressing climate change.

Table 4-6 Capacity-Building Support Received by China for Addressing Climate Change

No.	Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Subsector	Status of activity	Use, impact and estimated results
1	Global Environment Facility - Enabling Zero Carbon Energy in Rural Towns and Villages in China (EZCERTV) Project	Through the development of rural renewable energy such as biomass and solar energy, as well as the adoption of advanced energy-saving, storage and substitution technologies, this project aims to realize the substitution of renewable energy for traditional fossil fuels, accelerate the zero-carbon transition in rural China, and contribute to mitigating climate change and achieving the United Nations 2030 Sustainable Development Goals.	2022-2027	MOF	Ministry of Agriculture and Rural Affairs	Mitigation	Energy	Low-carbon energy	Ongoing	A management organization, an expert team and a technical support team have been established to initiate the preparation of energy plans and programs for zero-carbon demonstration villages and towns. Renewable energy policies have been introduced, laying the foundation for the demonstration and promotion of zero-carbon village and town construction.
2	Global Environment Facility - Innovative Transformation of China's Food Production Systems and Agroecological Landscapes	Through activities such as agricultural ecosystem landscape planning, sustainable climate-smart agricultural production, and ecological value assessment of agricultural products, this project aims to promote the innovative transformation of China's agricultural landscapes and agri-food value chains toward environmental and ecological sustainability, and support the United Nations 2030 Sustainable Development Goals, rural revitalization, and climate adaptation.	2021-2026	MOF	Ministry of Agriculture and Rural Affairs	Cross-cutting	Agriculture	Agricultural transformation	Ongoing	Through systematic efforts in the preparation of project area demonstration plans, technical demonstration application, knowledge management and publicity training, as well as project monitoring and evaluation, agricultural ecological landscape technologies have been integrated and developed, and an agricultural ecological project monitoring guide has been compiled, laying the foundation for an innovative transformation towards sustainable agricultural ecosystems.

No.	Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Subsector	Status of activity	Use, impact and estimated results
3	Global Environment Facility - Facilitating Cleaner and Energy Efficient Phosphate Chemicals Industry in China (PhosChemEE) Project	The project aims to improve the policy system, standard system and finance system for the green and low-carbon development of the phosphorus chemical industry chain, promote technological innovation and industrial application in the phosphorus chemical industry, establish a replicable and scalable benchmark for phosphorus chemical production, build a green manufacturing system across the entire phosphorus chemical industry chain, and promote the energy-saving and green low-carbon transformation across the entire phosphorus chemical industry chain in China.	2022-2027	MOF	Ministry of Industry and Information Technology and Ministry of Natural Resources	Mitigation	Industry	Low-carbon chemical industry	Ongoing	The project has initiated research on seven topics, including the research on an energy-saving and carbon-reduction evaluation indicator system for the phosphorus chemical industry chain under the "dual carbon" goals. Additionally, three demonstration projects have been launched, such as the production of high-purity wet-process purified phosphoric acid using advanced purification technologies.
4	Global Environment Facility - Green and Carbon Neutral Cities	The project aims to integrate biodiversity conservation in participating cities' urban development and establish their pathway to carbon neutrality.	2022-2027	MOF	China Center for Urban Development, NDRC, Chongqing, Chengdu, and Ningbo Municipal Governments	Cross-cutting	Multi-sector	Biodiversity conservation	Ongoing	The project has organized one annual training session, produced three quarterly reports, and conducted two project inspections. Research, pilot projects, and capacity-building activities related to urban green and low-carbon transformation are being carried out according to plan.
5	Asian Development Bank - Strengthening Capacity, Institutions, and Policies for Enabling High-Quality Green Development in the Yellow River Ecological Corridor -	This subproject aims to develop pilot activities in the Haiyan County within the source area of the Huangshui River, a major tributary of the Yellow River, and to improve ecological protection and green development management in Haiyan County.	2020-2022	MOF	Haiyan County Government, Qinghai Province	Adaptation	Multi-sector	Ecological protection	Ongoing	Two training sessions and one out-of-province visit have been organized, enhancing the technical capabilities of technicians in relevant fields through on-site technical exchange discussions and field visits, and also strengthening the knowledge and skills of managers in sustainable and well-

No.	Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Subsector	Status of activity	Use, impact and estimated results
	Improving Policies and Planning for Nature-Positive Development in the Huangshui River Source Area (Subproject 8)									planned development.
6	Asian Development Bank - Climate Investment and Financing Innovation Research Based on Hainan's Carbon Neutrality Pilot	The project will help develop a roadmap for creating enabling policies and regulations, financial, and institutional mechanisms for scaling up climate finance; strengthen capacity for project development and investment opportunities in low carbon, climate resilient infrastructure; and identify pilot climate finance project on low-carbon technologies.	2021-2024	MOF	Hainan Department of Ecology and Environment	Mitigation	Multi-sector	Climate financing	Ongoing	Two capacity-building training sessions have been organized on project development and investment in low-carbon and climate-adaptive infrastructure.
7	Asian Development Bank - Jiangxi Ganzhou Rural Vitalization and Comprehensive Environment Improvement Project	The project will promote rural revitalization and ecological protection in Ganzhou City, Jiangxi Province, by: enhancing regional and local ecological and environmental management capacities; promoting rural transformation and the transition toward green development in the region; developing rural environmental infrastructure to address environmental degradation caused by economic development; improving ecosystem protection in the region to enhance the living environment.	2021-2028	MOF	Jiangxi Provincial People's Government, Ganzhou Municipal People's Government, and its subordinate Development and Reform Commission and Finance Bureau	Cross-cutting	Multi-sector	Ecological protection; urban and rural planning and construction	Ongoing	Capacity-building training sessions were conducted on water conservation, ecological restoration, and forestry technologies, along with research on forestry carbon trading, air pollution prevention, and greenhouse vegetable waste management.

No.	Title of activity, programme, project or other	Programme/project description	Time frame	Recipient entity	Implementing entity	Type of support	Sector	Subsector	Status of activity	Use, impact and estimated results
8	Germany - Sino-German Cooperation on Climate Change - NDC Implementation	The project mainly supports the Ministry of Ecology and Environment in implementing the Nationally Determined Contribution (NDC) during the "14th Five-Year Plan" period and advancing more ambitious NDC implementation during the "15th Five-Year Plan" period.	2021-2024	MEE	National Center for Climate Change Strategy and International Cooperation	Cross-cutting	Multi-sector	Climate policy	Ongoing	The project facilitated dialogue between Chinese and German experts on NDC implementation, provided peak emission scenarios and roadmap recommendations for provincial governments/cities, proposed emission reduction roadmaps for the industrial sector, established a national monitoring and evaluation framework for climate change adaptation, and supported capacity-building training in climate legislation and climate investment and financing.
9	Switzerland - Chinese Zero Emission Buildings with Swiss Know-how Project (ZEB CHINA)	The project aims to draw on Switzerland's accumulated experience in the field of zero-carbon buildings by transferring advanced technologies and experience to China through the development of standards for zero-energy buildings and zero-carbon buildings, demonstration projects, and capacity-building initiatives, ultimately reducing GHG emissions from the building sector.	2021-2025	Ministry of Housing and Urban-Rural Development	China Academy of Building Research	Mitigation	Construction	Low-carbon building	Ongoing	The project contributed to the development of the national standard - Technical Standard for Zero-carbon Buildings and collaborated on research into the impact of zero-carbon buildings on carbon emissions in China's construction sector. Ten demonstration projects received technical support from Swiss experts. It also supported the recording of training courses for mayors organized by the Ministry of Housing and Urban-Rural Development, as well as the delivery of a 10-session lectures and seminars.

Table 4-7 Support Needed for China's Implementation of Article 13 of the Paris Agreement and Transparency-related Activities (Including Transparency-related Capacity Building)

No.	Title of activity, programme, project or other	Objectives and description	Expected time frame	Recipient entity	Channel	Amount (USD)	Status of activity	Expected use, impact and estimated results
10	China's Capacity-Building Project for Preparing the Fifth National Communication on Climate Change and the Biennial Transparency Report	Continuously enhance the technical capacity of China's compliance team to support the preparation and submission of the Fifth National Communication and the Second Biennial Transparency Report to the UNFCCC Secretariat by the end of 2026, and undergo international expert review and multilateral consideration. By the end of 2028, prepare and submit the Third Biennial Transparency Report to the UNFCCC Secretariat, and undergo international expert review and multilateral consideration, so as to fulfill the reporting obligations under the Paris Agreement and its implementing rules, while simultaneously improving China's capacity in climate change transparency.	2026-2030	MOF	Multilateral	4,566,210	Under application	Project activities focus on addressing issues and capacity-building recommendations identified by international experts during previous compliance processes, as well as identifying and resolving new issues and challenges arising in the compliance process, with the aim of continuously enhancing compliance capacity and level.
11	Transparency Capacity-Building Initiative Phase II	Continuously enhance China's capacity to conduct transparency-related methodological research, institutional design, data platform integration, and capacity building at the national, local and enterprise levels, to better support the formulation of domestic low-carbon development goals and the high-level implementation of the Paris Agreement.	2025-2028	MOF	Multilateral	3,780,000	Under application	CBIT identified the need to strengthen capacity in several areas, including the development of China's 2035 NDC plan, institutional capacity for evaluating the effectiveness of mitigation policies and actions under the NDC, improving methodologies for tracking progress and assessing mitigation effects in the NDC mitigation field, optimizing the mitigation effect accounting framework and good practice guidelines, enhancing the capacity to track the implementation effects of methane emission control action plans, improving the capacity to forecast the future emission reduction effects of mitigation policies, and enhancing professional skills and capacity-building training for personnel involved in progress assessment and forecasting.

Table 4-8 Support Received for China's Implementation of Article 13 of the Paris Agreement and Transparency-related Activities (Including Transparency-related Capacity Building)

No.	Title of activity, programme, project or other	Programme/ project description	Channel	Recipient entity	Implementing entities	Amount received (climate-specific) (USD)	Time frame	Financial instrument	Status	Type of support	Sector	Contribution to technology development and transfer objectives	Contribution to capacity-building objectives	Status of activity
1	Global Environment Facility - China Capacity Building for Enhanced Transparency Phase I	In line with the new requirements of the enhanced transparency framework under the Paris Agreement, identify the capacity-building needs for national GHG emission data management and transparency systems, conduct training on methodologies, institutional design, data system application and capacity building at the national, local and enterprise levels, and improve the integrated management platform for national GHG information and emission data to better support the achievement of national low-carbon development goals and the implementation of the Paris Agreement.	Multilateral	MOF	MEE	1,650,000	2021-2023	Grant	Received	Cross-cutting	Multi-sector	No	Yes	Completed
2	Global Environment Facility - Enabling China to Prepare its Fourth National Communication and Biennial Update Report on Climate Change	Support China in fulfilling its commitments under the UNFCCC and preparing the Fourth National Communication, the Third Biennial Update Report, and the Fourth Biennial Update Report.	Multilateral	MOF	MEE	4,566,210	2022-2026	Grant	Received	Cross-cutting	Multi-sector	No	Yes	Ongoing
3	Global Environment Facility - Enabling China to Prepare Its First Biennial Transparency Reports on Climate Change under UNFCCC	Support China in fulfilling its commitments under the UNFCCC and its Paris Agreement, preparing the First Biennial Transparency Report and completing the corresponding common data reports, and submitting them to the UNFCCC Secretariat by the end of 2024.	Multilateral	MOF	MEE	250,000	2024-2026	Grant	Received	Cross-cutting	Multi-sector	No	Yes	Ongoing

Part V Information of HKSAR on Climate Change

HKSAR is a special administrative region of the People’s Republic of China. It is a vibrant city featuring mild climate, with limited land and natural resources, high population density and highly-developed service industries. It is also an eminent international financial, trading and shipping hub.

Chapter 1 HKSAR’s GHG Inventory

I. Institutional Arrangements

The Environment and Ecology Bureau (EBB)[45] of the Government of the HKSAR (hereinafter referred to as the HKSAR Government) is responsible for coordinating, preparing, and managing HKSAR's GHG inventories, and publishing inventories and trends[46] every year. The HKSAR's GHG inventory is compiled with reference to the GPG 2000 and the 2006 IPCC Guidelines, covering sectors such as Energy, IPPU, Agriculture, LULUCF, and Waste. GHGs covered include CO_2, CH_4, N_2O, and F-gases (including HFCs, PFCs, and SF_6). EBB annual statistical data and activity data in relevant sectors from relevant government departments, including the Environmental Protection Department (EPD), the Census and Statistics Department (C&SD), the Electrical and Mechanical Services Department (EMSD), the Transport Department (TD), the Civil Aviation Department (CAD), the Agriculture, Fisheries and Conservation Department (AFCD), the Drainage Services Department (DSD), and the Planning Department (PlanD). Furthermore, EEB also annual statistical data from relevant emitters (including power companies, gas companies, cement producers, port and shipping operators, and public transport operators).

II. GHG Emissions and Removals in HKSAR

(i) Key Category Analysis

The key categories are prioritized in the GHG inventory as their estimated values, either in terms of the absolute emission levels and/or trends, have a significant impact on HKSAR's overall GHG inventory. HKSAR has identified the key categories in the GHG inventories for 2005, 2020, and 2021 through Tier 1 level and trend assessment (see Table 5-1) with reference to the recommendations on key category analysis in the 2006 IPCC Guidelines. The complete results of the key category analysis are detailed in the attached appendix.

[45] Formerly the Environment Bureau. The HKSAR Government has been re-organized with effective from 1 July 2022. The newly set up EEB has enlarged the policy functions of the former Environment Bureau to consolidate the polices and work related to environmental protection, conservation of natural ecology, environmental hygiene, food safety, agriculture, fisheries, animal welfare, etc. so as to achieve synergy in enhancing the overall environment of Hong Kong and maintaining environmental hygiene, as well as the work related to driving climate action, promoting biodiversity, etc.
[46] GHG emissions and trends in Hong Kong can be found at: https://cnsd.gov.hk/en/climate-ready/ghg-emissions-and-trends/.

Table 5-1 Key Category Analysis Results of HKSAR's GHG Inventory for 2020-2021

No.	Sector	Category	GHGs	Key Category or Not (with LULUCF)			Key Category or Not (without LULUCF)		
				Level assessment		Trend assessment	Level assessment		Trend assessment
				2020	2021	2020-2021	2020	2021	2020-2021
1	Energy	1A1ai Power generation - gaseous fuels	CO_2	√	√	√	√	√	√
2	Energy	1A1ai Power generation - solid fuels	CO_2	√	√	√	√	√	√
3	Energy	1A1ai Power generation - biomass	N_2O			√			√
4	Energy	1A1ciii Other energy industries - gaseous fuels	CO_2		√	√		√	√
5	Energy	1A1ciii Other energy industries - liquid fuels	CO_2	√		√	√		√
6	Energy	1A2f Manufacturing and construction -- non-metallic minerals -- solid fuels	CO_2	√	√	√	√	√	√
7	Energy	1A2gi Manufacturing and construction - machinery - liquid fuels	CO_2			√			√
8	Energy	1A3b Road transport	CO_2	√	√	√	√	√	√
9	Energy	1A3d Local water transport	CO_2	√	√	√	√	√	√
10	Energy	1A3e Other transport	CO_2	√			√		
11	Energy	1A4a Business/institutions - gaseous fuels	CO_2	√	√		√	√	
12	Energy	1A4a Business/institutions - liquid fuels	CO_2			√			√
13	Energy	1A4b Residential - gaseous fuels	CO_2	√	√	√	√	√	√
14	Energy	1A5 Other (not specified) - gaseous fuels	CO_2		√			√	
15	IPPU	2A1 Cement production	CO_2	√	√	√	√	√	√
16	IPPU	2F1 Refrigeration and air-conditioning	F-gases	√	√	√	√	√	√
17	LULUCF	4A1 Land that has been forest land	CO_2	√	√				
18	Waste	5A Solid waste disposal	CH_4	√	√	√	√	√	√

(ii) Overview of GHG Inventories for 2005 and 2020-2021 and Overall Trends

1. Updated GHG inventory for 2005

HKSAR's GHG emissions inventories will be updated as appropriate in response to updated estimation methods, expanded scope of calculation and necessary updates of underlying data. The 2005 GHG inventory was updated using the same compilation method as for 2021. The updated total emissions in 2005 increased by 3.5%, mainly due to the adoption of GWP values from the IPCC AR5.

In 2005, HKSAR's updated total net GHG emissions (with LULUCF) were about 42,335 $ktCO_2eq$, with CO_2, CH_4, N_2O, and F-gases accounting for 90.34%, 6.87%, 0.75%, and 2.04% respectively; the carbon sinks from LULUCF were about 412.4 $ktCO_2eq$. In 2005, HKSAR's total GHG emissions (without LULUCF) were approximately 42,747.4 $ktCO_2eq$, with CO_2, CH_4, N_2O, and F-gases accounting for 90.43%, 6.80%, 0.75% and 2.02%, respectively (see Table 5-2). Table 5-3 presents the updated CO_2, CH_4 and N_2O emissions in 2005 by sector. Table 5-4 presents the updated F-gas emissions in 2005.

Table 5-2 HKSAR's Total GHG Emissions in 2005 ($ktCO_2eq$)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	38,631.4	121.9	158.7				38,911.9
IPPU	NO	NO	NO	741.1	1.9	120.7	863.7
Agriculture		40.8	34.4				75.2
LULUCF	-412.4	NE	NE				-412.4
Waste	25.5	2,744.8	126.3				2,896.6
Total (without LULUCF)	38,656.9	2,907.4	319.3	741.1	1.9	120.7	42,747.4
Total (with LULUCF)	38,244.5	2,907.4	319.3	741.1	1.9	120.7	42,335.0

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
4). "NO" (not occurring) indicates that a particular source or sink category do not occur.
5). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

Table 5-3 HKSAR's CO_2, CH_4 and N_2O Emissions in 2005 (kt)

GHG Source/Sink Categories	CO_2	CH_4	N_2O
Total (without LULUCF)	38,656.9	103.8	1.2
Total (with LULUCF)	38,244.5	103.8	1.2
Energy	38,631.4	4.4	0.6
- Fuel combustion	38,631.4	0.4	0.6
♦Energy industry	28,423.4	0.3	0.5
♦Manufacturing and construction	383.6	0.0	0.0

GHG Source/Sink Categories	CO_2	CH_4	N_2O
♦Transport	7,447.0	0.1	0.1
♦Other sectors	2,377.4	0.1	0.0
- Fugitive emissions		3.9	
♦Solid fuel		NO	
♦Oil and natural gas systems		3.9	
IPPU	0.0	NO	NO
- Cement production	0.0		
- Production of halocarbons and SF_6			
- Consumption of halocarbons and SF_6			
Agriculture		1.5	0.1
- Enteric fermentation		0.3	
- Manure management		1.1	0.0
- Rice cultivation		NO	
- Agricultural land		NO	NO
- Agricultural soils		0.0	0.1
- Prescribed burning of savannas		0.0	0.0
LULUCF	-412.4	NE	NE
- Changes in forest and other woody biomass stocks	-412.4		
- Forest conversion	0.0	NE	NE
Waste	25.5	98.0	0.5
- MSW disposal	25.5	94.3	NO
- Wastewater treatment		3.7	0.5
Memo items			
- Special regional aviation	1,011.5	0.0	0.0
- Special regional marine	6,920.0	0.6	0.2
- International aviation	10,322.2	0.1	0.3
- International marine	10,983.5	1.0	0.3

Notes: 1). Shaded cells do not require entries;

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.

4). "NO" (not occurring) indicates that a particular source or sink category do not occur.

5). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

6). Memo items are not counted in the total emissions.

7). "Special regional aviation" and "special regional marine" represent aviation and marine between HKSAR and other parts of China (including Macao SAR and Taiwan).

Table 5-4 HKSAR's F-gas Emissions in 2005 (t)

GHG Source Categories	HFCs					PFCs	SF_6
	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-227ea		
Total	2	4	520	2	12	0	5
Energy							
IPPU	2	4	520	2	12	0	5
- Non-metallic mineral products							
- Chemical industry							
- Metal smelting						NO	
- Production of halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO
- Consumption of halocarbons and SF_6	2	4	520	2	12	0	5
Agriculture							
LULUCF							
Waste							

Notes: 1). Shaded cells do not require entries;

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). 0 indicates that a calculation is available but is displayed as 0 because the number is too small.

4). "NO" (not occurring) indicates that a particular source or sink category do not occur.

Energy is the major source of CO_2 emissions in HKSAR. In 2005, HKSAR's CO_2 emissions (without LULUCF) were about 38,656.9 kt, of which 38,631.4 kt or 99.93% were from Energy, while 25.5 kt from Waste. In 2005, LULUCF in HKSAR removed about 412.4 kt of CO_2, and CO_2 emissions (with LULUCF) were about 38,244.5 kt.

CH_4 emissions were mainly sourced from Waste, followed by Energy and Agriculture. In 2005, HKSAR emitted 103.8 kt of CH_4, equivalent to 2,907.4 ktCO_2eq, of which Waste accounted for 94.41%, Energy accounted for 4.19%, and Agriculture accounted for 1.40%.

N_2O emissions were mainly sourced from Energy, Waste and Agriculture. In 2005, HKSAR emitted 1.2 kt of N_2O, equivalent to 319.3 ktCO_2eq, of which Energy accounted for 49.68%, Waste accounted for 39.54%, and Agriculture accounted for 10.77%.

In 2005, IPPU in HKSAR emitted F-gas of around 863.7 ktCO_2eq.

2. GHG inventory for 2020-2021

In 2020, HKSAR's net total GHG emissions (with LULUCF), amounted to about 34,436.1 ktCO_2eq, of which carbon sinks from LULUCF were about 465 ktCO_2eq. In 2020, HKSAR's total GHG emissions (without LULUCF) amounted to about 34,901.2 ktCO_2eq, among which CO_2 emissions were about 29,433.7 kt (84.33%); CH_4 emissions were about 3,796.6 kt (10.88%); N_2O emissions were about 459.4 kt (1.32%); and F-gas[47] emissions were about 1,211.5 kt (3.47%) (See Table 5-5). Table 5-6 presents the CO_2, CH_4 and N_2O emissions in 2020 by sector. Table 5-7 presents the F-gas emissions in 2020.

[47] F-gases include HFCs, PFCs, and SF_6.

Table 5-5 HKSAR's Total GHG Emissions in 2020 ($ktCO_2eq$)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	28,835.1	122.4	268.6				29,226.1
IPPU	575.9	NO	NO	1,131.4	NO	80.1	1,787.4
Agriculture		16.2	14.8				31.0
LULUCF	-465.0	NE	NE				-465.0
Waste	22.7	3,657.9	176.0				3,856.6
Total (without LULUCF)	29,433.7	3,796.6	459.4	1,131.4	NO	80.1	34,901.2
Total (with LULUCF)	28,968.6	3,796.6	459.4	1,131.4	NO	80.1	34,436.1

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
4). "NO" (not occurring) indicates that a particular source or sink category do not occur.
5). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

Table 5-6 HKSAR's CO_2, CH_4 and N_2O Emissions in 2020 (kt)

GHG Source/Sink Categories	CO_2	CH_4	N_2O
Total (without LULUCF)	29,433.7	135.6	1.7
Total (with LULUCF)	28,968.6	135.6	1.7
Energy	28,835.1	4.4	1.0
- Fuel combustion	28,835.1	2.7	1.0
♦Energy industry	20,253.3	1.0	0.6
♦Manufacturing and construction	710.4	0.1	0.0
♦Transport	6,107.1	1.6	0.4
♦Other sectors	1,764.3	0.0	0.0
- Fugitive emissions		1.6	
♦Solid fuel		NO	
♦Oil and natural gas systems		1.6	
IPPU	575.9	NO	NO
- Cement production	575.9		
- Production of halocarbons and SF_6			
- Consumption of halocarbons and SF_6			
Agriculture		0.6	0.1
- Enteric fermentation		0.2	
- Manure management		0.4	0.0
- Rice cultivation		NO	
- Agricultural land		NO	NO
- Agricultural soils		0.0	0.0
- Prescribed burning of savannas		0.0	0.0
LULUCF	-465.0	NE	NE
- Changes in forest and other woody biomass stocks	-46.5.0		

GHG Source/Sink Categories	CO_2	CH_4	N_2O
- Forest conversion	0.0	NE	NE
Waste	22.7	130.6	0.7
- MSW disposal	22.7	125.6	NO
- Wastewater treatment		5.0	0.7
Memo items			
- Special regional aviation	540.4	0.0	0.0
- Special regional marine	9,988.2	0.9	0.3
- International aviation	7,660.8	0.1	0.2
- International marine	12,621.4	1.2	0.3

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
4). "NO" (not occurring) indicates that a particular source or sink category do not occur.
5). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.
6). Memo items are not counted in the total emissions.
7). "Special regional aviation" and "special regional marine" represent aviation and marine between HKSAR and other parts of China (including Macao SAR and Taiwan).

Table 5-7 HKSAR's F-gas Emissions in 2020 (t)

GHG Source Categories	HFCs					PFCs	SF_6
	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-227ea		
Total	4	7	793	3	19	NO	3
Energy							
IPPU	4	7	793	3	19	NO	3
- Non-metallic mineral products							
- Chemical industry							
- Metal smelting						NO	
- Production of halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO
- Consumption of halocarbons and SF_6	4	7	793	3	19	NO	3
Agriculture							
LULUCF							
Waste							

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
4). "NO" (not occurring) indicates that a particular source or sink category do not occur.

In 2021, HKSAR's total GHG emissions (with LULUCF), amounted to about 35,866.3 ktCO_2eq, of which removals from LULUCF were about 467.5 ktCO_2eq. In 2021, HKSAR's total GHG emissions (without LULUCF) amounted to about 36,333.8 ktCO_2eq, in which, CO_2 emissions were about 30,890.2 kt (85.02%); CH_4 emissions were about 3,731.3 kt (10.27%); N_2O emissions were about 470.2 kt (1.29%); and F-gas emissions were about 1,242.1 kt (3.42%) (See Table 5-8). Table 5-9 presents the CO_2, CH_4 and N_2O emissions in 2021 by sector. Table 5-10 presents the F-gas emissions in 2021.

Table 5-8 HKSAR's Total GHG Emissions in 2021 ($ktCO_2eq$)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	30,393.7	126.7	281.7				30,802.1
IPPU	477.4	NO	NO	1,146.8	NO	95.3	1,719.5
Agriculture		15.5	14.5				30.0
LULUCF	-467.5	NE	NE				-467.5
Waste	19.1	3,589.1	174.0				3,782.2
Total (without LULUCF)	30,890.2	3,731.3	470.2	1,146.8	NO	95.3	36,333.8
Total (with LULUCF)	30,422.7	3,731.3	470.2	1,146.8	NO	95.3	35,866.3

Notes: 1). Shaded cells do not require entries;

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.

4). "NO" (not occurring) indicates that a particular source or sink category do not occur.

5). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

Table 5-9 HKSAR's CO_2, CH_4 and N_2O Emissions in 2021 (kt)

GHG Source/Sink Categories	CO_2	CH_4	N_2O
Total (without LULUCF)	30,890.2	133.3	1.8
Total (with LULUCF)	30,422.7	133.3	1.8
Energy	30,393.7	4.5	1.1
- Fuel combustion	30,393.7	2.8	1.1
♦Energy industry	21,578.1	1.0	0.6
♦Manufacturing and construction	647.8	0.0	0.0
♦Transport	6,338.3	1.7	0.5
♦Other sectors	1,829.6	0.0	0.0
- Fugitive emissions		1.7	
♦Solid fuel		NO	
♦Oil and natural gas systems		1.7	
IPPU	477.4	NO	NO
- Cement production	477.4		
- Production of halocarbons and SF_6			
- Consumption of halocarbons and SF_6			
Agriculture		0.6	0.1
- Enteric fermentation		0.2	
- Manure management		0.4	0.0
- Rice cultivation		NO	
- Agricultural land		NO	NO
- Agricultural soils		0.0	0.0
- Prescribed burning of savannas		0.0	0.0
LULUCF	-467.5	NE	NE
- Changes in forest and other woody biomass stocks	-467.5		

GHG Source/Sink Categories	CO_2	CH_4	N_2O
- Forest conversion	0.0	NE	NE
Waste	19.1	128.2	0.7
- MSW disposal	19.1	125.1	NO
- Wastewater treatment		3.1	0.7
Memo items			
- Special regional aviation	503.3	0.0	0.0
- Special regional marine	8.864.8	0.8	0.2
- International aviation	6.935.3	0.1	0.2
- International marine	11.314.1	1.0	0.3

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
4). “NO” (not occurring) indicates that a particular source or sink category do not occur.
5). “NE” (not estimated) indicates that a particular source or sink category has not been estimated.
6). Memo items are not counted in the total emissions.
7). "Special regional aviation" and "special regional marine" represent aviation and marine between HKSAR and other parts of China (including Macao SAR and Taiwan).

Table 5-10 HKSAR's F-gas Emissions in 2021 (t)

GHG Source Categories	HFCs					PFCs	SF_6
	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-227ea		
Total	5	8	799	4	19	NO	4
Energy							
IPPU	5	8	799	4	19	NO	4
- Non-metallic mineral products							
- Chemical industry							
- Metal smelting						NO	
- Production of halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO
- Consumption of halocarbons and SF_6	5	8	799	4	19	NO	4
Agriculture							
LULUCF							
Waste							

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). 0 indicates that a calculation is available but is displayed as 0 because the number is too small.
4). “NO” (not occurring) indicates that a particular source or sink category do not occur.

Energy is the major source of GHG emissions in HKSAR. In 2020 and 2021, GHG emissions (without LULUCF) from Energy accounted for 83.74% and 84.78%, followed by Waste (11.05% and 10.41%), IPPU (5.12% and 4.73%), and Agriculture (0.09% and 0.08%) (See Figures 5-1 and 5-2).

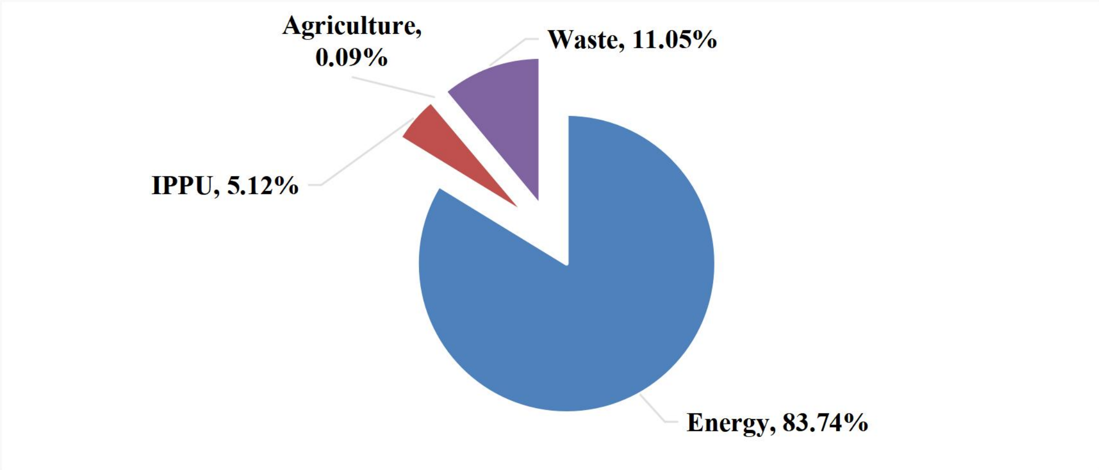


Figure 5-1 HKSAR's GHG Emissions by Sector in 2020 (without LULUCF)

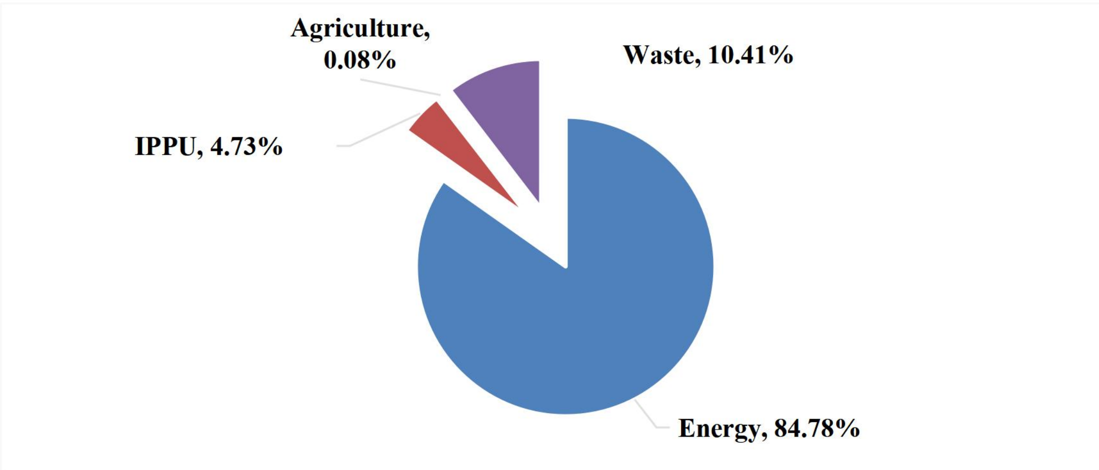


Figure 5-2 HKSAR's GHG Emissions by Sector in 2021 (without LULUCF)

The GHG emissions in HKSAR are primarily CO_2. In 2020 and 2021, CO_2 emissions accounted for 84.33% and 85.02%, followed by CH_4 (10.88% and 10.27%), F-gases (3.47% and 3.42%), and N_2O (1.32% and 1.29%) in terms of CO_2eq (see Figures 5-3 and 5-4).

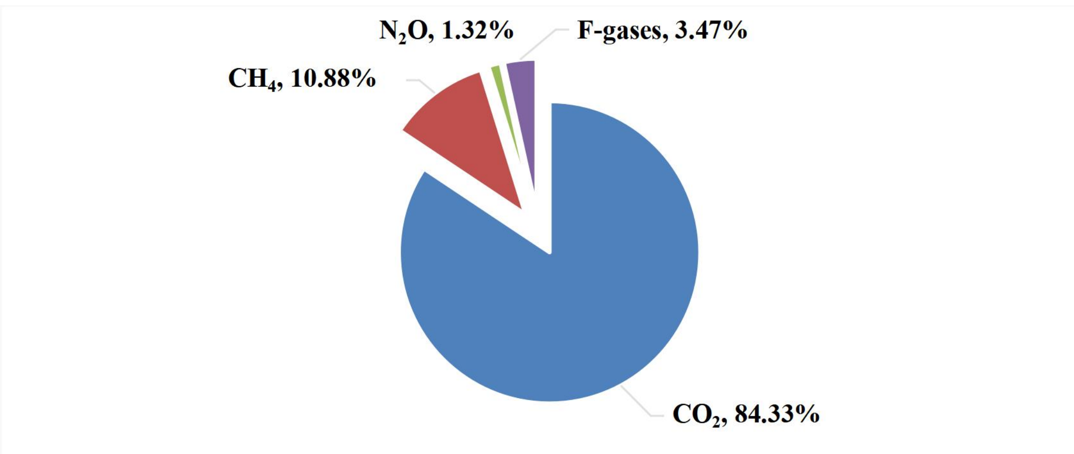


Figure 5-3 HKSAR's GHG Emissions by Gas in 2020

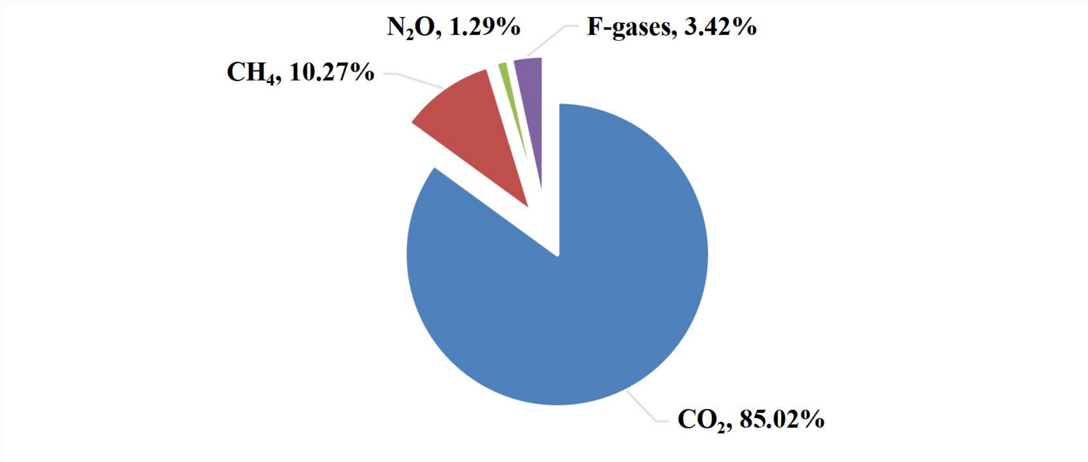


Figure 5-4 HKSAR's GHG Emissions by Gas in 2021

In 2020 and 2021, HKSAR's GHG emissions from special regional and international bunkers (aviation and maritime) amounted to about 31,098.5 ktCO_2eq and 27,874.6 ktCO_2eq, including about 10,629.2 ktCO_2eq and 9,457.3 ktCO_2eq from special regional maritime and aviation, and about 20,469.2 ktCO_2eq and 18,417.3 ktCO_2eq from international maritime and aviation. These emissions were listed separately as memo items and not accounted into HKSAR's total emissions.

3. Overall Uncertainty Analysis

Based on the analysis conducted in accordance with the propagation of error stated in the 2006 IPCC Guidelines, the overall uncertainties of HKSAR's GHG inventories for 2005, 2020, and 2021 were about 4.22%, 5.99%, and 5.78% respectively. The results of the uncertainty analysis for each sector were reported under each sector.

4. Overview of Overall Trends and Analysis

HKSAR has been importing nuclear energy from the Chinese mainland since 1994, which accounted for around a quarter of HKSAR's fuel mix for electricity generation in 2022. Since 1997, HKSAR has stopped building coal-fired electricity generation units. The share of coal in the overall fuel mix for electricity generation in HKSAR has decreased from about half in 2015 to about a quarter currently, while the share of natural gas has significantly increased from about a quarter in 2015 to about half currently. Furthermore, buildings account for 90% of the total electricity consumption in HKSAR, i.e., over 50% of the total GHG emissions. Through coordinated efforts in improving the energy efficiency standards of buildings, carrying out energy saving and emission reduction, as well as adjusting the fuel mix for electricity generation, GHG emissions from the energy industry in 2021 were reduced by about 24% compared to 2005.

HKSAR has continued to reduce emissions from transport by expanding "green transport" such as public transport networks, promoting electric vehicle, and developing new energy transport solutions. With the advancement of emission reduction technologies, GHG emissions from the transport sector in 2021 were decreased by about 13% compared to 2005.

HKSAR's GHG emissions peaked in 2014 and shows a downward trend since then. HKSAR's total GHG emissions in 2022 were decreased by about 19% and 24% compared to the 2005 and 2014 respectively. In 2022, the per capita GHG emissions were about 4.73 tCO_2eq, a reduction of around 25% compared to both 2005 and 2014.

Implementing the four major decarbonization strategies outlined in the "Hong Kong's Climate Action Plan 2050" - "Net-zero Electricity Generation", "Energy Saving and Green Buildings", "Green Transport", and "Waste Reduction" - is a crucial step towards achieving carbon neutrality in HKSAR by 2050[48]. GHG emissions from the energy industry (power generation and Towngas production) and transport account for about 80% of HKSAR's total. As electric vehicles become more popular, GHG emissions from transport are expected to decrease in the future. The popularization of electric vehicles and the growing demand for charging are expected to increase the demand for electricity supply. However, due to the HKSAR's focus on promoting "Net-zero Electricity Generation" and "Energy Saving and Green Buildings" strategies, even if the widespread adoption of electric vehicles is expected to increase the demand for electricity supply, it will not change the overall downward trend in GHG emissions.

As for the Waste sector, over 90% of CH_4 emissions in HKSAR are sourced from the long-term decomposition of MSW in landfills. The "Waste Reduction" strategy advocates waste reduction and recycling to reduce overall waste volume. HKSAR is committed to develop sufficient waste-to-energy facilities by 2035 or earlier, in order to move away from the current reliance on landfills for MSW disposal. As landfill gas recovery capabilities continue to improve and waste-to-energy facilities are gradually put into operation, it is expected to both reduce CH_4 emissions and increase the supply of renewable energy.

III. Energy

(i) Overview

1. Scope

The Inventory of Energy mainly covers CO_2, CH_4 and N_2O emissions from fossil fuel burning in the energy industry, manufacturing and construction industries, transport and other sectors, as well as fugitive CH_4 emissions from oil and natural gas systems.

2. Methods

The calculation of emissions from Energy in HKSAR was mainly based on the 2006 IPCC Guidelines. Tier 3 method was used for CO_2, CH_4 and N_2O emissions from electricity generation. Tier 2 method was used for CO_2 emissions while Tier 1 method was used for CH_4 and N_2O emissions from Towngas production. Tier 2 method was used for CO_2 emissions while Tier 1 method was used for CH_4 and N_2O emissions in utilizing landfill gas for energy purposes. Tier 2 method was used for the calculation of CO_2 emissions while

[48] The URL for the Hong Kong Climate Action Plan 2050 is https://cnsd.gov.hk/wp-content/uploads/pdf/CAP2050_booklet_en.pdf. Detailed information on the four main carbon reduction strategies can be found in Chapter 2, Section 4, "Climate Change Mitigation Policy Actions and Their Effectiveness."

Tier 1 method was used for the calculation of CH_4 and N_2O emissions from manufacturing and construction industries and other sectors.

Tier 1 and 2 methods were used for the calculation of CO_2, CH_4 and N_2O emissions from local aviation and marine transport, rail, non-road transport and road transport sources.

Special regional transport refers to the aviation and marine transport departing from HKSAR with destinations in other parts of the Chinese mainland (including Macao SAR and Taiwan) while international transport refers to aviation and marine transport departing from HKSAR with destinations other than the Chinese mainland (including Macao SAR and Taiwan). Tier 3(a) method was used for the calculation of CO_2, CH_4 and N_2O emissions from special regional and international aviation transport. Tier 1 method was used for the calculation CO_2, CH_4 and N_2O emissions from special regional and international marine transport.

Tier 1 method was used for the calculation of fugitive CH_4 emissions from gas transmission while Tier 3 method was used for the calculation of other fugitive CH_4 emissions.

(ii) GHG Emissions Trend of Energy

Table 5-11 and Table 5-12 sets out emissions inventories on Energy by gas and by sector respectively.

Table 5-11 GHG Emissions of Energy in HKSAR by Gas for 2005, 2020 and 2021 (ktCO$_2$eq)

GHG Categories	2005	2020	2021
CO_2	38,631.4	28,835.1	30,393.7
CH_4	121.9	122.4	126.7
N_2O	158.7	268.6	281.7
Total	38,911.9	29,226.1	30,802.1

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.

Table 5-12 GHG Emissions of Energy in HKSAR by Sector for 2005, 2020 and 2021 (ktCO$_2$eq)

Energy	2005	2020	2021
Energy industry (electricity generation and gas production)	28,553.2	20,429.6	21,764.6
Transport	7,483.6	6,270.3	6,506.6
Other fuel combustion (including commercial and residential)	2,380.7	1,766.2	1,831.5
Manufacturing and construction industries	384.7	714.0	650.9
Fugitive CH_4 emissions	109.8	45.9	48.5
Total	38,911.9	29,226.1	30,802.1

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.

(iii) Uncertainty and Time-Series Consistency Analysis

The GHG inventory of Energy sector (including subsectors) of each year was calculated in accordance with the 2006 IPCC Guidelines, using a harmonized method, to ensure the time-consistency of the inventory.

Based on the error propagation method in the 2006 IPCC Guidelines, the overall uncertainties of GHG emissions inventories of Energy sector for 2005, 2020, and 2021 were about 2.15%, 1.55%, and 1.64% respectively. Among them, the uncertainties in the energy industry (electricity generation and Towngas production) were about 2.10%, 1.42% and 1.52%, respectively; and the uncertainties in the transport sector were about 1.14%, 1.11% and 1.11%, respectively.

Emissions from coal combustion in electricity generation were the major source of uncertainty in the inventory among sub-sectors of Energy, mainly due to limitations in statistical data such as the variety and quantity of coal consumed by power plants.

IV. IPPU

(i) Overview

1. Scope

The Inventory of IPPU mainly covers CO_2 emissions from cement production; HFCs and PFCs emissions from refrigeration, air-conditioning and fire-fighting equipment; and SF_6 emissions from electrical equipment.

2. Methods

Based on cement clinker production data and related information, Tier 2 method was used for the calculation of CO_2 emissions from cement production; Tier 2 method was used for the calculation of emissions from HFCs consumption in refrigeration and air-conditioning; Tier 1 method was used for the calculation of PFCs emissions from solvents; Tier 1 method was used for the calculation of HFCs and PFCs emissions from fire-fighting equipment; and Tier 3 method was used for the calculation of emissions from the use of SF_6 in electrical equipment.

(ii) GHG Emissions Trend of IPPU

Table 5-13 and Table 5-14 sets out inventories on IPPU by gas and by sector respectively.

Table 5-13 GHG Emissions of IPPU in HKSAR by Gas ($ktCO_2eq$)

Gas	2005	2020	2021
CO_2	0.0	575.9	477.4
HFCs	741.1	1,131.4	1,146.8
PFCs	1.9	NO	NO
SF_6	120.7	80.1	95.3
Total	863.7	1,787.4	1,719.5

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
3). "NO" (not occurring) indicates that a particular source or sink category do not occur.

Table 5-14 GHG Emissions of IPPU in HKSAR by Sector ($ktCO_2eq$)

IPPU	2005	2020	2021
Cement production (CO_2)	0.0	575.9	477.4
Use of refrigeration and air conditioning, fire extinguishing equipment (HFCs)	741.1	1,131.4	1,146.8
Use of refrigeration and air conditioning, fire extinguishing equipment (PFCs)	01.9	NO	NO
Use of electrical equipment (SF_6)	120.7	80.1	95.3
Total	863.7	1,787.4	1,719.5

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.
3). "NO" (not occurring) indicates that a particular source or sink category do not occur.

(iii) Uncertainty and Time-Series Consistency Analysis

The GHG inventory of IPPU (including subsectors) of each year was calculated in accordance with the 2006 IPCC Guidelines, using a harmonized method, to ensure the time-consistency of the inventory.

According to the error propagation method in the 2006 IPCC Guidelines, the overall uncertainties of the GHG inventory of IPPU for 2005, 2020 and 2021 were about 0.37%, 0.85%, and 0.82% respectively.

V. Agriculture

(i) Overview

1. Scope

The Inventory of Agriculture mainly covers CH_4 and N_2O emissions from livestock enteric fermentation and manure management, N_2O emissions from agricultural soils, and CO_2, CH_4 and N_2O emissions from grassland burning.

2. Methods

Tier 1 method was used for the calculation of CH_4 emissions from enteric fermentation, direct and indirect N_2O emissions from agricultural land, and CH_4 and N_2O emissions from prescribed grassland burning.

(ii) GHG Emissions Trend of Agriculture

Table 5-15 and Table 5-16 sets out inventories on Agriculture by gas and by sector respectively.

Table 5-15 GHG Emissions of Agriculture in HKSAR by Gas ($ktCO_2eq$)

GHG Categories	2005	2020	2021
CO_2			
CH_4	40.8	16.2	15.5
N_2O	34.4	14.8	14.5
Total	75.2	31.0	30.0

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.

Table 5-16 GHG Emissions of Agriculture in HKSAR by Sector ($ktCO_2eq$)

Agriculture	2005	2020	2021
Enteric fermentation	8.7	4.8	4.7
Manure management	41.9	14.9	14.4
Agricultural soils	24.5	10.9	10.8
Prescribed burning of savannas	0.1	0.4	0.0
Total	75.2	31.0	30.0

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.

(iii) Uncertainty and Time-Series Consistency Analysis

The GHG inventory of Agriculture (including subsectors) in each year was calculated in accordance with the 2006 IPCC Guidelines, using a harmonized method, to ensure the time-consistency of the inventory.

Based on the error propagation method in the 2006 IPCC Guidelines, the overall uncertainties of GHG emissions inventories of Agriculture for 2005, 2020, and 2021 were about 0.07%, 0.04%, and 0.04% respectively.

VI. LULUCF

(i) Overview

1. Scope

The Inventory of LULUCF mainly covers the changes in biomass carbon stock caused by the conversion of forest land, cropland and grassland.

2. Methods

CO_2 emissions from the conversion of forest land, cropland and grassland were calculated using the Tier 1 method with reference to the relevant emission factors; CO_2 emissions and removals from changes in carbon stocks in forests and other woody biomass were also calculated using the Tier 1 method.

(ii) GHG Emissions Trends of LULUCF

Table 5-17 and Table 5-18 sets out inventories on LULUCF by gas and by sector respectively.

Table 5-17 GHG Emissions of LULUCF in HKSAR by Gas ($ktCO_2eq$)

GHG Categories	2005	2020	2021
CO_2	-412.4	-465.0	-467.5
CH_4			
N_2O			
Total (carbon sinks)	-412.4	-465.0	-467.5

Notes: 1). Shaded cells do not require entries;

2). Due to rounding, the aggregation of various items may be slightly different from the total.

Table 5-18 GHG Emissions of LULUCF in HKSAR by Sector ($ktCO_2eq$)

LULUCF	2005	2020	2021
Changes in forest and other woody biomass stocks	-412.4	-465.0	-467.5
Forest conversion	0.0	0.0	0.0
Total (carbon sinks)	-412.4	-465.0	-467.5

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.
2). 0.0 indicates that a calculation is available but is displayed as 0.0 because the number is too small.

(iii) Uncertainty and Time-Series Consistency Analysis

The GHG inventory of LULUCF (including subsectors) of each year was calculated in accordance with the 2006 IPCC Guidelines, using a harmonized method, to ensure the time-consistency of the inventory.

According to the error propagation method in the 2006 IPCC Guidelines, the overall uncertainties of the GHG inventory of LULUCF for 2005, 2020 and 2021 were about 0.10%, 0.13%, and 0.13% respectively.

VII. Waste

(i) Overview

1. Scope

The Inventory on Waste mainly covers CH_4 emissions from solid waste landfills; CH_4 and N_2O emissions from treatment of domestic sewage and industrial wastewater; and CO_2 emissions from waste incineration.

2. Methods

GHG Emissions from Waste were mainly calculated based on the 2006 IPCC Guidelines. Tier 2 method was used for the calculation of CH_4 emissions from landfilling of solid waste. Tier 1 method were used for the calculation of CH_4 and N_2O emissions from wastewater treatment, as well as for CO_2 emissions from chemical waste disposal.

(ii) GHG Emissions Trends of Waste

Table 5-19 and Table 5-20 sets out inventories on Waste by gas and by sector respectively.

Table 5-19 GHG Emissions of Waste in HKSAR by Gas ($ktCO_2eq$)

GHG Categories	2005	2020	2021
CO_2	25.5	22.7	19.1
CH_4	2,744.8	3,657.9	3,589.1
N_2O	126.3	176.0	174.0
Total	2,896.6	3,856.6	3,782.2

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.

Table 5-20 GHG Emissions of Waste in HKSAR by Sector (ktCO$_2$eq)

Waste	2005	2020	2021
MSW disposal	2,665.8	3,540.6	3,520.7
Wastewater treatment	230.4	315.4	260.8
Total	2,896.6	3,856.6	3,782.2

Note: 1). Due to rounding, the aggregation of various items may be slightly different from the total.

(iii) Uncertainty and Time-Consistency Analysis

The GHG inventory of Waste (including subsectors) of each year was calculated in accordance with the 2006 IPCC Guidelines, using a harmonized method, to ensure the time-consistency of the inventory.

Based on the error propagation method in the 2006 IPCC Guidelines, the overall uncertainties of GHG emissions inventories of Waste sector for 2005, 2020, and 2021 were about 3.43%, 5.62%, and 5.37% respectively.

VIII. Issues Related to Cross-Cutting Sectors

The cement production process, the waste-to-energy facilities, and the MSW at landfills in HKSAR involve GHG emissions from cross-cutting sectors. To avoid double-counting across different sectors, the HKSAR Government has adopted the following data refinement and emission source classification measures in processing the annual activity raw data and emissions data in the above-mentioned sectors.

In the cement production process, GHG emissions are sourced from the use of silicate cement clinker and the consumption of fossil fuels (mainly coal and oil). Based on the annual raw data of fossil fuel consumption and use of silicate cement clinker provided by cement producers, GHG emissions from fossil fuel consumption and the use of silicate cement clinker were calculated respectively. According to the 2006 IPCC Guidelines, GHG emissions from fossil fuel consumption were classified as "fuel consumption" under Energy sector while those from the use of silicate cement clinker were classified as the "cement production" under IPPU.

Regarding waste-to-energy facilities, HKSAR mainly relies on sludge incineration and converting food waste into biogas for electricity generation. Based on annual data collected from waste-to-energy facilities, GHG emissions from electricity generation were reported under the "energy industry (electricity generation and gas production)" of Energy sector in accordance with the 2006 IPCC Guidelines.

In addition, the landfill gas produced by MSW disposal at landfills utilized for electricity generation and Towngas production[49]. Based on annual MSW disposal and landfill gas recovery statistics collected from landfills, GHG emissions from MSW disposal were calculated according to the 2006 IPCC Guidelines and put under MSW disposal under Waste sector after deducting the volume of landfill gas recovered. On the other hand, GHG

[49] For details, see Chapter 2, Section 4, on "Strengthening Control of Non-CO$_2$ GHG emissions."

emissions from electricity generation and Towngas production by utilizing landfill gas were included in the "energy industry (electricity generation and gas production)" under Energy sector in accordance with the 2006 IPCC Guidelines.

IX. Quality Assurance, Quality Control and Verification

The HKSAR Government has put effort in strengthening the QA/QC work during the compilation of GHG inventory. Measures to improve the quality of inventory compilation have been carried out, including:

First, the 2006 IPCC Guidelines was strictly followed to ensure the scientific rigor, comparability, and transparency in inventory compilation.

Second, based on the data availability, higher-tier methods were used where possible to ensure the accuracy of the inventory results.

Third, during activity data collection and analysis, the inventory compilation team has worked closely with relevant departments to obtain authoritative first-hand official data. Designated officer has been arranged for GHG inventory management, verification, and inspection in order to ensure the authority and reasonableness of the data used.

Fourth, while determining the emission factors, those suitable for HKSAR's actual conditions were adopted where possible. In case of no emission factors reflecting HKSAR's characteristics, the default emission factors provided in the 2006 IPCC Guidelines were used to ensure the accuracy of the inventory results.

The measures taken to reduce uncertainty mainly include the following two aspects: The first is to improve the data collection work. Official published statistical data, and local measured emission factors and parameters were used and refer to the latest relevant parameters in the 2006 IPCC Guidelines. The second is to select appropriate methodologies. Based on the data availability, higher-tier methods were adopted in emissions calculations.

When there are significant changes in the key categories and the calculation methods of inventory, as well as major revisions to the data of individual categories, the HKSAR Government would examine the impact of such changes or revisions on every inventory years, and adopt a harmonized method for the every inventory years as far as possible based on data availability so as to ensure the time-series consistency and comparability of the inventory. To ensure the traceability and completeness of the records, all changes or revisions to the inventory (including the reasons, revision methods, etc.) would be recorded in detail. Original calculation data would be retained for future reference.

As part of the inventory quality assurance, the HKSAR Government would cross-check the data related to GHG emissions (such as electricity sent-out, energy consumption, vehicle mileage, etc.) with other agencies/departments. By comparing the differences between various data, the uncertainty of the data can be reduced, thereby improving the accuracy of GHG emission calculations. Furthermore, the HKSAR Government would review inviting a non-inventory team as a third independent party to review the inventory.

X. Inventory Improvement Plan

(i) Improvement in Accuracy of inventory Calculations

1. Road Transport

GHG emissions from road transport were calculated based on the vehicle mileage and fuel consumption data obtained through modeling, which accounted for about 16% of HKSAR's total GHG emissions in 2022. To enhance the accuracy of the inventory, the HKSAR Government has improved the methodology for estimating GHG emissions from road transport by using the annual raw data on vehicle mileage, fuel economy and model projection data to calculate GHG emissions. Furthermore, the HKSAR Government compared annual vehicle fuel sales data with the vehicle mileage data and estimated GHG emissions data. Through comparison of differences between various data, the uncertainty in data can be reduced, and the accuracy of GHG emission calculations can be improved.

2. HFCs Emissions from Refrigerants

Annual GHG emissions from HFCs in HKSAR were estimated using imports and exports statistics of refrigerants and related industry-wide surveys on the usage of refrigerants. Given that HKSAR will fulfill the provisions of the Kigali Amendment regarding the gradual phase-down of the local production and use of 18 types of HFCs, in order to improve the accuracy and comprehensiveness of calculating the usage and emissions of HFCs, the HKSAR Government will stay up-to-date and consider optimizing the survey content on refrigerant usage, including the usage of low-GWP refrigerants[50] and incorporating low-GWP refrigerants into the inventory calculations, in preparation for future development in HFC emission reductions. This can accurately reflect the GHG emissions caused by refrigerant use, and lay a foundation for accurately estimating and predicting GHG emissions and trends from HFCs, thus improving the effectiveness of the HKSAR Government's monitoring policies.

(ii) Inventory Refinement for Improved Representativeness

The HKSAR Government will review the classification of fuel combustion activities (other than electricity generation and transport) under Energy. GHG emissions from fuel combustion in the residential, commercial and industrial sectors will be clearly distinguished by comparing more detailed annual energy statistics data with the 2006 IPCC Guidelines. The inventory improvement will make the refined GHG emission data more representative and will also help the HKSAR Government to further analyze and understand the GHG emissions from fuel combustion in HKSAR.

[50] Alongside the global commitment to combating climate change and the adoption of the Kigali Amendment, refrigerant manufacturers have developed more and more low-GWP refrigerants that can serve as alternatives to HFCs refrigerants. At present, different types of such alternatives are available in the global market and many of them have already been introduced to the Hong Kong market, such as R1233zd and R514A for water-cooled chillers, R600a for household refrigerators, and R1234yf for automotive air conditioners Their GWP values are below 5.

Chapter 2 Progress in the Determined Contributions of HKSAR

I. Regional Circumstances and Institutional Arrangements

(i) HKSAR Government Structure and Institutional Arrangements Related to Climate Change Response

The Chief Executive is the head of the HKSAR, who is responsible for making decisions on government policies and issuing Executive Orders, and is assisted in policy making by the Executive Council. The main administrative and executive functions of government are carried out by 15 policy bureaux and their subordinate departments[51].

The HKSAR Government proactively implements relevant provisions of the UNFCCC. It strives to coordinate present and future work and activities to address climate change, enhance capacity to mitigate and adapt to climate change and promote public awareness and understanding of climate change through cooperating closely among relevant policy bureaus, departments and other bodies. In 2021, the Government set up the new interdepartmental "Steering Committee on Climate Change and Carbon Neutrality" under the chairmanship of the Chief Executive of the HKSAR. It replaced the "Steering Committee on Climate Change" chaired by the Chief Secretary for Administration. The new Steering Committee is responsible for formulating the overall strategies and overseeing the coordination of various actions and will bring them to the highest level for deliberating and decision-making. In January 2023, the Environment and Ecology Bureau (EEB) of Hong Kong also set up a new Office of Climate Change and Carbon Neutrality to strengthen coordination and promote deep decarbonization, and to encourage different sectors in the community, especially young people, to participate actively in climate change.

(ii) Population and Economic Development

HKSAR had a population of around 7.47 million in 2022, representing a 4% increase compared to 2012. The labor force was around 3.78 million in 2022, of which 49.9% were males and 50.1% were females.

Hong Kong is a highly urbanized economy. The Gross Domestic Product (GDP) of HKSAR at current market prices in 2022 was approximately HK$ 2.81 trillion, or about HK$ 382,400 per capita. The annual rates of change of GDP in 2021 and 2022 were +7.2% and -2.1% respectively. In 2022, the ratio among the primary, secondary and tertiary industries [52] was 0.1:6.4:93.5. The value added of and persons engaged in the primary industry both had a small share. Since the early 1980s, the manufacturing industry has substantially relocated to the Mainland China, resulting in a gradual shrinkage in its contribution to the value added of HKSAR's economy. The contribution of the tertiary

[51] For the organizational structure of the HKSAR Government, see: https://www.gov.hk/en/about/govdirectory/govstructure.htm.

[52] The primary industry includes agriculture, fisheries, mining, and quarrying; the secondary industry includes manufacturing, electricity, gas and water supply, waste management, and construction; the tertiary industry includes service industries.

industry (the services sector) has been increasing progressively. Of the tertiary industry, financial services, tourism, trading and logistics, professional services and other producer services have become the pillar industries of HKSAR. In 2022, the total value of external merchandise trade amounted to HK$ 9.5 trillion; the value added of the financing and insurance industry was HK$ 613 billion. Affected by the COVID-19 epidemic in 2019, the number of visitor arrivals greatly reduced from 55.91 million (including around 43.77 million Chinese Mainland visitors) in 2019 to 0.6 million (including around 0.38 million Chinese Mainland visitors) in 2022.

There is basically no primary energy production in Hong Kong. HKSAR's electricity consumption is mainly from local thermal power and primarily supplemented by nuclear energy imported from the Guangdong Province. In the annual electricity consumption of the HKSAR in 2022, coal accounted for around 25%, natural gas accounted for around 48%, and renewable energy and nuclear energy accounted for around 27%.

HKSAR has a well-developed public transport system. The public transport comprises railways, tramways, buses, minibuses, taxis and ferries. The public transport system on average carried 9.67 million passenger trips daily in 2022. This represented nearly 90% of the daily number of passenger trips. By the end of 2022, there were around 810,000 licensed motor vehicles in HKSAR, with around 571,000 of them being private cars. The motor vehicle and private car ownership were 126 and 88 per 1,000 people respectively.

Hong Kong is a highly urbanized, service-oriented city with limited energy-intensive industries. Most of its energy consumption is used for electricity generation (90% of which is consumed by buildings), followed by transportation. As a result, electricity generation, transportation and waste are the three major sources of GHG emissions in the HKSAR, collectively accounting for around 90% of total emissions. The HKSAR's decarbonization efforts primarily focus on these three critical areas to formulate overall decarbonization strategies accordingly.

(iii) Natural Conditions and Resources

HKSAR is located in the southern part of China, bordering Shenzhen City of Guangdong Province in the north and surrounded by sea on three sides. As of 2022, HKSAR has a land area of 1,113.76 km^2 comprising Hong Kong Island, Kowloon, the New Territories and the Islands. With hilly terrain, nearly 300 km^2 of land has been developed for living and economic activities. More than 500 km^2 of land has been designated for nature conservation, including country parks and other conservation-related areas. HKSAR is located within the sub-tropical region with a mild climate. The average annual mean temperature was 23.6°C and the average annual rainfall was about 2,438 mm for the past 30 years (1993-2022). Extreme weather conditions that occur in HKSAR include tropical cyclones, strong monsoon, monsoon troughs and severe convective weather. Sub-tropical evergreen broad-leaved forest is the main vegetation in HKSAR. HKSAR has a rich biodiversity of marine species such as fish and crustaceans. However, fresh water resource is relatively scarce. Rainwater collected from local catchment accounts for about 20% to 30% of the fresh water supply, and the remaining 70% to 80% of fresh water supply relies on import from the Dongjiang River in Guangdong Province.

To address climate change, the development of carbon reduction infrastructure requires land and space resources. However, HKSAR has a hilly terrain, dense urban areas, scarce land resources, and limited sea area. Given the above natural conditions in HKSAR, HKSAR has relatively limited potential for large-scale development of renewable energy [53].

II. Description of HKSAR's Determined Contribution Targets

(i) Carbon Peaking and Carbon Neutrality

The HKSAR Government places great emphasis on addressing climate change and released the "Hong Kong's Climate Action Plan 2030+" [54] in 2017, which outlines the major measures taken in the areas of mitigation, adaptation and resilience to climate change. To align with the NDC target of achieving carbon neutrality by 2060, the Chief Executive of HKSAR announced in the 2020 Policy Address that HKSAR would strive to achieve carbon neutrality before 2050. Subsequently, the "Hong Kong's Climate Action Plan 2050" was released in 2021, setting more ambitious carbon reduction strategies and measures, strengthening the interim target, and aiming to halve Hong Kong's carbon emissions before 2035 as compared with the 2005 level. Focusing on the three major GHG emission sources, namely power generation, transport and waste, the Plan sets out four major decarbonization strategies, i.e. "net-zero electricity generation", "energy saving and green buildings", "green transport" and "waste reduction"[55], to lead Hong Kong towards carbon neutrality.

(ii) Non-fossil Fuels (as a percentage of the fuel mix for electricity generation)

HKSAR has been importing nuclear energy from the Chinese Mainland since 1994, which accounted for around a quarter of HKSAR's fuel mix for electricity generation in 2022. The HKSAR's Clean Energy Transmission System connecting to the mainland power grid is currently undergoing an upgrade for enhancement of transmission capacity. Upon completion of the project in 2025, the share of clean energy imported from the Chinese Mainland in HKSAR's fuel mix for electricity generation is expected to increase by 8% from 27% to about 35%. HKSAR aims to further increase the share of zero-carbon energy in its fuel mix for electricity generation to about 60%~70% before 2035 and achieve net-zero electricity generation before 2050.

(iii) Renewable Energy (as a percentage of the fuel mix for electricity generation)

The HKSAR Government established the decarbonization strategy of "net-zero electricity generation" in the "Hong Kong's Climate Action Plan 2050". To this end, the HKSAR Government will strive to grapple with the geographical and environmental constraints in

[53] For challenges faced in development, refer to Chapter 2, Section 3, "Challenges in Tracking Indicator Progress."
[54] The URL for the Hong Kong Climate Action Plan 2030+ is https://cnsd.gov.hk/wp-content/uploads/pdf/HK_Climate_Action_Plan_2030+_booklet_En.pdf.
[55] Detailed information on the four main carbon reduction strategies can be found in Chapter 2, Section 4, "Climate Change Mitigation Policy Actions and Their Effectiveness."

driving the development of renewable energy, with view to striving to increase the share of renewable energy in fuel mix for electricity generation to 7.5%~10% by 2035 and further increasing it to 15% before 2050. In addition, through joint efforts by the private sector and relevant government departments, the share of solar energy in the fuel mix for electricity generation is expected to increase from about 0.5% in 2022 to about 1% in 2028.

(iv) Other Targets

In international shipping, as an Associate Member of the International Maritime Organization (IMO) and an international maritime center, HKSAR is actively implementing green port measures. These include implementing the latest IMO environmental protection resolutions into local legislation, gradually reducing GHG emissions from ships, and requiring the industry to pursue technological improvements and operational adjustments in the direction of decarbonization, in order to follow the IMO's target of achieving net-zero GHG emissions by or around 2050.

III. Progress in HKSAR's Determined Contribution Targets

(i) Progress Tracking

1. Progress in carbon peaking and carbon neutrality

HKSAR's total GHG emissions peaked in 2014. In 2022, HKSAR's total GHG emissions were about 34.776 $MtCO_2eq$, a decrease of about 4% compared to 2021. This represents a reduction of about 19% from the 2005 base year (42.747 $MtCO_2eq$) and about 24% from the peak emissions in 2014 (45.535 $MtCO_2eq$).

2. Progress in the share of non-fossil fuels in the fuel mix for electricity generation

In 2022, non-fossil fuels accounted for approximately 25% of the HKSAR's fuel mix for electricity generation.

3. Progress in the share of renewable energy in the fuel mix for electricity generation

In 2022, renewable energy accounted for no more than 1% of the HKSAR's fuel mix for electricity generation.

(ii) Challenges in Tracking Progress on Indicators

The development of carbon reduction infrastructure requires land and space resources. However, HKSAR has a hilly terrain, dense urban areas, scarce land resources, and limited sea area, leading to relatively limited potential for large-scale development of renewable energy. As such, it is essential to explore room for improvement, including promoting local renewable energy projects and strengthening regional cooperation and joint ventures, etc. The goal is to increase the share of zero-carbon energy in the fuel mix for electricity generation to about 60% to 70% before 2035.

The HKSAR Government has been actively working to plan for the strengthening of regional cooperation to stabilize electricity tariffs, ensure energy security and secure access to more clean energy. The HKSAR Government, together with power companies, will explore ways to enhance regional cooperation on zero-carbon energy, and collaborate with neighboring regions to explore additional zero-carbon energy supply, including seeking joint ventures and joint development opportunities for participating in and operating zero-carbon energy projects near Hong Kong. In addition, the HKSAR Government has reserved land to build electricity facilities, which will connect to the electricity supply systems of the power companies to strengthen their interconnection and the ability of electricity transmission. The project is currently still in the planning stage, and it is estimated to take around 10 years to plan, construct and complete the new cross-boundary electricity transmission and receiving facilities. They are expected to be commissioned before 2035, and the share of imported zero-carbon energy electricity may have a further increase by then.

In terms of building energy efficiency, HKSAR faces the challenge of aging buildings. Some buildings were not designed with energy efficiency in mind, and their electrical systems may not be easily upgraded to accommodate new energy-saving devices. To this end, the HKSAR Government is actively promoting retro-commissioning. This involves regular inspection, adjustment, correction and repair of existing control/monitoring systems in existing buildings. This initiative aims to continuously improve the energy efficiency of building installations and reduce energy consumption.

In 2022, HKSAR disposed of municipal solid waste totaling 4.06 million tonnes, an average of 11,128 tonnes per day. To monitor the latest trend in waste disposal and recycling, the HKSAR Government collects data from various sources, including records from waste treatment facilities of the HKSAR Government, statistical surveys from different recyclers to gather data on the quantities of various materials recycled, and sampling at waste treatment facilities to analyze the waste components and collect data on the disposal quantities of various waste materials in municipal solid waste. The HKSAR Government consolidates and processes the above data to compile statistics on recycling and disposal quantities categorized by waste type and publish them in the publicly available solid waste monitoring report annually.

In promoting green transport, it is essential to put in place a comprehensive electric vehicle charging network to support the popularization of electric vehicles. As the technologies of electric vehicle batteries and quick chargers are advancing and the electric vehicle market environment is evolving, the HKSAR Government will continue to keep in view the relevant technological developments, and expand the charging network as well as the associated supporting facilities on various fronts, with a view to providing drivers with the necessary electric vehicle charging services. Additionally, it will use the traffic data from the Transport Department to track the number of new energy vehicles and assess the progress in the implementation of relevant policies.

IV. Mitigation Policies, Actions and Effects

(i) Mitigation Policies and Actions

In order to effectively control the GHG emissions, the HKSAR Government released the

"Hong Kong's Climate Action Plan 2050" in 2021. Focusing on the three major local GHG emission sources, namely power generation, transport and waste, the HKSAR Government sets out four major decarbonization strategies, i.e. "net-zero electricity generation", "energy saving and green buildings", "green transport" and "waste reduction", and formulates relevant policies and actions to effectively mitigate climate change.

1. Accelerating the Optimization and Adjustment of Energy Structure

Net-zero electricity generation. The HKSAR Government has set a target to cease the use of coal for daily electricity generation by 2035, and replace coal-fired electricity generation with natural gas with lower carbon emissions and zero-carbon energy. The HKSAR Government needs to increase the share of zero-carbon energy in the fuel mix for electricity generation to 60%~70% before 2035, increase the share of renewable energy to 7.5%~10% and further increase it to 15% subsequently, and achieve the medium-term target of reducing carbon emissions by half from the 2005 level before 2035. To this end, since 1997, HKSAR has ceased to build coal-fired electricity generation units. Currently, the share of coal in the fuel mix for electricity generation has been reduced from around half in 2015 to around a quarter, while the share of natural gas has significantly increased from around a quarter in 2015 to almost half. The HKSAR Government will take into account the four energy policy objectives of safety, reliability, affordability and environmental performance to develop a diversified fuel mix for electricity generation. It will also try out the use of new energy sources and strengthen cooperation with neighbouring regions to increase zero-carbon electricity generation, with a view to ultimately achieving the goal of "net-zero electricity generation" before 2050.

Vigorously promoting renewable energy. In the public sector, the HKSAR Government is taking the lead in developing renewable energy, including the development of large-scale projects in reservoirs and restored landfills. The HKSAR Government is constructing a 10-megawatt solar farm at the South East New Territories Landfill in Tseung Kwan O. Upon completion in 2026, this large-scale project is expected to supply about 10 million kWh of electricity to nearby water facilities, which could meet the annual electricity demand of about 3,000 households and reduce carbon emissions by 7,000 tons per year.

Building small-scale renewable energy systems. Since 2017-2018, the HKSAR Government has earmarked a total of HK$ 3 billion for the installation of small-scale renewable energy systems at government premises. To date, around HK$ 2 billion has been approved for approximately 220 projects, which collectively generate about 25 million kWh of electricity per year. In addition, through inter-departmental efforts, the HKSAR Government has been collaborating with various departments, including the Environmental Protection Department (EPD), Water Supplies Department (WSD) and Drainage Services Department (DSD), since 2022 to implement projects of small-scale system at about 50 selected premises, such as refuse transfer stations, waterworks facilities including pumping stations and service reservoirs, as well as sewage treatment facilities including sewage treatment works and sewage pumping stations, with a view to enhancing space utilization. Thes electricity generated from them is anticipated on-site use, thereby saving electricity costs for the relevant departments and reducing carbon emissions.

"Feed-in Tariff" Scheme. To encourage the private sector to develop renewable energy on their land and properties, the HKSAR Government launched the "Feed-in Tariff" Scheme in 2018. This initiative allows the private sector to sell the renewable energy electricity they generate to the power companies at a rate higher than the normal electricity tariff rate, in order to foster an investment market centered on renewable energy. To complement the "Feed-in Tariff" Scheme, the HKSAR Government has also introduced a series of supporting measures, such as facilitating the private sector in installing solar energy generation systems at open car parks, suitably relaxing he requirements for the installation of solar energy generation systems on the rooftops of New Territories Exempted Houses (i.e. village houses), revamping the "HK RE Net" and setting up an enquiry hotline, introducing legislative amendments to provide exemption from the requirements to apply for business registration and pay profits tax n respect of participation in and the payment received under the Feed-in Tariff Scheme, etc.

2. Advancing Green, Low-Carbon Development in the Building Sector

Energy Saving and Green Buildings. In HKSAR, 90% of electricity is consumed by buildings, and more than 50% of carbon emissions come from electricity generation associated with building energy consumption. Promoting green buildings, improving building energy efficiency and adopting low-carbon lifestyles can reduce electricity consumption and power generation demand, as well as lessen the financial burden on citizens associated with the transition to cleaner energy generation. The HKSAR Government aims to reduce electricity consumption in commercial buildings by 30%~40% and residential buildings by 20%~30% by 2050 or earlier, compared to 2015 levels. The HKSAR Government aims to achieve half of the above targets by 2035 or earlier.

Emphasizing building energy efficiency. Under the energy-saving measures related to the Buildings Energy Efficiency Ordinance (hereinafter referred to as the "Ordinance"), the 2015 energy-saving benchmarks include the improved energy efficiency for newly constructed buildings and major renovation projects as a result of the triennial review of the Ordinance and the Code of Practice for Building Energy Audit, as well as the energy-saving results from regular energy audits. The third phase of the Mandatory Energy Efficiency Labelling Scheme came into effect in 2020. The HKSAR Government gazetted and promulgated the Building Energy Code (2021 edition) on December 31, 2021, which comprehensively raised energy efficiency standards. Compared to the 2015 edition, the updated standards have improved overall energy efficiency by more than 15%. It is estimated that by 2035, these measures could save approximately 4.7 to 5.3 billion kWh of electricity in buildings per year (compared to the 2015 level). By the end of 2022, the energy-saving measures implemented by the HKSAR Government had collectively saved 3.1 billion kWh of electricity (compared to the 2015 level). Of this, measures related to the Ordinance had saved approximately 2.2 billion kWh of electricity for buildings per year (compared to the 2015 level). Additionally, the relevant codes are being revised and will be introduced in 2024 to further enhance energy efficiency. As of the 2021-2022 financial year, the overall energy performance of the HKSAR Government improved by approximately 3.2%. By the 2022-2023 financial year, this improvement had increased to approximately

5.3%. Leading by example, the HKSAR Government planned to improve the overall energy performance of government buildings and infrastructure [56] by more than 6% in the 2024-2025 financial year [57] (compared to the 2018-2019 base year).

Conducting building energy audits. The HKSAR Government has conducted energy audits for about 250 government buildings to systematically review the energy-consuming equipment and systems in the buildings and identify energy management opportunities. It also encourages government departments to actively implement the energy-saving measures recommended in the energy audit reports. The government will conduct retro-commissioning its buildings and implement energy-saving projects, such as replacement with LED lamps and adoption of high-efficiency air-conditioning units. During the financial years 2017-2018 to 2021-2022, the total funding allocated for these projects amounted to approximately HK$ 800 million. The completed projects are expected to achieve annual savings of approximately 50 million kWh of electricity.

Focusing on carbon audits. In 2008, the HKSAR Government introduced the Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential, or Public Use) in Hong Kong. In 2017, it further published nine carbon audit guidelines covering different types of buildings. Since 2017/2018 Fiscal Year, the HKSAR Government has taken the lead in conducting regular carbon audits for major government buildings with an annual electricity consumption exceeding 500,000 kWh. These audits aim to explore the potential for carbon reduction, and the results are disclosed upon completion. Currently, the HKSAR Government requires more than 300 major government buildings of different uses to undergo carbon audit processes.

Energy Efficiency Labelling Scheme. The HKSAR Government has implemented the Mandatory Energy Efficiency Labeling Scheme (hereinafter referred to as the "Scheme"), requiring prescribed products [58] supplied in the market to carry energy labels. This allows consumers to understand the energy efficiency performance of the products. The Scheme has been implemented by phases and covers eight categories of specified products as of the end of 2022. The third phase has been fully implemented since December 1, 2019. Since the full implementation of the third phase, the grading standards have been upgraded twice. It is estimated that the entire Scheme can save about 750 million kWh of electricity per year (compared to 2015) for the consumers. The HKSAR Government will continue to expand the Mandatory Energy Efficiency Labeling Scheme by phases by including more products and raising the energy efficiency rating standards.

3. Establishing a Low-Carbon Transportation System

Green transport. The HKSAR Government has been advocating green transport and building a public transport system with an efficient and zero-emission railway system as the backbone. HKSAR's railway system carries over 4 million passengers daily, accounting

[56] Overall energy performance refers to the percentage difference in energy savings performance and renewable energy generation performance compared to the baseline year under comparable operating conditions.
[57] The fiscal year for the HKSAR runs from April 1 of each year to March 31 of the following year.
[58] Prescribed Products refers to products specified in the *Energy Efficiency (Labelling of Products) Ordinance*.

for more than 40% of the total public transport ridership in Hong Kong. The operators will continue to actively implement various environmental protection and low-carbon measures to contribute to the achievement of carbon neutrality before 2050. For land transport, the HKSAR Government introduced the first "Hong Kong Roadmap on Popularisation of Electric Vehicles"[59] (hereinafter referred to as the "Roadmap") in 2021, which sets out a clear direction for the full electrification of road transport in the future, including setting the target to have at least 150,000 parking spaces in private residential and commercial buildings equipped with electric vehicle charging infrastructure by 2025 or earlier. The Roadmap states that by 2025, at least 5,000 public chargers will be made available for public use. This target was achieved ahead of schedule in 2022. In addition, the HKSAR Government will announce a roadmap for promoting electric public transport and commercial vehicles by 2025 the latest.

To combat global climate change, the full electrification of transportation system has become a global trend. In order to improve air quality and achieve the long-term goal of zero vehicle emissions, the HKSAR Government strive to promote the use of electric vehicles. The key measures and progress are as follows: First, the HKSAR Government introduced the first Roadmap in 2021, setting out a clear direction for the full electrification of road transport in the future. The number of electric vehicles in the HKSAR increased by more than 260 times from approximately 180 in 2010 to around 47,500 in 2022. The proportion of electric private cars in newly registered private cars jumped from 6.3% in 2019 to 78.0% in the first quarter of 2024. Second, the HKSAR Government has been offering various tax concessions in recent years to promote the popularization of electric vehicles, such as exempting electric commercial vehicles from first registration tax and implementing the "One-for-One Replacement" [60]Scheme for electric private cars. The HKSAR Government will also continue to expand the charging network and associated supporting infrastructure in multiple ways. Relevant measures include exempting the calculation of gross floor area of buildings and launching the "EV-charging at Home Subsidy Scheme" with a total funding of HK$ 3.5 billion, to substantially increase the provision of electric vehicle charging facilities in car parks of existing housing estates and newly built buildings.

The HKSAR Government is also actively promoting the trial of new energy commercial vehicles through the "New Energy Transport Fund", aiming to collect more practical and operational data for the trades’ reference. By the end of December 2022, the Fund had approved more than 290 trials with a total subsidy of HK$ 253 million, including subsidies for the new generation electric taxis.

[59] The URL for the Hong Kong Roadmap on Popularisation of Electric Vehicles is https://www.eeb.gov.hk/sites/default/files/pdf/EV_roadmap_eng.pdf.

[60] Since 1994, the HKSAR Government has exempted electric commercial vehicles from first registration tax (until March 31, 2026); since February 2018, the “One-for-One Replacement” Scheme for electric private cars has been implemented, providing higher first registration tax concession for private car owners who arrange to scrap and deregister their old private car and then first register a new electric private car under their name. In February 2024, the HKSAR Government announced a two-year extension of the electric vehicle first registration tax concession arrangement to March 31, 2026. From April 2024, the concession cap under the “One-for-One Replacement” Scheme is HKD 172,500, while that for electric private car in general is HKD 58,500.

The HKSAR Government is actively introducing more models of new energy vehicles, promoting trial projects for various types of electric public transport, and establishing a comprehensive charging network to promote wider adoption of electric commercial vehicles. The HKSAR Government has been working closely with relevant public transport operators, including franchised bus operators, to promote the trial and development of new energy public transport such as electric buses and hydrogen fuel cell buses. The HKSAR Government will also actively introduce smart and green mass transit systems to provide lightweight and eco-friendly transport connections to nearby railway stations and major public transport hubs.

In 2022, the HKSAR Government set up an Inter-departmental Working Group on Using Hydrogen as Fuel (hereinafter referred to as the "Working Group") to coordinate preparation works of bureaux and departments for using hydrogen as fuel locally, with a view to encouraging local adoption of hydrogen energy. The first key tasks of the Working Group are to examine applications for hydrogen trial projects, conduct risk assessments on hydrogen filling stations, arrangements for replenishing hydrogen filling stations, and the use of hydrogen fuel cell vehicles on roads, as well as to review relevant regulations, standards and technical guidelines for the formulation of an operational safety framework for the use of hydrogen fuel in the transportation sector locally in the long run. Based on local conditions, a hydrogen fuel cell double-decker bus commenced test run orderly in 2023. In 2024, trials will be conducted for hydrogen fuel cell heavy vehicles for street cleansing to test their performance under local conditions.

The Airport Authority Hong Kong (hereinafter referred to as the "AAHK"), together with its major aviation-related business partners, have committed to achieving net-zero carbon emissions by the end of 2050. They have also set a midpoint target of reducing actual emissions by 55% by 2035 from a 2018 baseline. The AAHK has developed a detailed carbon management action plan, outlining specific actions and a roadmap to achieve its carbon reduction targets. Specific measures include electrifying vehicles used at the airside, significantly increasing the number of electric vehicle charging stations to over 1,300 by the end of 2030, implementing a Ground Services Equipment Pooling Scheme [61], piloting the use of hydrogen energy, and launching the "Hong Kong International Airport Business Partners Carbon Support Programme"[62].

Shipping. As an international shipping hub, the HKSAR has been consistently promoting green port development through various measures and encouraging the industry to adopt

[61] Under the Ground Services Equipment Pooling Scheme, the AAHK is responsible for procuring, managing, and maintaining ground services equipment such as conveyor belt loaders, lower deck loaders and passenger steps. These critical ground services equipment will be stationed on each parking stand for rental by the ramp handling operators. To facilitate speedy ground services equipment servicing and reshuffling, the AAHK has built two dedicated ground services equipment maintenance workshops and deployed a fleet management system to monitor the usage and performance of each ground services equipment.

[62] As part of the "Hong Kong International Airport Business Partners Carbon Support Programme", the AAHK launched a Greenovation Fund in October 2022 to encourage business partners to pilot new technologies and accelerate decarbonization efforts. Additionally, in March 2022, the AAHK, in collaboration with the Business Environment Council, launched the Hong Kong International Airport Carbon Capacity Building Programme to help business partners build knowledge and skills in carbon management.

more sustainable shipping practices. The HKSAR is the first port in Asia to mandate ocean-going vessels to switch to low-sulfur fuel while at berth. The Government has also collaborated with Mainland China to reduce emissions from ships. In 2019, it partnered with the Guangdong Provincial Government to establish a vessel emission control area in the Pearl River Delta waters. The regulations were further tightened, requiring all vessels, whether in navigation or at berth, to use compliant fuels such as 0.5% low-sulfur fuel or liquefied natural gas. The HKSAR is actively promoting the use of clean energy such as liquefied natural gas for ocean-going vessels to attract those using clean energy to berth in Hong Kong for bunkering.

In response to the HKSAR Chief Executive's 2023 Policy Address, the Government has initiated a feasibility study on providing green methanol bunkering for both local and ocean-going vessels. An action plan will be promulgated in 2024 for the construction of bunkering facilities and development of supply chains. The Government will also take forward the preparatory work, including technical studies and installations, on providing liquefied natural gas bunkering for ocean-going vessels.

4. Strengthening Non-CO_2 GHG Emission Control

Waste reduction. In order to achieve the goal of carbon neutrality in waste management by 2050, the HKSAR Government released the Waste Blueprint for Hong Kong 2035[63] in 2021. Guided by the vision of "Waste Reduction, Resources Circulation, and Zero Landfill", the blueprint outlines various strategies and measures for waste management to promote waste reduction and recycling at full steam to minimize overall waste volume, with the aim of gradually reducing the per capita disposal rate of solid waste by 40%~45% and increasing the recycling rate from 32% to about 55%. At the same time, the HKSAR Government is pressing ahead with the development of a network of advanced and highly efficient modern waste-to-energy facilities, including modern waste-to-energy incinerators (I·PARKs), sludge treatment facility (T·PARK), and organic resources recovery centers (O·PARKs), with a view of moving away from the reliance on landfills for direct disposal of municipal solid waste by 2035. These facilities will convert waste into useful energy, contributing to HKSAR's transformation into a sustainable green city and the achievement of carbon neutrality.

Landfill disposal of municipal solid waste will produce landfill gas, which primarily consists of methane. In order to further mitigate the environmental issues caused by landfill gas emission, landfills have gradually installed gas extraction wells and pipelines based on the actual operation conditions. These wells and pipelines are connected to landfill gas collection system to ensure proper recovery and utilization. The recovered landfill gas is used for electricity generation to support the operation of the landfills themselves or as a heating fuel for the leachate treatment works. After purification, the remaining landfill gas is either transferred to the pipeline network of The Hong Kong and China Gas Company Limited or used for electricity generation and connected to the public power grid. The

[63] The URL for the Waste Blueprint for Hong Kong 2035 is https://www.eeb.gov.hk/sites/default/files/pdf/waste_blueprint_2035_eng.pdf.

Environmental Protection Department will continue to establish landfill gas collection systems to collect more landfill gas for treatment and utilization. In addition, mobile landfill gas flaring systems are installed at landfills as needed to completely combust a portion of the landfill gas delivered to the extraction system within the routine operational areas.

To ensure the community has adequate recycling facilities in the community, the HKSAR Government continues to expand the community recycling network, "GREEN@COMMUNITY", with a focus on supporting residents in residential premises with limited space for their own recycling facilities to participate in source separation and clean recycling. By the end of 2022, there were more than 160 collection points for at least eight types of common recyclables. In 2022, the recycling volume reached 20,000 tons, a 40% increase compared to 2021. In addition, the HKSAR Government plans to introduce legislation requiring large residential estates and single-block residential buildings with a significant of households to establish recycling systems for the separate collection of common recyclables, with a view to further expanding the recycling network.

The HKSAR Government fully implemented the Producer Responsibility Scheme (PRS) on Waste Electrical and Electronic Equipment (WEEE) in 2018, requiring relevant stakeholders to share the responsibility for the recovery, recycling, treatment and disposal of waste products with a view to preventing and minimizing their environmental impact. By the end of 2022, the treatment facilities funded by the HKSAR Government had processed over 100,000 tons of WEEE. In addition, the legislative procedure for the PRS on Glass Beverage Containers had been completed, and the scheme was implemented on May 1, 2023. In May 2021, the HKSAR Government conducted a public consultation on implementing a PRS on Plastic Beverage Containers and is currently drafting the details of the scheme.

In order to reduce and properly manage plastic waste, the HKSAR Government has fully implemented the Plastic Shopping Bag Charging Scheme (hereinafter referred to as the "Charging Scheme") since 2015. Compared to the period before the full implementation of the scheme (2014), the disposal quantity of plastic shopping bags had decreased by 8% by the end of 2022. In order to further reduce the use of plastic shopping bags, the HKSAR Government has increased the charge per bag from at least HK$0.5 to HK$1 and tightened the scope of exemption since December 31, 2022. The HKSAR Government has also started drafting legislation to regulate disposable plastic tableware and other plastic products, aiming to implement it in phases starting from the second quarter of 2024. In addition, starting from the end of March 2022, the HKSAR Government has gradually expanded the waste plastics recycling services to collect all types of non-industrial and non-commercial waste plastics for proper recycling and treatment. Together with the waste plastics collected through the "GREEN@COMMUNITY" recycling network, as well as by other non-profit and private organizations, the total amount of recycled waste plastics in 2022 was approximately 120,000 tons.

The HKSAR Government launched a territory-wide waste paper collection and recycling service in September 2020, with a total recycling volume of approximately 580,000 tons by the end of 2022. The construction of HKSAR's first modern pulping facility was confirmed in 2022 and it is expected to commence operation in 2025, with a capacity to process about 630,000 tons of local waste paper annually (including cardboard, newspapers and office paper). In addition, to complement the implementation of the "PRS on Glass Beverage Containers", the HKSAR Government has progressively introduced waste glass container collection services since 2018, with a total recycling volume of more than 84,000 tons by the end of 2022.

5. Comprehensive Promotion of Low-Carbon Industrial Transformation

HKSAR does not have large-scale industries, and local industrial GHG emissions mainly originate from cement production processes and coal-based energy consumption. Since 2019, cement production enterprises in the HKSAR have been using biomass (wood) and alternative fuels (polyurethane and rubber from recycling) as auxiliary fuels. Starting from 2020, these enterprises have reduced the percentage of using silicate cement clinker and substituted by Ground Granulated Blast-furnace Slag (GGBS). These measures have not only successfully reduced the consumption of fossil fuels but also significantly alleviated the waste burden on landfills in the HKSAR. CO_2 emissions was reduced due to using less silicate cement clinker.

In addition, the HKSAR Government, through the "Cleaner Production Partnership Programme"[64], supports Hong Kong-owned factories located in HKSAR and Guangdong Province to adopt cleaner production technologies and practices to enhance their environmental performance, reducing raw material consumption and save energy.

6. Strengthening and Enhancing Ecosystem Carbon Sinks

HKSAR has established 24 country parks and 22 special areas, covering a total area of approximately 44,300 hectares, which accounts for about 40% of Hong Kong's land area. These areas have been managed and protected properly over the years. Between 2020 and 2022, the Agriculture, Fisheries and Conservation Department (AFCD) of the HKSAR Government planted over 730,000 native trees in the protected areas. AFCD also continuously carried out plantation enrichment work in manmade plantation areas of low ecological value and implemented effective hill fire prevention measures. These efforts aim to gradually expand forest coverage, enhance biodiversity and sustainability, and protect the natural "carbon sink" function of ecosystems.

Additionally, the wetlands of about 1,500 hectares in Mai Po and Inner Deep Bay are designated as internationally important wetlands under the Ramsar Convention. The Mai Po and Inner Deep Bay wetlands, with over 400 hectares of mangroves, serve as important and efficient blue-green carbon sinks, offering exceptional carbon sequestration efficiency. AFCD is responsible for the overall conservation of the internationally important wetlands in Mai Po and Inner Deep Bay. This includes implementing the Mai Po Inner Deep Bay Ramsar Site Management Plan, categorizing the Ramsar sites into different management

[64] For detailed policy descriptions, refer to Chapter 3, Section 3, "3. Strengthening Adaptation Actions for SAR to Climate Change."

zones based on habitat types, ecological value, and existing land uses, and developing conservation measures for the wise use of the wetlands.

In addition, to further conserve these important wetland ecosystems and improve their carbon sequestration capacity, the HKSAR Government proposed in 2021 the establishment of a wetland conservation park system in the Northern Metropolis and the implementation of active management measures. AFCD commenced a strategic feasibility study in August 2022 to investigate the relevant details for taking forward the proposed establishment of the wetland conservation parks system in the Northern Metropolis and the implementation of proactive management measures. Currently, HKSAR is planning for the development of the Sam Po Shue Wetland Conservation Park, which will create synergy with the Mai Po Nature Reserve and other existing wetlands to effectively protect the wetland habitats in the Deep Bay area.

7. Promoting Synergies in Reducing Pollution and Cutting Carbon Emissions

The Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (Kigali Amendment), adopted in 2016, aims to gradually reduce the annual production and consumption of 18 hydrofluorocarbons (HFCs) with high Global Warming Potential (GWP). Under the Kigali Amendment, the HKSAR is required to establish and implement a licensing and quota system on the import and export of HFCs and to gradually reduce the consumption of HFCs by 85% from the baseline level in 2036. Since China's formal acceptance of the Kigali Amendment in June 2021, the HKSAR Government has actively engaged with relevant trade, including trade associations, equipment suppliers and HFC importers, to discuss the introduction of low-GWP products and equipment to Hong Kong. In 2022, the HKSAR Government established an inter-departmental working group to develop control proposal based on the collected information and planned to consult industry stakeholders on these proposals in 2023.

8. Promoting the Establishment of Systems and Mechanisms for Controlling GHG Emissions

In "Hong Kong's Climate Action Plan 2050" announced in October 2021, the HKSAR Government announced that it would invest about HK$ 240 billion over the next 15 to 20 years to implement various mitigation and adaptation measures. These include energy conservation and renewable energy, green transport, waste management, strengthening coastal management, slope reinforcement, and drainage system improvement works.

In 2018, the HKSAR Government launched the "Government Green Bond Programme" (hereinafter referred to as the "GGB Programme") to fund the government's green projects. In May 2024, the scope of the GGB Programme was expanded to include sustainable projects, and it was therefore renamed as the "Government Sustainable Bond Programme". At present, the HKSAR Government has successfully issued government green bonds equivalent to a total of approximately HK$ 195 billion, covering 72 green projects. In the 2024-2025 financial year, the HKSAR Government plans to issue bonds totaling HK$ 120 billion, of which HK$ 70 billion will be retail bonds, including HK$ 20 billion of green bonds and infrastructure bonds. In addition to promoting inclusive finance, it aims to enhance the public's sense of participation in infrastructure and sustainable development projects.

Achieving carbon neutrality requires significant financial resources. HKSAR needs to vigorously develop various financing tools to attract more capital towards projects that contribute to carbon reduction. The Green and Sustainable Finance Cross-Agency Steering Group (hereinafter referred to as the "Steering Group"), established in May 2020, is co-chaired by the Hong Kong Monetary Authority (hereinafter referred to as "HKMA") and the Securities & Futures Commission of Hong Kong (SFC), with members including the Environmental Bureau, Financial Services and the Treasury Bureau, Hong Kong Exchanges and Clearing Limited, Insurance Authority, and Mandatory Provident Fund Schemes Authority. The Steering Group aims to coordinate the financial sector's response to climate and environmental risks, accelerate the development of green and sustainable finance in Hong Kong, and support the government's climate strategies. The Steering Group will focus on advancing climate-related disclosure and sustainability reporting, exploring carbon market opportunities, and enhancing initiatives as a green and sustainable finance center, with the aim of consolidating HKSAR's leadership in green and sustainable finance and supporting the financial ecosystem's transition toward carbon neutrality.

In October 2022, the HKEX launched Core Climate, a new international carbon marketplace. It is currently the only carbon market that offers settlement services in both Hong Kong dollars (HK$) and Renminbi (RMB) for international voluntary carbon credit product trading. By the end of 2023, the number of registered participants had tripled to about 80 members. Core Climate supports efficient and transparent trading of carbon credit products and instruments, facilitating the global net-zero emission transition. The high-quality carbon credits traded on the Core Climate platform are sourced from over 40 internationally certified carbon reduction projects, including forestry, solar energy, wind energy and biomass projects in Asia, South America, and West Africa. All projects on the platform, including carbon avoidance, reduction and removal projects, are verified under the Verified Carbon Standard (VCS) by Verra.

Accurate information disclosure is crucial to promoting sustainable finance. This will also be a priority for international organizations and government agencies in the coming years. To deepen the development of green and sustainable finance in HKSAR, enterprises must align their sustainability disclosure in financial reporting with international standards. In March 2024, the Financial Services and the Treasury Bureau issued a statement setting out the vision and approach of the government and financial regulators for developing a comprehensive sustainability disclosure ecosystem in Hong Kong. The Hong Kong Institute of Certified Public Accountants (HKICPA), as the sustainability disclosure standard setter of Hong Kong, will develop local Sustainability Reporting Standards (hereinafter referred to as the "Hong Kong Standards") aligned with the ISSB Standards, as well as complementary application and implementation guidance. The goal is to launch a roadmap in 2024 for appropriately adopting the ISSB Standards in Hong Kong, and provide enterprises with a transparent and well-defined pathway for sustainability reporting, ensuring they have sufficient time for making preparations and developing readiness for the pragmatic implementation of the Hong Kong Standards. To prepare listed companies towards eventual sustainability reporting under the Hong Kong Standards, the Hong Kong Exchanges and Clearing Limited published the Consultation summary in April 2024 regarding the Consultation Paper on the Enhancement of Climate-related Disclosures under the Environmental, Social and Governance Framework and introduced new climate-related disclosure requirements (hereinafter referred to as the "new climate requirements"). The new climate requirements are developed based on ISSB Standard No. 2: Climate-related Disclosures and include implementation reliefs. These reliefs include proportionality and scaling-in measures to address concerns over the reporting challenges that some issuers may face. The revised Hong Kong Exchanges and Clearing Limited Listing Rules will come into effect on January 1, 2025.

The GHG Emission Calculation Tools, jointly developed by the Steering Group and the Hong Kong University of Science and Technology, was launched in February 2024. It is available to the public for free on the Steering Group's website to assist Hong Kong enterprises and financial institutions in sustainability reporting. The tool can help small and medium-sized enterprises manage their environmental footprint while encouraging market participants to improve their sustainable business practices.

In early May 2024, the HKMA published the "Hong Kong Taxonomy for Sustainable Finance" (hereinafter referred to as the "Hong Kong Taxonomy"), which serves as a pivotal tool to raise awareness about green finance, promote common understanding on green activities, facilitate green finance flows, and provide a foundation for further application. The Hong Kong Taxonomy aligns with the two major standards from China and the European Union. Currently, it encompasses twelve economic activities under four sectors: power generation, transportation, construction, water and waste management. For the next step, the HKMA will expand the coverage of the taxonomy to include more sectors and activities, including transition activities.

(ii) Quantitative Assessment of Mitigation Policies and Actions

The specific mitigation measures and effects across various sectors in HKSAR are detailed in Table 5-21.

Table 5-21 Summary of Mitigation Actions and Their Effects in HKSAR

No.	Action	Objectives or Main Elements	Sectors and Gases Involved	Timescale	Nature	Regulatory Authorities	Status	Progress	Methodologies and Assumptions	Estimated Emission Reductions	Support Received
1	Hong Kong's Climate Action Plan 2050	In October 2021, Hong Kong's Climate Action Plan 2050 was released, setting out four major decarbonization strategies, i.e. "net-zero electricity generation", "energy saving and green buildings", "green transport" and "waste reduction". The plan aims to achieve carbon neutrality before 2050 and halve Hong Kong's GHG emissions before 2035 as compared with the 2005 level. In addition to the aforementioned decarbonization targets, the two plans also detail key measures related to mitigation, adaptation and resilience.	All sectors/CO_2, CH_4, N_2O and F-gases	2017-2050	Mandatory/Government	Environment and Ecology Bureau	Under progress	In 2022, the total GHG emissions in HKSAR decreased by approximately 19% compared to 2005, with per capita carbon emissions reduced to 4.73 tCO2eq	Per capita carbon emission reduction rate = (1 − per capita emissions in target year/per capita emissions in base year) ×100%	It is expected that Hong Kong's GHG emissions will be halved from 2005 levels by 2035 and carbon neutrality will be achieved before 2050	HKSAR Government
Net-zero power generation											
2	10MW Solar Farm at South East New Territories Landfill	To develop a solar farm with a generating capacity of 10MW at the South East New Territories Landfill in Tseung Kwan O to supply electricity to nearby waterworks facilities.	Renewable energy	Expected to be completed in 2026	Construction: Government Use: Voluntary/government	Environment and Ecology Bureau/Water Supplies Department	Facilities under construction	GHG reduction	Emission reduction = alternative solar power generation × emission factor	Expected emission reduction is 7,000 tons per year	HKSAR Government
Energy-efficient and green buildings											
3	Energy Saving Plan for Hong Kong's Built Environment 2015~2025+	This is Hong Kong's first urban energy saving plan, which analyzes energy usage and formulates related policies, strategies, targets and key action plans to align with HKSAR's energy-saving targets	Energy/CO_2	2015-after 2025	Mandatory/voluntary/government/market	Environment and Ecology Bureau	Under progress	The plan sets a target to reduce energy intensity (i.e. energy end-use per unit of local GDP) by 40% by 2025,	Emission reduction = energy savings × emission factor	The expected emission reduction is 1.4 million tons per year by 2025	HKSAR Government

								with 2005 as the base year. From 2005 to 2019, energy intensity decreased by over 30%			
4	Buildings Energy Efficiency Ordinance	Under the Buildings Energy Efficiency Ordinance, central building services installations in newly constructed buildings or buildings with major retrofitting works carried out must comply with the energy efficiency standards specified in the Code of Practice for Energy Efficiency of Building Services Installation. The Ordinance also requires owners of commercial buildings to conduct mandatory buildings to conduct mandatory energy audits for central building services installations every 10 years in accordance with the Code of Practice for Building Energy Audit. The above two Codes are revised every three years.	Building operation/ CO_2	Since 2012	Mandatory/government/market	Environment and Ecology Bureau/Electrical and Mechanical Services Department	Under progress	Reduction in electricity demand The Code of Practice for Energy Efficiency of Building Services Installation (2021 edition) and the Code of Practice for Building Energy Audit (2021 edition) were revised to review the latest developments in relevant technologies and internationally adopted energy efficiency standards	Emission reduction = energy savings × emission factor	The expected emission reduction is 2.4 million tons/year by 2025 (and 3 million tons/year by 2028)	HKSAR Government
5	Mandatory Energy	Under the Scheme, specified	Energy/CO_2	Since 2009	Mandatory/government/market	Environment and	Under progress	Reduction in electricity	Emission reduction =	The expected emission	HKSAR

	Efficiency Labelling Scheme	products[65] supplied in the market must bear energy labels, enabling consumers to understand their energy efficiency performance.				Ecology Bureau/Electrical and Mechanical Services Department		demand. The Scheme has been implemented by phases. The third phase has been fully implemented since December 2019, covering a total of eight prescribed products	energy savings × emission factor	reduction is 720,000 tons per year by 2025	Government
6	District Cooling System in the Kai Tak Development Area	The District Cooling System in the Kai Tak Development Area is a large-scale centralized air-conditioning system. It uses seawater to produce chilled water at the central cooling plant, and distributes it to user buildings in the Kai Tak Development Area through an underground pipeline network. The entire District Cooling System project is expected to be completed by 2028.	Energy/CO_2	2011-2028	Voluntary/government/market	Environment and Ecology Bureau/Electrical and Mechanical Services Department	Under progress	Reduction in electricity demand. The first phase of the District Cooling System began operation in 2013. To accommodate the increased development density in the area, construction of the additional District Cooling System project for the next phase	Emission reduction = energy savings × emission factor	When the District Cooling System is fully operational in 2028, the expected emission reduction will be 96,600 tons per year	HKSAR Government

[65] Prescribed Products refers to products specified in the *Energy Efficiency (Labelling of Products) Ordinance*.

								commenced in December 2020			
7	District Cooling System for the Tung Chung New Town Extension (East)	The District Cooling System in the Tung Chung New Town Extension (East) is a large-scale centralized air-conditioning system. It produces chilled water at the central cooling plant and distributes it to user buildings within the Tung Chung New Town Extension (East) through an underground pipeline network. The cooling plants and chilled water distribution pipelines for the project are expected to be substantially completed by 2030, and the entire District Cooling System project is to be completed by 2034.	Energy/CO_2	2021-2034	Voluntary/government/market	Environment and Ecology Bureau/Electrical and Mechanical Services Department	System construction in progress	The construction works began in June 2021, and the system is expected to be operational in 2027.	Emission reduction = energy savings × emission factor	When the District Cooling System is fully operational in 2034, the expected emission reduction will be 21,500 tons per year	HKSAR Government
8	District Cooling System in the Kwu Tung North New Development Area	The District Cooling System in the Kwu Tung North New Development Area is a large-scale centralized air-conditioning system. It produces chilled water at the central cooling plant, and distributes it to user buildings in the Kwu Tung North New Development Area through an underground pipeline network. The cooling plants and chilled water distribution pipelines for the project are expected to be substantially completed by 2032, and the entire District Cooling System project is to be completed by 2040.	Energy/CO_2	2021-2040	Voluntary/government/market	Environment and Ecology Bureau/Electrical and Mechanical Services Department	System construction in progress	The construction works began in March 2021, and the system is expected to be operational in 2026.	Emission reduction = energy savings × emission factor	When the District Cooling System is fully operational in 2040, the expected emission reduction will be 29,400 tons per year	HKSAR Government
9	Wider Use of Fresh Water in Cooling Towers for energy	Since the launch of the Fresh Water Cooling Tower Scheme in 2000, more than 2,800 fresh water cooling towers have been constructed and put into	Energy/CO_2	Since 2000	Voluntary/government/market	Environment and Ecology Bureau/El	Under progress	Reduction in electricity demand	Emission reduction = energy savings ×	The expected emission reduction is 60,000 tons per	HKSAR Government

	efficient air conditioning system	operation as of the end of 2023. It is estimated that about 300 new fresh water cooling towers will be completed between 2024 and 2028. The Electrical and Mechanical Services Department will continue to promote the wider use of fresh water cooling towers				ectrical and Mechanical Services Department			emission factor	year by 2028	
Green transport											
10	Hong Kong Roadmap on Popularization of Electric Vehicles	In 2021, the HKSAR Government announced the first "Hong Kong Roadmap on Popularization of Electric Vehicles" (hereinafter referred to as the "Roadmap"), putting forward the vision of "Zero Carbon Emissions · Clean Air · Smart City", and setting out the long-term policy objectives and plans to promote adoption of electric vehicles, in order to achieve zero vehicular emissions before 2050. The Roadmap proposes various measures, including the target to cease new registrations of fuel-propelled and hybrid private cars by 2035 or earlier	Energy/ CO_2	Since 2021	Mandatory/Government	Environment and Ecology Bureau/Environmental Protection Department	Under progress	The number of electric vehicles in the HKSAR increased by more than 260 times from approximately 180 in 2010 to around 47,500 in 2022. In 2022, GHG emissions from the transport sector decreased by approximately 14% compared to 2005.	Emission reduction = reduction in vehicle fuel consumption × emission factor	The GHG emissions from the road transport sector in HKSAR are expected to be halved by 2035 compared to 2005 levels	HKSAR Government
Waste-to-energy											
11	Sludge Treatment Facility (T.PARK)	The sludge treatment facility has started operation since April 2015. It utilizes advanced incineration technology to treat sludge generated from sewage treatment plants. The heat energy produced by the incineration is converted into	Energy and waste treatment/ CO_2, CH_4	Operational since 2015	Mandatory/Government	Environmental Protection Department	Under progress	GHG reduction	Emission reduction = substituted fossil energy amount × emission factor +	The expected emission reduction is 240,000 tons per year	HKSAR Government

		electricity to meet the electricity demand of the facility, and the surplus electricity is exported to the public power grid							avoided landfill gas generation		
12	Organic Resources Recovery Centre Phase 1 (O.PARK1)	O.PARK1 was completed and put into operation in July 2018. The facility adopts biological treatment technology to convert food waste into useful resources, such as biogas and compost products	Energy and waste treatment/ CO_2, CH_4, N_2O	Operational since 2018	Construction: Government Use: Voluntary/market/government	Environmental Protection Department	Under progress	GHG reduction	Emission reduction = substituted fossil energy amount × emission factor + avoided landfill gas generation	The expected emission reduction is 42,000 tons per year	HKSAR Government
13	Organic Resources Recovery Centre Phase 2 (O.PARK2)	The HKSAR Government began the design and construction of O.PARK2 in September 2019. The facility adopts biological treatment technology to convert food waste into useful resources, including biogas and fertilizers	Energy and waste treatment/ CO_2, CH_4, N_2O	Operational since 2024	Construction: Government Use: Voluntary/market/government	Environmental Protection Department	Facilities under construction	GHG reduction	Emission reduction = substituted fossil energy amount × emission factor + avoided landfill gas generation	The expected emission reduction is 67,000 tons per year	HKSAR Government
14	Integrated Waste Management Facility Phase 1 (I.PARK1)	The HKSAR Government began the design and construction of Integrated Waste Management Facility Phase 1 in December 2017. The facility adopts advanced waste-to-energy technology to significantly reduce the volume of municipal solid waste and convert it into energy	Energy and waste treatment/ CO_2	Expected operational in 2025	Mandatory/Government	Environmental Protection Department	Facilities under construction	GHG reduction	Emission reduction = substituted fossil energy amount × emission factor + avoided landfill gas generation	The expected emission reduction is 440,000 tons per year	HKSAR Government

Chapter 3 Climate Change Impacts and Adaptation in HKSAR

I. Regional Circumstances and Institutional Arrangements

Like other coastal cities, Hong Kong is vulnerable to climate change and extreme weather. The sea level at Victoria Harbour has shown a significant rising trend. Over the past century, the number of very hot days and hot nights in Hong Kong has increased significantly; the intensity of tropical cyclones and associated extreme rainfall has also risen. The HKSAR Government will continue relevant studies and optimize various response measures.

Since its establishment in 2016, the "Climate Change Working Group on Infrastructure" (hereinafter referred to as CCWGI) of the HKSAR Government has been coordinating climate change adaptation efforts in the infrastructure sector as well as relevant studies to strengthen the resilience of infrastructure. The CCWGI is convened by the Civil Engineering and Development Department (CEDD) with members from the Development Bureau, the Architectural Services Department, the Buildings Department, the Drainage Services Department (DSD), the Electrical and Mechanical Services Department (EMSD), the Highways Department (HyD), the Hong Kong Observatory (HKO) and the Water Supplies Department (WSD). The CCWGI regularly reports its work plans and progress to the interdepartmental "Steering Committee on Climate Change and Carbon Neutrality", chaired by the Chief Executive of the HKSAR.

II. Climate Change Impacts, Vulnerability Assessment, and Loss and Damage Status

(i) Characteristics and Trends of Climate Change

The trends in climate change observed in HKSAR basically align with the overall global trends. The HKO began to make systematic observations of meteorological parameters in the 1880s. As shown by the temperature trend, the annual mean temperature increased at an average rate of 0.28°C per decade during 1990-2022 (Figure 5-5). The inter-annual variation in annual rainfall is significant, with an overall long-term upward trend. Regarding the rising trend in sea level, there was s significant rise of sea level at Victoria Harbour of Hong Kong during 1990-2022, with an average rate of increase of 41 mm per decade.

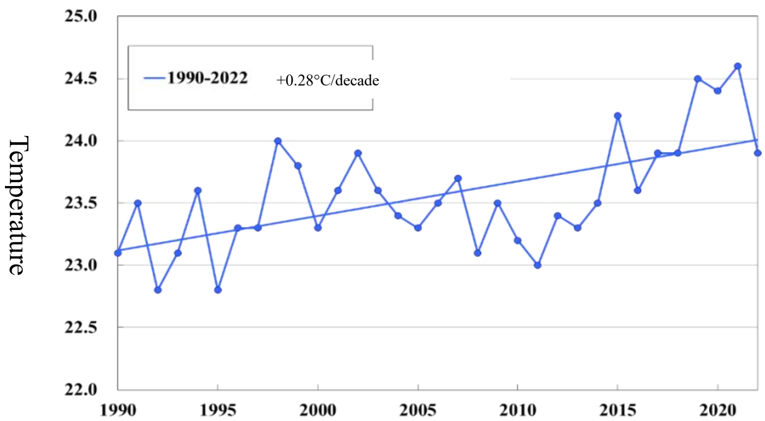


Figure 5-5 Annual Mean Temperature Recorded at the Hong Kong Observatory Headquarter

HKO updated the climate projections for Hong Kong based on global climate model data of the Sixth Assessment Report of IPCC. The conclusion are as follows: First, under the low, intermediate and very high GHG emissions scenarios [66], the average annual mean temperature in 2081-2100 is expected to rise by about 1.2°C, 2.0°C and 3.6°C respectively, when compared with the average annual mean temperature of 23.4°C during 1995-2014, while the average annual maximum temperature in 2081-2100 is expected to rise by about 1.2°C, 1.9°C and 4.1°C respectively, when compared with the average figure of 34.4°C during 1995-2014. Second, under the low, intermediate and very high GHG emissions scenarios, the average annual rainfall in 2081-2100 is expected to rise by about 8%, 7% and 9% when compared to the average annual rainfall of 2,456 mm during 1995-2014 [67], while the average annual maximum daily rainfall in 2081-2100 is expected to rise by about 9%, 16% and 28% respectively when compared to the average figure of 203 mm during 1995-2014. Third, under the low, intermediate and very high GHG emissions scenarios, the annual mean sea level of Hong Kong in 2100 is expected to rise by about 0.42 m, 0.56 m and 0.78 m respectively (in terms of median), compared with the average value during 1995-2014 (1.45 m above Hong Kong Chart Datum); extreme water levels caused by sea level rise are also expected to increase significantly.

(ii) Extreme Weather and Climate Events and Resulting Losses and Damages

Some significant weather events that occurred in HKSAR from 2020 to 2022 are summarized below:

1. Extreme heat

Year 2021 was the warmest year on record in HKSAR since 1884, with an annual mean temperature of 24.6°C, which was 1.1°C above the normal value in 1991-2020. In 2021, the number of hot nights [68] was 61, and the number of very hot days [69] was 54, both being the highest on record.

July 2022 was the hottest month on record in HKSAR. The monthly mean temperature reached 30.3°C, 1.4°C above the normal, marking the highest monthly mean temperature on record. In July 2022, the HKO recorded 10 days with a daily maximum temperature of 35.0°C or above, 21 very hot days, and 25 hot nights, all breaking their respective monthly records. The 21 consecutive hot nights starting from July 9 also set a new record.

2. Rainstorm

Affected by a trough of low pressure over the coastal area of Guangdong, heavy rain and severe squally thunderstorms occurred in HKSAR on the morning of June 6, 2020. On that day, most parts of HKSAR recorded over 100 mm of rainfall, with some areas receiving more

[66] For projections under alternative GHG emissions scenarios, see https://www.hko.gov.hk/en/climate_change/future_climate.htm.

[67] Due to fluctuations in rainfall, although the overall trend is increasing, years with lower-than-average rainfall cannot be ruled out.

[68] This refers to days when the minimum temperature is 28.0°C or above.

[69] This refers to days when the maximum temperature reaches 33.0°C or above.

than 200 mm of rainfall. Severe flooding occurred in some areas. The heavy rainstorm is estimated to have caused direct economic losses of approximately HK$ 37 million in HKSAR.

3. Tropical cyclones

Typhoon Higos struck HKSAR on the morning of August 19, 2020, with offshore areas and some high ground experiencing storm-force and hurricane-force winds, respectively. The heavy squally showers associated with the rain bands of Typhoon Higos brought over 150 mm of rainfall to most parts of HKSAR on August 18 and 19, 2020. During the passage of Typhoon Higos in HKSAR, at least 7 people were injured, with around 800 reports of fallen trees and 2 reports of flooding. Typhoon Higos is estimated to have caused direct economic losses of approximately HK$ 388 million in HKSAR.

Tropical Storm Lionrock and Typhoon Kompasu successively affected HKSAR during the week of October 8 to 14, 2021. Lionrock brought gale-force winds and heavy squally showers to HKSAR from October 8 to 10, 2021. On October 8, 2021, the rainfall was particularly heavy and persistent, with over 200 mm of rainfall generally recorded in HKSAR. The HKO recorded a rainfall of 329.7 mm on that day, the highest daily rainfall recorded in October. During the passage of Typhoon Lionrock in Hong Kong, two people died, at least 14 were injured, and there were over 1,100 reports of fallen trees, 6 reports of flooding, and 3 reports of landslides. Typhoon Lionrock is estimated to have caused direct economic losses of approximately HK$ 220 million in HKSAR. During the passage of Typhoon Kompasu in HKSAR, at least 20 people were injured, with 877 reports of fallen trees and 10 reports of flooding. Typhoon Kompasu is estimated to have caused direct economic losses of approximately HK$ 35 million in HKSAR.

(iii) Climate Change Impacts and Vulnerability Assessment on Natural Ecosystems (Including Current Status Evaluation and Future Projections)

1. Water resources

HKSAR lacks fresh water resources. There are no natural lakes, rivers or substantial underground water sources. Besides rainwater collected from local catchment, HKSAR needs to import water from the Dongjiang River in Guangdong Province with annual supply ceiling of 820 million m^3 according to the current Dongjiang water supply agreement. In 2022, the total water consumption of Hong Kong was about 1,385 million m^3, of which around 58% was imported water from the Dongjiang River in Guangdong Province, 19% was locally collected rainwater, and the remaining 23% was seawater for toilet flushing. In face of the challenges of climate change and increasing fresh water demand due to population and economic growth, the HKSAR Government has included climate change adaptation into its water resources management strategy since 2008 to ensure water security and support for sustainable development in HKSAR. In addition to implementing hardware measures (such as using flow controllers), the Water Supplies Department has launched publicity and promotion of water conservation; implemented initiatives to reduce water loss in supply networks; built up a diversified water resource portfolio through exploitation of new water resources that are not susceptible to climate change, which include development of seawater desalination and expansion of the use of lower grade water (viz. seawater and recycled water) for non-potable purposes; and has been continuously exploring efficient utilization of local water resources to enhance the resilience of Hong Kong's water supply.

2. Terrestrial ecosystems

The main vegetation in HKSAR includes woodland, shrublands and grasslands, collectively covering more than 60% of the land area. These areas serve as important habitats for a wide variety of native flora and fauna. Climate change may potentially impact the composition, structure and function of vegetation. With changes in temperature and rainfall, the phenology, migratory habits and interactions of wildlife may be altered, thereby affecting the distribution and survival of populations. Cold-adapted organisms in higher-altitude habitats are particularly more sensitive to climate change. Frequent disasters caused by extreme weather, such as flash floods and landslides, will severely impact the habitats of terrestrial wildlife and pose significant threats to fragile ecosystems.

3. Oceans and coastal zones

HKSAR is located in a subtropical region with the marine environment suitable for the growth of organisms adapted to tropical and temperate climates, boasting a wide variety of marine species. Although Hong Kong is close to the northern edge of the growth zone for stony corals, over 80 species of stony corals are still found within its territory. Data shows that the sea temperature in Hong Kong increased by 1.25°C between 1986 and 2014. Studies from other parts of the world indicate that rising sea temperatures can drive the distribution of marine species toward the poles. Additionally, increased sea temperatures can cause coral bleaching by expelling their symbiotic algae, making corals fragile and vulnerable to disease. Furthermore, ocean warming will reduce the solubility of oxygen in seawater, leading to a decrease in overall oxygen content in the ocean and resulting in the death of marine organisms. As surface seawater absorbs more carbon dioxide, its pH value decreases, leading to ocean acidification, which impacts the calcification process of marine organisms that need to build calcium-containing shells and tissues. Sea level rising will also impact coastal ecosystems, including mangroves and shallow coral reefs. The HKSAR Government will continue to support research on the impacts of climate change on marine ecosystems, including collaborating with universities to monitor coral bleaching. The monitoring results indicate that most bleached coral communities will recover afterward.

(iv) Climate Change Impacts and Vulnerability Assessment on Socio-economic Systems (Including Current Status Evaluation and Future Projections)

1. Agriculture and food security

Hong Kong is an open economy with minimal agricultural and livestock production. Local farms mainly produce vegetables, live pigs and live chickens, accounting for 1.9%, 13.8% and 100% of the annual local consumption, respectively. Over 90% of Hong Kong's food supply relies on imports.

The policy objective of the HKSAR Government regarding food is to ensure an open market as well as food safety and stable supply. Considering HKSAR's high dependency on imported food, the government has been maintaining close communication with key stakeholders in the food supply industry, including major market players at both the import and retail levels, so as to ensure a comprehensive understanding of market conditions at various levels and take timely measures to safeguard the stability of food supply.

At the same time, the HKSAR Government has implemented various measures to assist the industry in addressing climate change and promoting sustainable development. In terms of crop production, the HKSAR Government provides technical training to guide farmers in selecting suitable crop varieties to enhance crop yield and quality. It also assists farmers in transitioning to environmentally friendly organic farming to reduce their carbon footprint and actively promote sustainable development. Additionally, the government encourages the adoption of controlled-environment greenhouse technology and hydroponic technology, enabling all-weather agricultural production. In terms of poultry and livestock production, the HKSAR Government encourages the industry to adopt multi-story poultry and livestock farming facilities to effectively improve the resource utilization efficiency. Simultaneously, the government aims to reduce GHG emissions by implementing environmental control, advanced technologies and automated equipment, and also integrates energy-saving technologies to further reduce energy consumption.

2. Health and public health

In order to prevent vector-borne diseases and heat-related diseases caused by climate change, the Department of Health (DH) has been disseminating related information through various channels. In addition to enhancing public awareness of mosquito-borne diseases and promoting protective measures against mosquito bites, the DH also collaborates with the HKO to timely issue press releases to remind the public to take appropriate measures against heat stroke and ultraviolet radiation during very hot weather.

3. Infrastructure and major projects

The HKSAR Government has identified approximately 350 critical infrastructure facilities from seven categories including buildings infrastructure, port works infrastructure, drainage and sewerage infrastructure, transport infrastructure, water supplies infrastructure, waste management infrastructure and fill management infrastructure for vulnerability and impact assessments. The HKSAR Government has formulated the scope of enhancement works for the Government critical infrastructure.

4. Urban and living environment

The HKSAR Government's completed and ongoing planning and engineering feasibility studies have not specifically provided quantitative or qualitative assessments of the socioeconomic impacts of climate change on urban and living environment. However, considering the impact of frequent extreme weather events on citizens' daily lives and potential economic losses, the HKSAR Government has incorporated climate change and other environmental factors as key considerations in its planning and development processes. It advocates for an integrated planning approach that incorporates the concepts of wisdom, environmental protection and resilience to ensure that essential infrastructure in HKSAR is equipped to address climate change, providing communities with uninterrupted and convenient services.

5. Sensitive secondary and tertiary industries

HKSAR's economy is dominated by the tertiary industry, with limited energy-intensive industries. The service sector accounted for 93.5% of Hong Kong's GDP in 2022, in which transportation contributed 6.9% of GDP. In the secondary industry, manufacturing industry, and water, electricity and gas supply accounted for only 1.0% and 1.2% of GDP, respectively, while the construction industry accounted for 4.3%. In 2022, electricity generation was the largest source of carbon emissions, followed by transport and waste. These three major emission sources collectively accounted for about 90% of total emissions, making them the three most key areas for HKSAR's decarbonization efforts.

Climate change may impact various aspects of the HKSAR's economy. For example, the frequent occurrence of extreme weather events and the related damage results in higher maintenance and insurance costs for businesses and industries. On financial services, damage from extreme weather poses risks to telecommunications and computer system failure, potentially disrupting financial market transactions. The insurance industry is also exposed to heightened extreme weather risks. Moreover, on energy supply, extreme weather can damage power lines and other capital, and rising temperatures and extreme weather events drive up energy demand, thereby increasing the risk of power supply interruptions and power spikesß.

III. Actions and Challenges in Adapting to Climate Change

(i) Progress and Effects of Strategies, Policies, Goals and Actions for Adapting to Climate Change

1. Strengthening climate change monitoring and early warning capabilities

To address the impacts of sea level rise and extreme sea waves due to climate change, the HKSAR Government has established an early alert system. When the HKO predicts that sea levels in certain high-risk areas will exceed the warning threshold, it will issue alerts to relevant departments. The relevant departments will dispatch emergency response teams to assist local residents and notify affected individuals. Temporary shelters are also opened when necessary to mitigate the effects of seawater inundation on local residents.

Landslides in HKSAR are mostly triggered by heavy rainfall. The CEDD and the HKO will issue landslip warnings when a heavy rainfall which may trigger landslide is forecasted, alerting the public to take precautionary measures. Government departments will also activate emergency response systems to quickly mobilize manpower and resources to address landslides incidents. The DSD has also set up an "Emergency Control Center" and installed telemetry systems at various locations across Hong Kong. These systems collect data on rainfall, tide levels and water levels at the site, and transmit it to the monitoring center for rapid analysis of flooding situations. When necessary, the center will notify other departments to prepare for rescue, evacuation and the opening of temporary shelters. The HKO continues to review and enhance its meteorological observation network in a timely manner to support long-term climate change monitoring and analysis. Since 2018, the Guangdong

Meteorological Bureau, the HKO, and the Macao Meteorological and Geophysical Bureau have jointly compiled the Guangdong-Hong Kong-Macao Greater Bay Area Climate Bulletin annually.

Based on the Natural Disaster Contingency Plan, various departments of the HKSAR Government perform their respective roles in disaster preparedness, response and rehabilitation, and continuously improve their response strategies and plans. Various government departments have also established regular monitoring systems to address extreme weather and natural disasters. These systems will give early alerts to the public during disaster response efforts.

Climate change has led to more extreme rainfall and increasingly intense tropical cyclones. To enhance capabilities for monitoring and forecasting of heavy rain and tropical cyclones, the HKO has applied artificial intelligence technology to its forecasting systems, and developed an experimental flood risk assessment system to support emergency departments in making preparations and implementing contingency plans. Additionally, the HKSAR Government has established an early alert system for coastal low-lying and windy areas in response to storm surges caused by tropical cyclones. Meanwhile, in order to address the increase in high-temperature weather due to global warming, the HKO has strengthened its very hot weather warning service by providing special alerts for "prolonged heat" and "extremely hot weather" with a view to reminding the public to take appropriate precautionary measures.

In 2023, the Labour Department introduced the "Heat Stress at Work Warning" based on the "Hong Kong Heat Index". The warning system includes three levels: amber, red and black, to guide employers and employees in assessing heat stress risks and formulating preventive and control measures. In addition, the Labour Department will promulgate the active levels of the "Heat Stress at Work Warning" and preventive measures against heat stress in relevant work through mobile applications, government press releases, websites and major media outlets.

2. Enhancing the assessment of climate change impacts and risks

The "Climate Change Working Group on Infrastructure" has completed several studies, including "Study on Resilience of Government Critical Infrastructure in Hong Kong under Extreme Weather", "Sensitivity Test under Direct Hit by Super Typhoons", "Frequency Analysis of Extreme Sea Levels", "Projection of Extreme Winds", and "Study of Potential Impacts on Government Infrastructure under Extreme Temperatures". In addition, the "Climate Change Working Group on Infrastructure" has shared its experience and studies findings with public organizations and utilities through relevant government departments, helping enhance the overall resilience of infrastructure across society.

The CEDD launched the "Landslip Prevention and Mitigation Programme" in 2010. Adopting a "risk-based" approach, the programme systematically and continuously manages landslides risks for natural hillsides and man-made slopes. The CEDD prioritizes actions based on factors such as the size, gradient, geological and hydrological conditions of man-made slopes and natural hillsides, as well as the occurrence of recent landslides, and the potential impact on nearby facilities in the event of a landslides (e.g. proximity to existing buildings and critical transport corridors). These actions include the stabilization of government man-made slopes, safety screening studies for private man-made slopes, and risk mitigation works for natural hillsides. In 2022, the CEDD initiated the study of "Shoreline Management Plan" to provide guidelines on coastal planning and formulate long-term strategies and preventive measures to enhance the capacity of the government and relevant stakeholders to address climate change.

Additionally, the DSD has been continuously reviewing the stormwater drainage master plans for various districts across Hong Kong, with the aim of assessing the flood discharge capacity of stormwater drainage systems and the flooding risks under climate change. It has also allocated resources to implement improvement works for stormwater drainage systems. The DSD has also initiated the "Flood Management Strategy Planning Study to Address Sea Level Rise and Extreme Rainfall", with the aim of developing flood management strategies to address sea level rise and extreme rainfall, thereby enhancing Hong Kong's flood resilience and taking proactive measures.

In terms of water resources, in face of the challenges of climate change and increasing fresh water demand due to population and economic growth, the Water Supplies Department has included climate change adaptation into its water resources management strategy since 2008 to ensure water security and support for sustainable development in Hong Kong. The strategy with emphasis on containing fresh water demand growth, including promotion of water conservation, adoption of smart technologies to enhance the implementation of water loss management initiatives, expansion of use of lower grade water (viz. seawater and recycled water) for non-potable purposes, and building resilience in the fresh water supply to cope with extreme droughts and safeguard water supply reliability by constructing desalination plants.

3. Strengthening climate change adaptation actions in Guangdong and Hong Kong

The "Guangdong-Hong Kong Joint Working Group on Environmental Protection and Combating Climate Change" conducts consultation and coordination on issues related to environmental quality, natural resources, ecological environment, climate change response and sustainable development in Guangdong and Hong Kong. The "Special Panel on Combating Climate Change " (SPCCC) is responsible for advancing exchanges, cooperation and scientific research on climate change mitigation and adaptation, conducting and following up on cooperation and exchange programs concerning issues of mutual concern, promoting the exchange and enhancement of collaboration on extreme climate event monitoring and prediction to jointly advance capacity building for climate change adaptation in both regions, facilitating research in meteorology, improve disaster management and contingency planning in Guangdong and Hong Kong and advancing public education on climate change adaptation and strengthening institutional capacity in both regions. The key work of the "SPCCC" includes exchanging information in the following areas: progress of research on strategies and pathways to achieve carbon peaking and carbon neutrality, the development of carbon trading and carbon markets, renewable energy technologies and projects, re-calibration devices and technologies for existing buildings, new energy vehicle technologies and developments, Guangdong's experience in carbon-inclusive initiatives, conservation efforts in natural reserves of both regions, strengthening research on sea level rise, urban drainage system and slope safety management, water resource management strategies, and the latest research developments in the fields related to climate change and human health, as well as ongoing cooperation in the development of short-term climate forecasting technologies.

In addition, the Environmental Protection Department, in collaboration with the then Economic and Information Technology Commission of Guangdong Provincial (now known as the Department of Industry and Information Technology of Guangdong Province), launched the "Cleaner Production Partnership Programme" in 2008 to facilitate Hong Kong-owned factories located in both Hong Kong and Guangdong Province in adopting cleaner production technologies and practices. Through cleaner production, factories can enhance their environmental performance while reducing raw material consumption and saving energy. This not only lowers production costs but also increases competitiveness, thereby improving profitability and generating economic benefits. Since the launch of the programme, the HKSAR Government has invested approximately HK$ 293 million. In view of the environmental benefits brought by the programme, the Government allocated an additional HK$ 311 million in 2020 to extend the programme for another five years until March 31, 2025.

4. Enhancing the climate resilience of natural ecosystems

In addition to potentially affecting the distribution and survival of wildlife populations within habitats, climate change may also increase the risk of wildfires, resulting in the destruction of wooded areas, soil erosion, and impacts on forest coverage and ecological functions. The woodlands within Hong Kong's country parks and special areas play a vital role in combating climate change. AFCD will continue to properly manage and protect these habitats to enhance their resilience to climate change.

The approximately 2,000 hectares of wetlands in the Mai Po and Inner Deep Bay areas of Hong Kong, including mangroves, gei wai (tidal shrimp ponds), fishponds and reed beds, are vital habitats for combating climate change and enhancing climate resilience. Therefore, wetland conservation is also crucial for coping with extreme weather. AFCD will continue to enhance the quality of wetland habitats and promote the sustainable use of wetland natural resources to maintain the ecological environment and functions of important wetlands. Furthermore, it plans to establish a wetland conservation parks system in the Northern Metropolis to further safeguard the ecosystem security of these wetland habitats.

In 2021, the CEDD completed a study on the effectiveness and feasibility of eco-shorelines. This innovative environmental technology involves using artificial ecological components to simulate microhabitats of natural coasts on man-made seawalls, aiming to enhance the biodiversity of water bodies. The application of eco-shorelines has already been extended to multiple areas. The government will further incorporate eco-shorelines into future reclamation projects, integrating the natural ecology concept into infrastructure development.

5. Strengthening the climate resilience of economic and social systems

Strengthening infrastructure facilities. With reference to the IPCC AR6 Report, the CCWGI updated the Port Works Design Manual and the Stormwater Drainage Manual, and included the concept of "design allowance" to further enhance the resilience of related facilities against climate change under this progressive adaptative approach. The CCWGI will continue to closely monitor the latest data, coordinate with relevant departments, and review and update the design standards for various infrastructure facilities as needed. The CCWGI will also continue to coordinate studies on the potential impacts of climate change on infrastructure, and develop measures and implementation plans to enhance their resilience.

Combating sea level rise and protecting shorelines. With reference to the IPCC AR6 Report and the related research on latest climate change, the CEDD updated the design parameters in the Part Words Design Manual in August 2022, taking into account the impacts of wind speed increase, storm surge increase, and sea-level rise on coastal infrastructure due to climate change. To strengthen the ability of coastal areas to withstand heightened waves, the CEDD completed the "Coastal Hazards Study" in 2021. This study assessed the likelihood and severity of coastal hazards in these areas and, with reference to the records of past coastal damage caused by super typhoons, identified 26 low-lying or windy residential areas with higher potential risk, and also recommended the implementation of improvement works and management measures. The CEDD commenced the design for the relevant improvement works in 2022 and plans to complete these works in a timely and orderly manner within five years (by 2027).

Combating extreme rainstorms. With reference to the IPCC AR6 Report and the related research on recent climate change conducted by relevant departments, the DSD updated the design parameters in the Stormwater Drainage Manual in August 2022, addressing the impacts of increased rainfall and sea level rise on drainage systems due to climate change. The DSD has adopted a "three-pronged flood prevention strategy" (i.e. stormwater interception at upstream, flood storage at midstream, and drainage improvement at downstream) to formulate appropriate flood prevention and drainage management measures. Over the years, the DSD has completed numerous major flood control projects, including four stormwater drainage tunnels, four flood storage schemes, and the improvement of over 100 kilometers of river channels. With the completion of several major flood control projects, flooding issues in many areas have been significantly alleviated. The number of flooding blackspots has also been significantly reduced, with a total of 127 flooding blackspots eliminated to date.

Combating landslide risks. The CEDD continues to implement the "Landslip Prevention and Mitigation Programme", adopting a risk-based approach to stabilize government man-made slopes and carry out risk mitigation works for natural hillsides. The CEDD will also enhance the technical design requirements for slope drainage to strengthen the ability of slopes to withstand extreme rainstorms.

Combating extreme heat. The HKSAR Government will continue to promote green building design and sustainable building environment, and advance urban forestry to mitigate and cope with temperature rise.

6. Strengthening disaster reduction and post-disaster recovery efforts

The HKSAR Government has developed the Natural Disaster Contingency Plan, which clarifies the strategies, organizational structure and warning systems for responding to natural disasters, as well as the functions and responsibilities of government decision-making bureaus/departments, utility companies and non-governmental organizations in the event of a natural disaster. In the event of a super typhoon or other large-scale natural disasters, the HKSAR Government will establish an inter-departmental steering committee led by the Chief Secretary for Administration and composed of principal officials. This committee will provide high-level coordination and oversight during the preparation, response and recovery phases, and set priorities for various tasks to enable citizens to quickly return to normal life. If a natural disaster causes extreme and widespread impacts, such as extensive flooding, severe landslides, or significant disruptions to public transportation services, the steering committee will consider declaring an "extreme situation" to advise citizens to remain in their current safe locations.

Under the current storm surge warning system, the government has established an early alert system. Relevant departments will deploy emergency response teams to assist residents in low-lying coastal areas, including handling flooding and installing water baffles and sandbags in specific locations, all aimed at reducing the impact of seawater inundation on local residents.

The DSD began implementing the "just-in-time clearance" arrangement in 2020. Before the onset of a rainstorm, the DSD will deploy teams in advance to inspect areas prone to blockage, allowing for quick clearance arrangements to reduce the risk of flooding. In addition, whenever a red or black rainstorm warning signal, or a tropical cyclone warning signal No. 8 or higher is issued, the DSD will activate the Emergency Control Center to dispatch emergency response teams to handle flooding incidents and clear blocked channels and river courses urgently. After a heavy rainstorm, the DSD will inspect the drainage channels, river courses and waterways, and carry out desilting operations if necessary to prepare for the next rainstorm. The CEDD provides 24-hour emergency services throughout the year. When handling emergency incidents related to landslides, it offers geotechnical advice and ensures that necessary emergency slope stabilization measures are implemented as soon as possible, so as to reduce the impact of landslides on citizens and enable them to return to normal life as quickly as possible.

To facilitate real-time communication of disaster-related incident information among government departments, assisting in assessing the situation and developing response plans and measures for natural disasters, the “Common Operational Pictures” covers incident information related to landslides, flooding, storm surges and other disasters. Participating government departments include the CEDD, DSD, HyD, and HKO. Chinese Mainland has strong emergency response capabilities, particularly in terms of heavy equipment.

An interconnected and mutually supportive emergency response mechanism for the Guangdong-Hong Kong-Macao Greater Bay Area (hereinafter referred to as the "Greater Bay

Area")[70] will generate synergies. HKSAR, together with other cities in the Greater Bay Area, will implement the new Greater Bay Area Emergency Response and Rescue Operational Plan. Based on the concepts of joint prevention and control, as well as complementary advantages, this plan aims to establish a systematic emergency response mechanism for the Greater Bay Area, enhancing the capacity of joint disaster prevention, mitigation, relief and response to major public emergencies.

(ii) Challenges in Climate Change Adaptation

Hong Kong has been actively participating in international organizations related to climate change, to ensure that it can keep abreast of the latest developments in policies and technologies for addressing climate change. The HKSAR Government will continue to develop adaptation policies and plans based on the latest developments in climate science and relevant international standards, including the assessment reports published by the United Nations IPCC, projections of Hong Kong's temperature and rainfall, as well as future changes in average sea levels. These efforts aim to enhance the city's adaptation and resilience capabilities. Stakeholders from all sectors also need to cooperate in implementing relevant adaptation and response measures for their properties and facilities, in order to reduce the impacts and losses caused by extreme weather.

IV. International Cooperation, Experiences, and Lessons Learned.

(i) Cooperation in Climate Change Adaptation

In October 2007, HKSAR joined the C40 Cities Climate Leadership Group (C40) under the city identity of "Hong Kong, China". In May 2011, it became a member of the C40 Steering Committee, promoting collective efforts among major cities worldwide to address climate change. To establish closer partnerships with C40 cities in the Asia and Oceania regions, the Environment and Ecology Bureau hosted the first C40 Climate Action Seminar (Asia and Oceania regions) on October 27, 2023. The seminar brought together representatives from 15 C40 Cities cities in Asia and Oceania regions to share their climate action initiatives, including the promotion of green transport and infrastructure, and the development of green economy and finance. Over 140 participants attended the seminar, including representatives from local organizations and relevant government departments.

(ii) Lessons and Insights in Climate Change Adaptation

Due to its coastal location, Hong Kong is vulnerable to weather-related threats such as tropical cyclones, heavy rain and storm surges. Between 2017 and 2022, Hong Kong was hit by multiple tropical storms, typhoons and super typhoons[71], causing widespread damage and

[70] The Guangdong-Hong Kong-Macao Greater Bay Area (GBA) includes the two Special Administrative Regions of Hong Kong and Macau, along with nine cities in Guangdong Province: Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing, with a total area of approximately 56,000 square kilometers. According to the latest data provided by the governments of Guangdong Province, and the HKSAR and MSAR, the total population of the GBA exceeded 86 million in 2023, with a GDP exceeding RMB 14 trillion. (Related website: https://www.bayarea.gov.hk/sc/about/overview.html)

[71] In 2017: Super Typhoon Hato; in 2018: Super Typhoon Mangkhut; in 2020: Typhoon Higos; in 2021: Tropical Storm Lionrock and Typhoon Kompasu.

resulting in severe backflow of seawater in some low-lying areas and the destruction of coastal facilities. In addition, climate change has led to the ongoing rise in sea levels, which may pose a threat to some low-lying areas in the future. In response to the increasing frequency of extreme weather events, the HKSAR Government must strengthen key public infrastructure facilities, enhance coastal protection, and continue to improve the city's flood resilience and reinforce slopes, in preparation for more frequent extreme weather in the future.

Hong Kong has accumulated experience in combating extreme weather events such as tropical cyclones and rainstorms. It has established a solid foundation in strengthening the design of buildings and infrastructure, enhancing drainage management and prevention of landslides. The public is increasingly concerned about the impacts of climate change and supports the HKSAR Government in allocating more public resources to implement measures for climate change adaptation. As technologies and methods for climate change adaptation continue to evolve, related projects can not only enhance the ability to withstand extreme weather but also beautify the environment. For example, the concept of revitalizing water bodies by incorporating greening and ecological conservation elements in drainage projects allows for effective drainage while promoting greening, protecting biodiversity and beautifying the environment.

Chapter 4 HKSAR's Finance, Technology and Capacity Building Needs and Support Received

I. Regional Circumstances and Institutional Arrangements

The promotion of a low-carbon transition around the world and the growing environmental awareness among the public are leading to the development of a green economy. For example, application of new energy, energy efficiency and green buildings, new energy vehicles and other green industries are creating new investment and employment opportunities. In the process of achieving carbon neutrality in Hong Kong, the HKSAR Government and all sectors of society will invest substantial financial resources for planning and implementation in promoting measures such as energy saving, clean energy, green infrastructure, electrification of transportation, and waste reduction and recycling. These efforts will not only help sustainably improve environmental quality, but will also create opportunities in green economy on many fronts.

Statistics indicate that in the next 30 years, the Asia region alone will need US$66 trillion in climate investment, highlighting the huge market demand for green finance. Hong Kong's green and sustainable finance market has been flourishing. In 2022, the total amount of green and sustainable debt issued in Hong Kong (including bonds and loans) increased by over 40% compared to 2021, reaching US$ 80.5 billion. Among them, the amount of green and sustainable bonds issued in Hong Kong accounted for 35% of the green and sustainable bond market in Asia. Under the "Government Green Bond Programme", the HKSAR Government has successfully issued a total of approximately US$ 25 billion in government green bonds since May 2019. Hong Kong will continue to accelerate the development of green and sustainable finance, support its path to carbon neutrality and respond to the immense business opportunities and financing needs in the global green transformation.

In terms of education and training, the HKSAR Government will enhance teachers' knowledge of climate change at the school level, strengthen relevant learning contents in different subjects and arrange diversified learning experiences to enhance students' understanding of climate change and its impacts, and encourage them to put into practice in their daily life and achieve low-carbon transformation. To cultivate professional talents, the universities and post-secondary institutions [72] need to enrich the learning contents related to climate change, low-carbon technology and green finance in relevant courses, and strengthen cooperation and exchanges between the universities and post-secondary institutions, so that teachers and students can keep abreast of the times and master relevant professional knowledge and skills.

The HKSAR Government will explore the integration of existing consultation platforms to continuously encourage all sectors of society, including young people, to actively participate in climate action. The government, business sector, schools and non-governmental organizations will work together and set examples to promote and encourage the public to adopt and practise low-carbon lifestyles.

II. Financial Needs and Support Received for Addressing Climate Change

(i) Financial Needs for Addressing Climate Change

Low-carbon transformation requires a lot of resources. According to the Hong Kong's Climate Action Plan 2050 released in 2021, in the past 10 years or so, the HKSAR Government has allocated more than HK$ 47 billion to implement various measures on energy saving and renewable energy, popularise electric vehicles, and introduce innovative waste-to-energy and waste-to- resource facilities, contributing to the reduction of waste and decarbonization. In the next 15 to 20 years, the HKSAR Government would invest another HK$ 240 billion to implement various mitigation and adaptation measures, including renewable energy, energy-efficient and green buildings, green transport and waste management.

Innovative technology plays a pivotal role in achieving carbon neutrality. In 2020, the HKSAR Government set up the "Green Tech Fund" (hereinafter referred to as the "Fund") to provide funding support for research and development projects which help Hong Kong decarbonize and enhance environmental protection. Since the establishment of the Fund, the HKSAR Government has injected a total of HK$ 400 million into the Fund, with the funding amount ranging from HK$ 2.5 million to up to HK$ 30 million for each project. As of the end of 2022, the Fund had approved 22 research projects from local universities, designated public research institutes and private enterprises, involving a total amount of approximately HK$ 100 million. The approved projects involve a wide array of subjects, including technologies for the production and storage of hydrogen fuel, biochar-based building materials, and production of noise-absorbing meta-materials using recycled plastics.

[72] Post-secondary institutions refer to higher education institutions, professional education colleges, and organizations that provide professional education in Hong Kong outside of universities.

(ii) Climate Finance Support Received by HKSAR

Not involved.

III. Technology Development and Transfer Needs and Support Received for Addressing Climate Change

(i) Technology Needs for Addressing Climate Change

Major needs for technologies for climate change mitigation include those on zero-carbon energy, renewable energy and waste-to-energy, energy-saving products in buildings, new wall materials, electric vehicles, high-efficiency fast recharging and changing facilities for electric vehicles, high-efficiency batteries and materials. Major needs for technologies for climate change adaptation include those for the protection of environment and ecosystems, climate risk assessment for building environment and infrastructure development, forecast of energy demand and supply changes, and analysis of the impacts on food chain, food hazards and water resources.

The "Green Tech Fund" established by the HKSAR Government helps promote the development and application of decarbonization technologies that meet Hong Kong's environmental needs. It supports research and development projects in the priority areas including net-zero electricity generation, energy saving and green buildings, green transport, and waste reduction. Moreover, when setting the energy efficiency standards of buildings, reference will be made to the relevant technical and international standards and harness innovative and intelligent technologies to ensure the energy efficiency standards of building services installations are up to date with continuous improvement.

(ii) Technology Support Received by HKSAR for Addressing Climate Change

Not involved.

IV. Capacity-Building Needs and Support Received for Addressing Climate Change

(i) Capacity-Building Needs for Addressing Climate Change

The Education Bureau, in collaboration with the Environment and Ecology Bureau and the Council for Sustainable Development, established the "E-Learning Platform on Long-term Decarbonisation" in the 2020/2021 school year with a view to enhancing the teaching and learning effectiveness of sustainable development topics under the Senior Secondary Liberal Studies curriculum. They also plan to extend the platform to support environmental education at junior secondary levels. The Education Bureau will continue to invite government departments, conservation organizations and schools to organize training activities on climate change for secondary and primary school teachers in Hong Kong. It will also provide schools with leaning and teaching resources on climate change to enhance students' awareness of environmental conservation and foster their proper values, attitudes and behaviour related to climate change mitigation. In April 2017, the Education Bureau issued a circular on " Environmental Policy and Energy Saving Measures in Schools" to all schools to remind them of the importance of formulating school-based environmental protection policies and implementing energy-saving measures, and provide the relevant up-to-date information and resources. In September 2019, the Education Bureau issued a circular memorandum on "Participation of Schools in Feed-in Tariff Scheme" to encourage schools, in line with their environmental policies, to install renewable energy systems on their campuses and actively showcase the results of implementing school-based environmental policies to the community and stakeholders to further promote environmental education.

In the post-secondary education sector, under the principle of institutional autonomy, post-secondary institutions have the flexibility to develop programmes that meet market needs and adjust the content and intake places of relevant programmes. Currently, among the programmes funded by the University Grants Committee, more than 80 undergraduate and postgraduate research programmes cover academic disciplines potentially related to climate change and carbon neutrality, including "Chemical Engineering and Materials Technology", "Manufacturing and Industrial Engineering", "Environmental Science", "Geography", "Transportation and Communication" and "Other Engineering". Over 7 500 undergraduates are enrolled in these programmes, along with more than 600 postgraduate research degree places. In addition, the Vocational Training Council (VTC) currently offers 12 environment-related vocational and professional education and training programmes, enabling secondary school graduates and working people to obtain qualifications at the certificate, diploma, higher diploma, and bachelor's degree levels. Various self-financing post-secondary institutions also offer nearly 20 related sub-degree and bachelor's degree programmes, with a total enrollment of over 2 000 students.

In addition, the HKSAR Government will organize various educational activities to raise community awareness of climate change and adopt low-carbon and sustainable lifestyles starting from practices of everyday life, as well as to encourage the youth to actively participate in promoting environmental protection and addressing climate change.

(ii) Capacity-Building Supports Received by HKSAR for Addressing Climate Change

Not involved.

V. Needs and Support Received for Enhancing Transparency in Compliance Efforts

At the end of 2018, the first Conference of the Parties to the Paris Agreement adopted the "Modalities, Procedures and Guidelines" (hereinafter referred to as MPGs) for the enhanced transparency framework. The content of relevant compliance reports includes annual GHG inventory, tracking progress on NDCs, climate change adaptation, and information on financial, technical and capacity-building support (FTC) provided and received. The compliance reports should undergo review by international expert and facilitative multilateral consideration. The establishment of the enhanced transparency framework has created new challenges for many developing countries, including more frequent reporting requirements, more detailed information reporting, and stricter review and assessment processes.

In assisting relevant institutions and chapter experts in report preparation to understand the requirements of the MPGs, the HKSAR Government, with the support and arrangement from the National Center for Climate Change Strategy and International Cooperation (NCSC) and the Foreign Environmental Cooperation Center (FECO) under the MEE, participated in the compliance report preparation expert training and discussion workshops held by NCSC and FECO in September 2022 and February 2024, respectively. The workshops focused on the new requirements of MPGs under the Paris Agreement, compliance status and gap analysis, report content for each chapter, and international review, with the aim of enhancing the report preparation experts' understanding on MPGs (including considerations during the negotiation process), and further clarifying data and information needs for government departments. This provides reference for policy-makers and experts in mitigation, adaptation and FTC methodologies.

Part VI Information of MSAR on Climate Change

Macao is a special administrative region of China. It is a vibrant city featuring mild climate, limited natural resources, high population density and a highly-developed hotel and gaming industry. It is also a world-renowned destination for tourism and entertainment.

Chapter 1 MSAR's GHG Inventory

I. Institutional Arrangements

The MSAR Government has always attached great importance to the issue of climate change. To effectively manage and coordinate climate change work, the MSAR Government has set up an inter-departmental working group on climate change (hereinafter referred to as the "Climate Change Group"). The Climate Change Group is responsible for coordinating work related to the implementation of the Convention, including formulating "measurable, reportable, and verifiable" emission reduction actions, promoting mitigation and adaptation in the private sector and among the general public, and mobilizing the participation of the entire population in addressing climate change.

The Climate Change Group regularly holds coordination meetings to discuss the latest international and national developments in climate change, as well as MSAR's emissions reduction policies, and to report on the latest GHG inventory accounting for MSAR. The Macao Meteorological and Geophysical Bureau (DSMG) is responsible for coordinating and collecting basic information of MSAR on climate change for NCs, BURs and BTRs.

DSMG coordinates the preparation of MSAR's GHG Inventory, and jointly prepares the inventory with the Environmental Protection Bureau (DSPA). The Statistics and Census Service (DSEC), the Transport Bureau (DSAT), and the Civil Aviation Authority (AACM) are responsible for collecting Energy-related activity data, and DSPA is responsible for collecting Waste-related activity data. MSAR's GHG Inventory was prepared according to the GHG inventory guidelines, and integrated as a separate chapter into NCs, BURs or BTRs. It was submitted to the national climate change authority, and uniformly reviewed by the national inventory experts.

II. GHG Emissions and Removals in MSAR

(i) Key Category Analysis

Based on the actual situation in MSAR and the availability of relevant data, MSAR's GHG Inventory primarily covers GHG emissions from Energy and Waste, as well as CO_2, CH_4, and N_2O. According to the 2006 IPCC Guidelines, Approach 1 level and trend assessment were used to identify key categories in MSAR's GHG Inventory for 2020-2021. The results show that there are 9 key categories in MSAR's GHG Inventory for 2020-2021 (see Table 6-1).

Table 6-1 Key Category Analysis Results of MSAR's GHG Inventory for 2020-2021

No.	Sector	Category	GHGs Gas	Key Category or Not (without LULUCF)		
				Level assessment		Trend assessment
				2020	2021	2020-2021
1	Energy	1.A.1.a - Main Activity Electricity and Heat Production -- liquid fuels	CO_2	√	√	√
2	Energy	1.A.1.a - Main Activity Electricity and Heat Production -- gaseous fuels	CO_2	√	√	√
3	Energy	1.A.1.a - Main Activity Electricity and Heat Production - MSW	CO_2	√	√	
4	Energy	1.A.1.a - Main Activity Electricity and Heat Production -- waste	N_2O		√	√
5	Energy	1.A.2 - Manufacturing Industries and Construction - liquid fuels	CO_2	√	√	√
6	Energy	1.A.3.b - Road Transportation - liquid fuels	CO_2	√	√	√
7	Energy	1.A.4 - Other Sectors - liquid fuels	CO_2	√	√	
8	Energy	1.A.4 - Other Sectors - gaseous fuels	CO_2	√	√	√
9	Waste	5.D - Wastewater Treatment and Discharge	N_2O	√	√	

Note: 1) Based on key category analysis, this table lists key categories for level or trend assessment according to the 95% threshold. Non-key categories are not included in this table.

Due to the inaccessibility to more detailed activity data and local emission factors, the key categories mentioned above all adopted the Tier 1 method provided in the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines, as well as default emission factors.

Statistics on fugitive emissions from fuels, IPPU and LULUCF are still under construction, with no activity data available, making it unable to estimate the relevant sources and sinks, which were not included in the reported inventory.

(ii) Overall Trends of Inventories for 2005 and 2020-2021

This section mainly outlines MSAR's GHG Inventory results for 2005 and 2020-2021. GHG emissions for these three years were 1,870.0 ktCO_2eq, 1,071.9 ktCO_2eq, and 1,083.1 ktCO_2eq, respectively. In 2020, GHG emissions were reduced by approximately 798.1 ktCO_2eq compared to 2005, a decrease of 42.7%. In 2021, GHG emissions increased by approximately 11.2 ktCO_2eq compared to 2020, a growth of 1.0%, but reduced by approximately 786.9 ktCO_2eq compared to 2005, a decrease of 42.1%.

1. Overview of GHG Inventory for 2020

In 2020, MSAR's total GHG emissions were 1,071.9 ktCO_2eq (see Table 6-2), with Energy and Waste accounting for 94.2% and 5.8%, respectively (see Table 6-3 and Figure 6-1). Of these, CO_2 emissions were approximately 987.9 kt, accounting for about 92.2%; CH_4 emissions were approximately 17.0 ktCO_2eq, accounting for about 1.6%; and N_2O emissions were approximately 67.0 ktCO_2eq, accounting for about 6.3% (see Figure 6-2).

Table 6-2 MSAR's Total GHG Emissions in 2020 (ktCO$_2$eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	984	8	19				1,010
IPPU	NE	NO	NE	NE	NO	NE	NE
Agriculture		NO	NO				NO
LULUCF	NE	NE	NE				NE
Waste	4	9	48				62
Total (without LULUCF)	988	17	67	NE	NO	NE	1,072
Total (with LULUCF)	988	17	67	NE	NO	NE	1,072

Notes: 1). Shaded cells do not require entries;

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). "NO" (not occurring) indicates that a particular source or sink category do not occur.

4). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

Table 6-3 MSAR's GHG Emissions in 2020 (kt)

GHG Source/Sink Categories	CO_2	CH_4	N_2O
Total (without LULUCF)	987.92	0.61	0.25
Energy	983.73	0.27	0.07
- Fuel combustion	983.73	0.27	0.07
◆ Energy industry	414.98	0.17	0.04
◆ Manufacturing and construction	94.41	0.00	0.00
◆ Transport	324.51	0.10	0.03
◆ Other sectors	149.83	0.00	0.00
- Fugitive emissions		NE	
IPPU	NE	NO	NE
Agriculture		NO	NO
LULUCF	NE	NE	NE
Waste	4.19	0.34	0.18
- Solid waste disposal	4.19	0.00	0.00
- Wastewater treatment		0.33	0.18
Memo items			
- Special regional aviation	130.12	0.00	0.00
- Special regional marine	12.15	0.00	0.00
- International aviation	60.21	0.00	0.00
- International marine	NO	NO	NO
- Biomass combustion	263.66		

Notes: 1). Shaded cells do not require entries;

2). Due to rounding, the aggregation of various items may be slightly different from the total.

3). "NO" (not occurring) indicates that a particular source or sink category do not occur.

4). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

5). The data of HFCs, PFCS and SF6 related activities that are not collected and estimated under the IPPU are presented as NE in total.

6). Fugitive emissions from fuels and LULUCF cannot be estimated due to the in-progress statistics system.

7). Values given in 'Memo items' are not counted in the total emissions, and CO_2 emissions from biomass combustion only include those from biogenic waste incineration.
8). "Special regional aviation" and "special regional marine" represent aviation and marine between MSAR and other parts of China (including HKSAR and Taiwan).
9). 0.0 indicates that the value is less than 0.005.

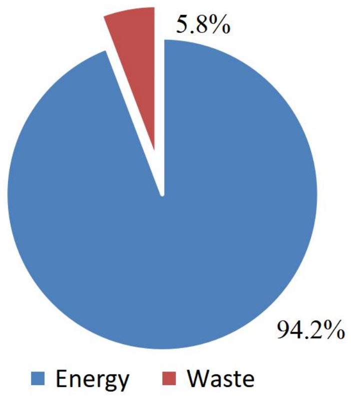


Figure 6-1 MSAR's GHG Emissions by Sector in 2020

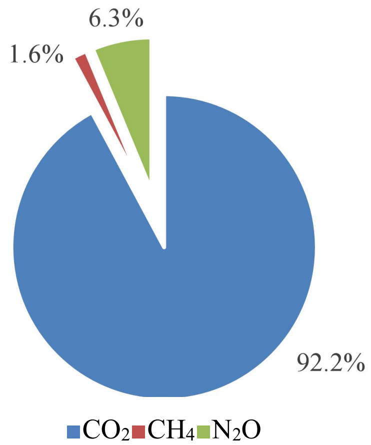


Figure 6-2 MSAR's GHG Emissions by Gas in 2020

In 2020, GHG emissions from international aviation and special regional aviation in MSAR were approximately 191.8 ktCO_2eq, special regional marine emissions were approximately 12.3 ktCO_2eq, and CO_2 emissions from biomass combustion under Waste were approximately 263.7 kt. The total GHG emissions from the above activities amounted to approximately 467.7 ktCO_2eq, which were listed separately as memo items, and not included in MSAR's total emissions.

2. Overview of GHG Inventory for 2021

In 2021, MSAR's total GHG emissions were 1,083.1 ktCO_2eq (see Table 6-4), with Energy and Waste accounting for 94.2% and 5.8%, respectively (see Table 6-5 and Figure 6-3). Of these, CO_2 emissions were approximately 994.8 kt, accounting for about 91.8%; CH_4 emissions were approximately 17.4 ktCO_2eq, accounting for about 1.6%; and N_2O emissions were approximately 70.9 ktCO_2eq, accounting for about 6.5% (see Figure 6-4).

Table 6-4 MSAR's Total GHG Emissions in 2021 ($ktCO_2eq$)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	991	8	22				1,020
IPPU	NE	NO	NE	NE	NO	NE	NE
Agriculture		NO	NO				NO
LULUCF	NE	NE	NE				NE
Waste	4	10	49				63
Total (without LULUCF)	995	17	71	NE	NO	NE	1,083
Total (with LULUCF)	995	17	71	NE	NO	NE	1,083

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). "NO" (not occurring) indicates that a particular source or sink category do not occur.
4). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

Table 6-5 MSAR's GHG Emissions in 2021 (kt)

GHG Source/Sink Categories	CO_2	CH_4	N_2O
Total (without LULUCF)	994.78	0.62	0.27
Energy	990.60	0.28	0.08
- Fuel combustion	990.60	0.28	0.08
◆ Energy industry	361.97	0.17	0.05
◆ Manufacturing and construction	114.44	0.0	0.0
◆ Transport	354.05	0.10	0.03
◆ Other sectors	160.15	0.0	0.0
- Fugitive emissions		NE	
IPPU	NE	NO	NE
Agriculture		NO	NO
LULUCF	NE	NE	NE
Waste	4.17	0.34	0.19
- Solid waste disposal	4.17	0.0	0.0
- Wastewater treatment		0.34	0.19
Memo items			
- Special regional aviation	177.42	0.0	0.01
- Special regional marine	9.86	0.0	0.0
- International aviation	53.12	0.0	0.0
- International marine	NO	NO	NO
- Biomass combustion	271.54		

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). "NO" (not occurring) indicates that a particular source or sink category do not occur.
4). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.
5). The data of HFCs, PFCS and SF_6 related activities that are not collected and estimated under the IPPU are presented as NE in total.

6). Fugitive emissions from fuels and LULUCF cannot be estimated due to the in-progress statistics system.
7). Values given in 'Memo items' are not counted in the total emissions, and CO_2 emissions from biomass combustion only include those from biogenic waste incineration.
8). "Special regional aviation" and "special regional marine" represent aviation and marine between MSAR and other parts of China (including HKSAR and Taiwan).
9). 0.0 indicates that the value is less than 0.005.

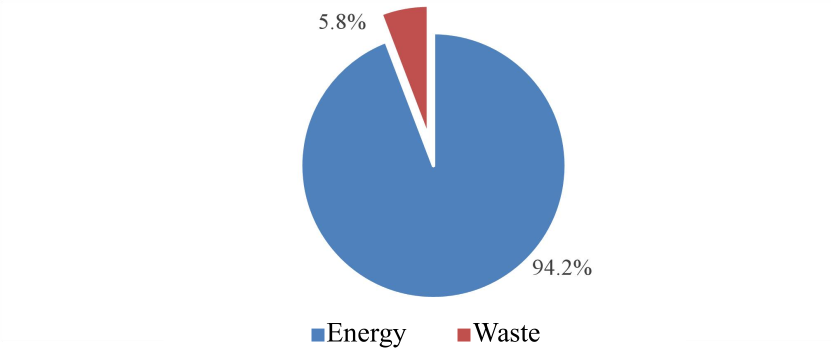


Figure 6-3 MSAR's GHG Emissions by Sector in 2021

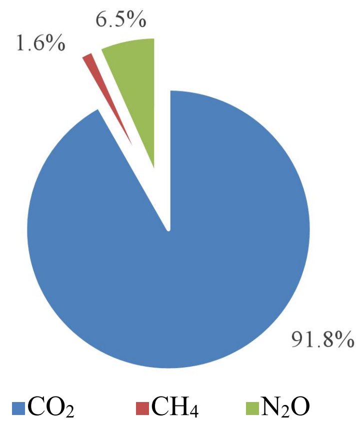


Figure 6-4 MSAR's GHG Emissions by Gas in 2021

In 2021, GHG emissions from international aviation and special regional aviation in MSAR were approximately 232.3 $ktCO_2eq$, special regional marine emissions were approximately 10.0 $ktCO_2eq$, and CO_2 emissions from biomass combustion under Waste were approximately 271.5 kt. The total GHG emissions from the above activities amounted to approximately 513.8 $ktCO_2eq$, which were listed separately as memo items, and not included in MSAR's total emissions.

3. Overview of GHG Inventory for 2005

In response to updated estimation methods, expanded scope of calculation and necessary updates of underlying data, MSAR's GHG Inventory 2005 was updated using the same methods as for 2020-2021.

In 2005, MSAR's total GHG emissions were 1,870.0 $ktCO_2eq$ (see Table 6-6), with Energy and Waste accounting for 97.9% and 2.1%, respectively (see Figure 6-5). Of these, CO_2 emissions were approximately 1,814.0 kt, accounting for about 97.0%; CH_4 emissions were approximately 12.7 ktCO_2eq, accounting for about 0.7%; and N_2O emissions were approximately 43.2 ktCO_2eq, accounting for about 2.3% (see Figure 6-6).

Table 6-6 MSAR's Total GHG Emissions in 2005 (ktCO_2eq)

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Energy	1,813	6	11				1,830
IPPU	NE	NO	NE	NE	NO	NE	NE
Agriculture		NO	NO				NO
LULUCF	NE	NE	NE				NE
Waste	1	7	32				40
Total (without LULUCF)	1,814	13	43	NE	NO	NE	1,870
Total (with LULUCF)	1,814	13	43	NE	NO	NE	1,870

Notes: 1). Shaded cells do not require entries;
2). Due to rounding, the aggregation of various items may be slightly different from the total.
3). "NO" (not occurring) indicates that a particular source or sink category do not occur.
4). "NE" (not estimated) indicates that a particular source or sink category has not been estimated.

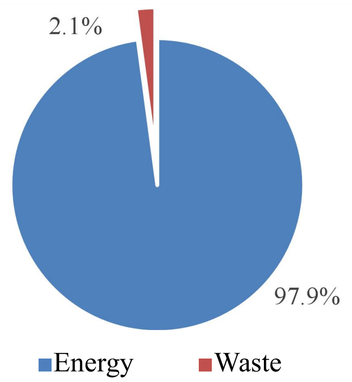


Figure 6-5 MSAR's GHG Emissions by Sector in 2005

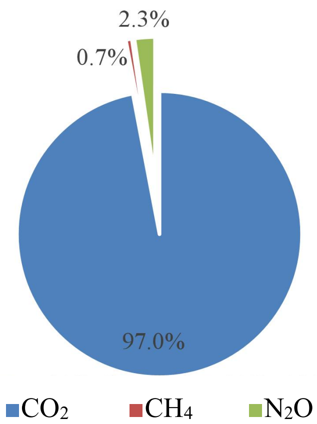


Figure 6-6 MSAR's GHG Emissions by Gas in 2005

(iii) Analysis of Trends by Gas

CO_2 is the most heavily emitted gas in MSAR. In 2005, 2020 and 2021, CO_2 emissions were approximately 1,814 kt, 987.9 kt and 994.8 kt; CH_4 emissions were 12.7 ktCO_2eq, 17.0

ktCO_2eq and 17.4 ktCO_2eq; N_2O emissions were 43.2 ktCO_2eq, 67.0 ktCO_2eq and 70.9 ktCO_2eq. The total CO_2 emissions have seen a significant decline and are gradually trending towards stabilization, while the total CH_4 and N_2O emissions have been steadily increasing.

In 2005, 2020 and 2021, CO_2 emissions accounted for 97.0%, 92.2% and 91.8%; N_2O emissions accounted for 2.3%, 6.3% and 6.5%; and CH_4 emissions accounted for 0.7%, 1.6% and 1.6%. While CO_2's share has decreased, N_2O and CH_4 have seen a noticeable increase in their contributions.

(iv) Analysis of Trends by Category

Energy is a major emission source in MSAR's GHG Inventory. In 2005, 2020 and 2021, GHG emissions from Energy were about 1,830.3 ktCO_2eq, 1,010.2 ktCO_2eq and 1,020.1 ktCO_2eq respectively. The total GHG emissions have seen a significant decline and are gradually trending towards stabilization. In 2005, 2020 and 2021, GHG emissions from Energy accounted for 97.9%, 94.2% and 94.2%, and those from Waste accounted for 2.1%, 5.8% and 5.8%, with the former seen a slight decline.

III. Energy

(i) Overview

1. Scope

For Energy, MSAR's GHG Inventory mainly covers the CO_2, CH_4 and N_2O emissions from fossil fuel combustion in energy industry, manufacturing and construction, road transport and other sectors. Considering the fact that incineration is the major approach for MSW disposal in MSAR, and the heat generated in the incineration process is retrieved to generate electricity and transmitted to MSAR's power grid, the GHG emissions from incineration of fossil-derived waste (such as clothing and plastics) were counted under Energy. While CO_2 emissions from biomass combustion under Waste were not counted in the total emissions but only listed as memo items.

Regarding fugitive emissions from Energy, MSAR has no coal, oil, or natural gas producers. This section only involves minor fugitive emissions during oil and natural gas distribution processes. These emissions were not estimated as no statistics are available.

2. Methods

For Energy, due to the lack of detailed activity data and local emission factors, CO_2, CH_4 and N_2O emissions from fossil fuel combustion in energy processing and conversion, manufacturing and construction, road transport, other sectors, and special regional marine transport were calculated using Tier 1 method and default emission factors in the 2006 IPCC Guidelines. Due to the availability of detailed flight activity data, CO_2, CH4 and N2O emissions from international aviation and special regional aviation were calculated using Tier 2 method.

The activity data were the statistical and sectoral data released by the MSAR Government. Both sector and fuel categories are basically the same as those given in the 2006 IPCC

Guidelines.

The selection of emission factors data is consistent with the national GHG inventory, primarily referring to the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines.

(ii) Trends in Inventories on Energy

In 2020, MSAR's GHG emissions from Energy amounted to approximately 1010.2 ktCO_2eq, accounting for 94.2%. This comprised approximately 983.7 ktCO_2eq of CO_2 emissions, 7.6 ktCO_2eq of CH_4 emissions, and 18.8 ktCO_2eq of N_2O emissions. Energy accounted for 99.6% of total CO_2 emissions in MSAR.

In 2020, among MSAR's emissions from Energy, approximately 430.2 ktCO_2eq from energy processing and conversion, accounting for 42.6%; about 335.2 ktCO_2eq from road transport, accounting for 33.2%; roughly 150.0 ktCO_2eq from other sectors (including commercial, food and beverage, hotels, and residential), accounting for 14.9%; and approximately 94.7 ktCO_2eq from manufacturing and construction, accounting for 9.4%.

In 2021, MSAR's GHG emissions from Energy amounted to approximately 1,020.1 ktCO_2eq, accounting for 94.2%. This comprised approximately 990.6 ktCO_2eq of CO_2 emissions, 7.9 ktCO_2eq of CH_4 emissions, and 21.6 ktCO_2eq of N_2O emissions. Energy accounted for 99.6% of total CO_2 emissions in MSAR.

In 2021, among MSAR's emissions from Energy, approximately 379.2 ktCO_2eq from energy processing and conversion, accounting for 37.2%; about 365.7 ktCO_2eq from road transport, accounting for 35.9%; roughly 160.4 ktCO_2eq from other sectors (including commercial, food and beverage, hotels, and residential), accounting for 15.7%; and approximately 114.8 ktCO_2eq from manufacturing and construction, accounting for 11.3%.

In 2005, MSAR's GHG emissions from Energy amounted to approximately 1,830.3 ktCO_2eq, accounting for 97.9%. This comprised approximately 1,813.3 ktCO_2eq of CO_2 emissions, 5.5 ktCO_2eq of CH_4 emissions, and 11.5 ktCO_2eq of N_2O emissions. Energy accounted for 99.96% of total CO_2 emissions in MSAR.

In 2005, among MSAR's emissions from Energy, approximately 1,335.9 ktCO_2eq from energy processing and conversion, accounting for 73.0%; about 204.8 ktCO_2eq from road transport, accounting for 11.2%; roughly 196.1 ktCO_2eq from other sectors (including commercial, food and beverage, hotels, and residential), accounting for 10.7%; and approximately 93.5 ktCO_2eq from manufacturing and construction, accounting for 5.1%.

(iii) Uncertainty and Time-Consistency Analysis

During the preparation of MSAR's GHG Inventory 2020 and 2021, despite substantial preparatory work in areas such as scope, methods, and quality, there remains a degree of uncertainty in MSAR's GHG Inventory.

MSAR's inventory preparation adopted the error propagation method provided in the 2006 IPCC Guidelines, and made reference to the uncertainty of emission factors in the 2006 IPCC

Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines. The uncertainty in MSAR's GHG Inventory on Energy for 2020 and 2021 was 11.7% and 11.8%, respectively, as shown in Table 6-7.

Table 6-7 Results of Uncertainty Analysis of MSAR's GHG Inventory on Energy

	Emissions ($ktCO_2eq$)	Uncertainty
2020	1,010	11.7%
2021	1,020	11.8%

The MSAR's GHG Inventory for 2020-2021 was prepared mainly based on the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines, and the GHG Inventory for 2005 was updated using the same methods as for 2020-2021, ensuring the consistency of the methodology and the completeness of the inventory.

IV. IPPU

Not estimated. Fugitive emissions from use of ODS substitutes in MSAR were not estimated as no relevant statistical data are available.

V. Agriculture

Not occurring.

VI. LULUCF

Not estimated. Emissions from this sector were not estimated as no statistical data on various types of land are available in MSAR.

VII. Waste

(i) Overview

1. Scope

For Waste, MSAR's GHG Inventory mainly covers the CH_4 and N_2O emissions from urban wastewater treatment, and CO_2, CH_4 and N_2O emissions from waste incineration.

2. Methods

Due to the lack of detailed activity data and local emission factors, Tier 1 method provided in the 2006 IPCC Guidelines and 2019 Refinement to the 2006 IPCC Guidelines was used to calculate GHG emissions from waste disposal in MSAR.

Activity data of N_2O emissions from wastewater treatment were based on the total population provided by DSEC, as well as MSAR's per capita annual protein consumption in 2020 provided by the FAO. The N_2O emission factors were based on IPCC default values; CO_2, CH_4 and N_2O emissions from waste incineration were estimated using the activity data provided by DSEC and DSPA, as well as the IPCC default values.

(ii) Trends in Inventories on Waste

In 2020, MSAR's GHG emissions from Waste were 61.8 $ktCO_2eq$, accounting for 5.8%. Of these, emissions from wastewater treatment and solid waste disposal were 57.5 $ktCO_2eq$ and 4.3 $ktCO_2eq$, accounting for 93.1% and 6.9%.

In 2021, MSAR's GHG emissions from Waste were 63.0 $ktCO_2eq$, accounting for 5.8%. Of these, emissions from wastewater treatment and solid waste disposal were 58.7 $ktCO_2eq$ and 4.3 $ktCO_2eq$, accounting for 93.2% and 6.8%.

In 2005, MSAR's GHG emissions from Waste were 39.6 $ktCO_2eq$, accounting for 2.1%. Of these, emissions from wastewater treatment and solid waste disposal were 35.9 $ktCO_2eq$ and 3.8 $ktCO_2eq$, accounting for 90.5% and 9.5%.

(iii) Uncertainty and Time-Consistency Analysis

The uncertainty of MSAR's GHG Inventory on Waste and the overall uncertainty of MSAR's GHG Inventory were estimated using a methodology consistent with that for Energy.

The overall uncertainty of the MSAR's GHG Inventory for 2020 and 2021 was about 13.9% and 14.1%, with the uncertainty on Waste being 147.5% and 147.9% (see Tables 6-8 and 6-9).

Table 6-8 Results of Uncertainty Analysis of MSAR's GHG Inventory 2020

	Emissions ($ktCO_2eq$)	**Uncertainty**
Waste	62	147.5%
Overall uncertainty	13.9%	

Table 6-9 Results of Uncertainty Analysis of MSAR's GHG Inventory 2021

	Emissions ($ktCO_2eq$)	**Uncertainty**
Waste	63	147.9%
Overall uncertainty	14.1%	

The MSAR's GHG Inventory for 2020-2021 was prepared mainly based on the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines, and the GHG Inventory for 2005 was updated using the same methods as for 2020-2021, ensuring the consistency of the methodology and the completeness of the inventory.

VIII. Issues Related to Cross-Cutting Sectors

Considering the fact that incineration is the major approach for MSW disposal in MSAR, and the heat generated in the incineration process is retrieved to generate electricity and transmitted to MSAR's power grid, the GHG emissions from incineration of fossil-derived waste (such as clothing and plastics) were counted under Energy. While CO_2 emissions from biomass combustion under Waste were not counted in the total emissions but only listed as memo items.

IX. Quality Assurance, Quality Control and Verification

The collection of various types of data, including statistical data, and emission factors was carried out in accordance with data collection priorities of the 2006 IPCC Guidelines, as detailed as follows:

First, to reduce uncertainties of the inventory, methods from the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines were adopted, ensuring scientific rigor, comparability, and consistency in inventory preparation. Based on available activity data, the higher-tier methods were used where possible. For example, Tier 2 method was used for international aviation and special regional aviation.

Second, as for activity data, to ensure data authority, official data verified by MSAR government departments were used whenever possible, including data from government departments such as DSEC, AACM, DSPA and DSAT.

Third, the activity data and emission factors used in the inventory were checked against the original data to validate the inventory results, and information related to the preparation of the inventory is kept on file.

Fourth, during the inventory preparation process, the national inventory team was invited as a third-party independent expert to review the inventory and carry out comparative analyses with data measured by other research institutions.

X. Inventory Improvement Plan

In order to improve the inventory quality and reduce uncertainty, future inventory preparation will focus in particular on strengthening QA/QC, including:

With regard to the inventory preparation methodology, on the premise of ensuring data availability and data quality, MSAR will carry out analysis of key categories, and gradually expand the key categories of MSAR's GHG Inventory, covering fugitive emissions. MSAR will adopt higher-tier methods, as well as local and national emission factors for both existing and new key categories in subsequent inventories where possible, to improve the accuracy of the inventory results, e.g., optimization of the methodology for estimating GHG emissions from the aviation sector.

With regard to activity data, MSAR will refine and increase the variety of statistics in the statistical reports of the relevant departments, and gradually incorporate the activity data required for the preparation of the MSAR's GHG Inventory into the Government's statistical system. Data research at the facility level of key enterprises will also be carried out on a regular basis in order to calibrate the inventory results.

With regard to emission factors, MSAR will strengthen communication with the national GHG inventory team, and prioritize the use of local emission factors in the subsequent inventories, followed by the use of national data, and the default values of the relevant IPCC guidelines will be adopted when they are not available.

In terms of data management, MSAR will focus on managing data documentation, preserving supporting materials for inventory preparation, and gradually improving the level of electronic management of relevant data and information. It aims to establish a GHG inventory data and information system for various sectors in MSAR, which will record the underlying data and information related to the inventory, the rationale for methodology selection, and the improvement process. In terms of seminar and exchange, MSAR will participate in relevant seminars on the inventory preparation, engage in in-depth exchanges and discussions with national research institutions and experts, fully draw on experience in national GHG inventory preparation, and gradually improve the inventory quality in line with MSAR's actual characteristics.

Chapter 2 Progress on the Determined Contributions of the Macao Special Administrative Region

I. Regional Circumstances and Institutional Arrangements

(i) Natural Conditions and Geographic Location

MSAR is located on the western side of the Pearl River Estuary in the Pearl River Delta along the southern coast of China. It borders Zhuhai City in Guangdong Province to the north, faces the eastern side of the estuary where Hong Kong is located, borders the South China Sea to the south, and is separated by water from Wan Chai and Hengqin Island in Zhuhai to the west. MSAR consists mainly of five parts: the Macao Peninsula, Taipa, Coloane, the Cotai reclamation area, and the new reclamation area in Macao. MSAR has a subtropical maritime climate, characterized by monsoon effects and mild weather.

Land resources in MSAR are extremely limited, and the region has continuously expanded its land area through land reclamation. According to the Statistics and Census Service, in 2022, the Cotai reclamation area increased by 0.1 square kilometers compared to 2020, and the New Urban Zone Area C added 0.3 square kilometers following the completion of landfilling, expanding the total land area of MSAR to 33.3 square kilometers, an increase of 1.2% compared to 2020.

MSAR has limited local water storage facilities, with over 98% of its raw drinking water supplied by Guangdong Province via Zhuhai City. In 2022, the total water consumption of MSAR was 83.25 million cubic meters, with domestic use accounting for 47.4%, industrial and commercial use 45.7%, and the remaining 6.9% for government departments and other facilities.

(ii) Population and Society

MSAR is one of the most densely populated regions in the world. In 2022, the total population of MSAR was approximately 673,000, a 1.5% decrease from 2021, with an average population density of 20,000 people per square kilometer. The labor force in MSAR was 379,000, with about 365,000 people employed. Only 0.3% of the employed population worked in the primary industry, 10.2% in the secondary industry, and 89.5% in the tertiary industry.

According to education statistics, in the 2021/2022 academic year, MSAR had 74 non-tertiary formal education schools, with about 84,800 students. There were 10 tertiary educational institutions, with approximately 44,000 students, of whom 35.8% were local and 64.2% from outside Macao.

In 2022, MSAR had 1,965 doctors, 2,863 nurses, and 1,721 hospital beds, with healthcare spending amounting to approximately MOP 13.9 billion, accounting for 12.0% of the total government expenditure (MOP 115.85 billion) and equivalent to 7.9% of the regional GDP.

(iii) Economic Development

In 2022, MSAR's Gross Domestic Product (GDP) was MOP 197.313 billion, with a per capita GDP (expenditure approach) of MOP 291,022, a 20.8% decrease from 2021. The primary industry contributed almost nothing to MSAR's GDP, while the secondary and tertiary industries accounted for 9.5% and 90.5%, respectively, with the gaming industry being the main economic pillar of MSAR. However, due to the COVID-19 pandemic, gaming accounted for only 15.2% of the GDP. Other major sectors included finance, real estate, and public administration. Visitor arrivals to MSAR continued to decline in 2022 to 5.7 million, with Chinese mainland accounting for 89.6% of the total visitors.

In 2022, MSAR's total primary energy consumption was 467 kt of standard coal, with light diesel, gasoline, natural gas, LPG, kerosene, and heavy oil accounting for 24.69%, 21.59%, 34.29%, 10.38%, 7.45%, and 1.60% of total energy consumption, respectively. By industry, road transport accounted for 32.83%, energy processing and conversion 30.44%, commercial, catering, and hotel sectors 11.46%, air transport 7.14%, industry and construction 11.68%, residential use 4.86%, water transport 0.69%, and other uses 0.88%.

In 2022, the total imported electricity in MSAR was 4.87 billion kWh (17,545 TJ), while local electricity generation was only 0.61 TWh. MSAR's electricity supply primarily comes from Guangdong Province, accounting for nearly 90% of its total supply.

The transport system in MSAR includes land, water, and air modes of transportation. In 2022, the total length of road lanes was approximately 468.9 kilometers, with about 250,000 vehicles in operation, 21,000 passenger ferry services, and 5,000 commercial flights recorded at Macao International Airport, categorized by destination and origin.

Table 6-10 provides statistical data on MSAR's basic situation in 2022.

Table 6-10 Basic Data on MSAR in 2022

Indicator	Data
Year-end population (10,000 people)	67.3
Area (sq. km)	33.3
Gross Domestic Product (expenditure approach, million MOP)	197313
Value-added share of industrial and construction sectors in GDP (production accounting approach) (%)[1)]	9.5
Value-added share of service sectors in GDP (production accounting approach) (%)	90.5
Value-added share of agriculture in GDP (production accounting approach) (%)	0
Agricultural land area (sq. km)	0

Urban population as a percentage of total population (%)	100
Cattle (head)	10
Horses (head)	502
Pigs (head)	283
Sheep (head)	0
Forest land area (sq. km)	5.21
Number of households benefiting from regular economic assistance	2898
Life expectancy at birth	Male 80.9 years, Female 86.7 years
Literacy rate (%)[2)]	97.4

Notes: 1) The industrial sector here includes manufacturing, water, electricity, and gas production and supply;
2) This data represents the literacy rate of the local population aged 15 and over, based on detailed results from MSAR's 2021 Population Census

(iv) Institutional Arrangements

The Climate Change Group, led by the Secretariat for Transport and Public Works, oversees climate change-related tasks across government departments. DSMG is responsible for coordination, greenhouse gas accounting, and carbon neutrality research. The Environmental Protection Bureau is the public agency in MSAR responsible for researching, planning, implementing, coordinating, and promoting environmental and energy policies, helping develop MSAR's environmental and energy policies. The Transport Bureau is responsible for studying, planning, promoting, and implementing MSAR's land transport policies, while the Civil Aviation Authority promotes the low-carbon development of MSAR's civil aviation sector.

II. Description of MSAR's Determined Contribution Targets

(i) Overview

To achieve the core goals of the Paris Agreement, the MSAR Government has been actively promoting climate change mitigation efforts, including further reducing carbon emissions from local power generation and increasing the share of clean electricity imports, enhancing energy efficiency in buildings, and improving public transport and urban rail systems. Additionally, the government has completed the *Research on Macao's Determined Contribution on Climate Change and Long-Term GHG Low Emission Development Strategy*, to effectively implement carbon peaking and carbon neutrality efforts in the MSAR. To align with the national autonomous emission reduction targets, the MSAR Government set carbon intensity reduction targets for 2020 and 2030. Furthermore, in the *Second Five-Year Plan for Economic and Social Development of the Macao Special Administrative Region (2021–2025)*, the government proposed to achieve carbon peaking by 2030 or earlier.

(ii) Targets and Their Implications

The carbon intensity indicator. The MSAR Government set a target to reduce carbon intensity by 40%-45% by 2020 compared to 2005. In 2021, Macao further proposed an enhanced target for climate change action: by 2030, reducing carbon intensity by 60%-65%

compared to 2005.

III. Progress on MSAR's Determined Contribution Targets

(i) Tracking Indicators

The carbon intensity tracking indicator. The carbon intensity tracking indicator measures CO_2 equivalent emissions per unit of GDP, with units of tons of CO_2 equivalent per million MOP. This indicator is influenced by factors such as MSAR's economic growth, energy consumption, and energy structure. The numerator is the carbon emission indicator, primarily based on MSAR's annual greenhouse gas inventory data, while the denominator is MSAR's year-on-year GDP. The base year for the carbon intensity indicator is 2005.

(ii) Tracking the Progress of MSAR's Determined Contribution

Overall progress. To achieve the carbon intensity reduction target, the MSAR Government has continuously implemented measures in recent years, including promoting low-carbon power generation, electric vehicles, green public transport, and adding green building requirements to public construction projects. Furthermore, the government has encouraged emissions reduction in the hotel industry through the Macao Green Hotel Award. As of 2020, carbon intensity was reduced by 41.6% compared to 2005, meeting the target of a 40%-45% reduction.

Tracking progress on carbon intensity. After reaching the 2020 target, MSAR's carbon intensity further decreased in 2021, down 52.5% from 2005. However, due to the impact of the COVID-19 pandemic, MSAR's GDP fell sharply in 2022, leading to a temporary increase in carbon intensity. In 2022, carbon intensity rose compared to 2021 but remained 35.2% lower than in 2005. As MSAR's economy gradually recovers, the 2023 GDP is expected to rebound, with carbon intensity projected to be 40%-50% lower than in 2005.

(iii) Challenges in Tracking Progress on Indicators

Nearly 90% of MSAR's electricity consumption comes from the China Southern Power Grid, making the power supply highly dependent on imports and causing fluctuations that pose challenges for measuring and tracking local actual carbon emissions. For example, GHG emissions rose in 2022 compared to 2021, mainly due to a 40% increase in local power generation.

MSAR's pillar industries are highly susceptible to external influences, and the carbon emission fluctuations caused by economic changes make real-time tracking challenging. Between 2020 and 2022, the COVID-19 pandemic led to slower economic growth in Macao, with GHG emissions showing year-to-year fluctuations, complicating the tracking and comparison of emissions data. For example, the number of flights at Macao International Airport dropped significantly between 2020-2022. Comparing to 2018, there was a decrease in the number of flights in 2022. Even though there were less flights but the airport still required basic energy use (especially electricity) for daily operations, leading to a higher per-flight carbon emission in 2021 and 2022 compared to 2018.

IV. Mitigation Policies, Actions and Effects

(i) Mitigation Policies and Actions

1. Accelerating the Optimization and Adjustment of Energy Structure

In terms of electricity supply, Macao has continued to increase the purchase of power from the Southern Power Grid, with a requirement in contracts that over 40% of the power comes from non-fossil fuel sources. Additionally, MSAR has increased the share of natural gas and reduced fuel oil in its power generation mix, with the share of natural gas in power generation rising from 57.1% in 2020 to 93.3% in 2022. The Macao government continues to improve the natural gas pipeline network to encourage broader use of natural gas. The pipeline network currently covers the main areas of Cotai and is expanding on the Macao Peninsula to promote natural gas use in projects such as large hotels, tourist facilities, and public housing.

To promote local renewable energy development, the MSAR Government has established *Regulation for Safety and Installation of Solar Energy PV Interconnections* and related feed-in tariffs to encourage photovoltaic (PV) system installations. As of the end of 2022, seven departments or organizations had installed PV systems and are connected to the grid for electricity sales. Simultaneously, the government is installing PV systems in social housing[73], government departments, and municipal facilities, and promoting smart grid development to optimize MSAR's energy supply structure.

2. Comprehensive Promotion of Low-Carbon Industrial Transformation

MSAR's industrial sector is small; to encourage low-carbon transformation, the government promotes the use of natural gas and electrification of equipment in industry. Additionally, to reduce air pollution emissions in commercial and industrial sites, the Macao government has, since 2014, implemented emission standards and regulatory measures for air pollutants in key commercial and industrial locations according to the *Macao Major Fixed Air Pollution Source Emission Standards and Regulatory System*.

3. Advancing Green, Low-Carbon Development in the Building Sector

Over 90% of MSAR's electricity consumption occurs within buildings, and promoting energy efficiency in buildings can effectively reduce end-use energy demand and achieve emissions reduction. Starting with public projects, the MSAR Government has added green building elements to new buildings and has included green building requirements in construction project tender documents to improve energy efficiency in buildings. The government has also continued to promote energy efficiency assessment plans for public departments and institutions, encouraging energy savings and emissions reductions in buildings.

In 2022, the MSAR Government released the *Macao Green Building Guidelines - Public Housing* and *Macao Green Building Guidelines - Public Buildings* to provide references for public sector and industry projects in design, construction, and operation. The *Second Five-Year Plan for Economic and Social Development of the Macao Special Administrative Region*

[73] Social housing refers to public housing built by the MSAR Government or developers, providing affordable rental options for low-income or specially disadvantaged families.

(2021–2025) requires that at least 30% of open roof areas in new public housing projects be allocated to PV power generation systems or vegetation coverage, gradually increasing the use of renewable energy in MSAR. The government has continued to hold the Macao Green Hotel Award to encourage environmental management in the hotel industry, recognizing hotels that have adopted environmental management practices to encourage emissions reduction and waste reduction. Additionally, in recent years, the MSAR Government has installed PV systems at selected locations, such as the car park at Taipa Ferry Terminal Station and the Macao Grand Prix Museum. A PV system has also been installed at the cross-border industrial area sewage treatment plant, which was completed and put into operation in early 2024.

4. Establishing a Low-Carbon Transportation System

The MSAR Government encourages green travel, including optimizing pedestrian systems and improving public and urban rail transit, to guide the public toward using public transportation and walking, thereby reducing carbon emissions from private vehicle use.

To lower the overall carbon emissions from vehicles, the MSAR Government leads by example in using electric vehicles and continues to promote new energy vehicles through various measures. Specific initiatives include providing tax incentives, implementing the *Plan to grant financial support for the scrapping of obsolete motorbikes and their replacement with new electric motorbikes*, and requiring charging capacity and infrastructure in all parking spaces in new public parking lots and buildings. They also promote increased charging facilities in older public parking lots. By the end of 2022, 2,146 public light vehicle charging stations and 500 electric motorcycle charging points were installed. Additional incentives encourage hotels and entertainment businesses to use new energy vehicles as shuttle buses and promote the application of new energy buses.

The MSAR Government will continue building a green transportation network, emphasizing a “public transportation priority” orientation to improve bus and pedestrian systems and promote the light rail system to encourage green travel and reduce the use of private vehicles. To accelerate the electrification of vehicles in the MSAR, the Environmental Protection Bureau developed the *Macao Electric Vehicle Promotion Plan*, proposing various measures from promoting the replacement of vehicles with electric alternatives to improving charging facilities and infrastructure, aiming for 100% of new registered light vehicles and motorcycles to be zero-emission vehicles (electric or other technology) by 2035.

In terms of air transportation, the MSAR Government is committed to reducing carbon emissions per flight at the airport, aiming for a 30% reduction per takeoff and landing by 2028 compared to 2018. They also aim to improve airport energy efficiency, replace lighting systems and environmentally friendly vehicles, implement energy management in airport buildings, and enhance waste management and recycling to reduce carbon emissions.

5. Strengthening and Enhancing Ecosystem Carbon Sinks

Despite limited land area, the MSAR Government prioritizes ecological restoration and biodiversity maintenance. From 2020 to 2022, more than 6,000 trees were planted in parks, recreational areas, and roadside green belts (Table 6-11). Additionally, the Municipal Affairs Bureau completed the third phase of forest restoration, covering 15 hectares in the Hac Sa Reservoir Country Park and the Taipa Grande Natural Park in 2022, planting approximately 15,000 saplings and implementing a 1-hectare forest reconstruction and planting approximately 1,000 saplings in Taipa. They also planted around 4,000 mangrove seedlings along the western coastal recreation area in Taipa, contributing to the protection of natural carbon sinks to address climate change.

Table 6-11 Statistics of Green Spaces and Trees in MSAR

	2021	2022	Annual Change Rate
Area of Green Spaces Managed by Municipal Affairs Bureau (square meters)	7,785,623	7,815,790	+0.4%
Per Capita Area of Green Spaces Managed by Municipal Affairs Bureau[74] (square meters/person)	11.4	11.5	+0.9%

6. Strengthening Non-CO_2 Greenhouse Gas Emission Control

Sewage treatment is the main source of N_2O emissions in the MSAR. The MSAR Government closely monitors the operation of all sewage treatment plants within its jurisdiction, continuously checking operational data and inspecting the facilities. The MSAR Government aligns with China's 14th Five-Year Plan for Urban Sewage Treatment and Resource Utilization Development, completing the addition of chemical-assisted primary treatment facilities at the Macao Peninsula Sewage Treatment Plant in 2021 and initiating the bidding process in 2023 for the upgrade of the Coloane Waste Water Treatment Plant to improve overall effluent quality. For sludge treatment, techniques like sludge concentration tanks, sludge storage tanks, and centrifugal sludge dewatering machines are primarily used. The dewatered sludge generated in the sewage treatment process is sent to the Macao Waste Incineration Center for incineration.

On September 15, 2021, the *Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (Kigali Amendment)* (hereinafter referred to as the Amendment) officially took effect in China. To fulfill the requirements of the Kigali Amendment, the Chinese government issued the *List of Controlled Ozone Depleting Substances in China* and the *List of Controlled Imports and Exports of Ozone Depleting Substances in China* (hereinafter referred to as the List), incorporating hydrofluorocarbons (HFCs) under control and implementing an import and export license management system for HFCs listed in the List. To support the implementation of the Amendment, the Economic and Technological Development Bureau (DSEDT) and the Environmental Protection Bureau jointly held an Amendment briefing for the refrigeration and firefighting industries in the MSAR, explaining the government's compliance work and regulatory measures. Since April 1, 2022, 18 common HFCs have been regulated, with a phased reduction in the total annual import of

[74] Refers to green space managed by the Municipal Affairs Bureau, not including green spaces managed by other public departments or privately owned green spaces, so it does not represent all green spaces in MSAR. The per capita green space managed by the Municipal Affairs Bureau is calculated using the year-end population based on the Bureau's calculation method.

HFCs.

7. Promoting Synergies in Reducing Pollution and Cutting Carbon Emissions

The MSAR Government issued the *Macao Environmental Protection Plan (2021–2025)* with the main themes of “Jointly Addressing Climate Change and Building a Green and Low-Carbon Macao” and “Strengthening Pollution Control to Build a Livable and Tourist-Friendly City,” formulating multiple action plans with a focus on promoting new energy vehicle use and gradually increasing the proportion of clean energy to enhance synergy in pollution reduction and carbon reduction.

For air pollution control, the MSAR Government has implemented a series of measures to improve emissions from motor vehicles and air pollution emissions from commercial and industrial establishments. Measures include continuously optimizing exhaust emission standards for imported new and in-use vehicles. Currently, emission standards for imported new automobiles have been raised to the equivalent of the EU’s Stage 6 level, and standards for imported new motorcycles have been raised to the equivalent of the EU’s Stage 4 level. The MSAR Government also launched the *Plan to grant financial support for the scrapping of obsolete motorbikes and their replacement with new electric motorbikes* in 2022 and the *Plan to grant financial support for the scrapping of old diesel-powered vehicles* in 2023, encouraging vehicle owners to accelerate the replacement of higher-pollution old diesel or motorcycle vehicles to meet “dual carbon” goals. Since 2014, the MSAR Government has implemented emission standards and regulatory measures for air pollutants in key commercial and industrial locations according to the *Macao Major Fixed Air Pollution Source Emission Standards and Regulatory System*.

In terms of solid waste management, the MSAR Government, through the *Macao Solid Waste Resources Management Programme (2017–2026)*, has developed a ten-year plan for solid waste management in MSAR. They continue to promote waste reduction and recycling at the source, reducing carbon emissions from waste disposal, expanding food waste reduction, and recycling. They are also expediting the construction of an organic resource recycling center for more environmentally friendly food waste disposal, which will also generate energy from waste. The first phase of the center, with a daily processing capacity of 150 tons of food waste, is expected to be operational by 2027, generating approximately 136,000 kWh of energy for internal and external use.

8. Promoting the Establishment of Systems and Mechanisms for Controlling GHG Emissions

To control GHG emissions, the MSAR Government released the *Second Five-Year Plan for Economic and Social Development of the Macao Special Administrative Region (2021–2025)* in 2021, proposing to seriously implement carbon peak and carbon neutrality efforts. The goal is to reduce the greenhouse gas emission intensity per unit of regional GDP by 55% from 2005 levels by 2025 and to strive to achieve carbon peaking by or before 2030.

9. Other Related Progress

Technological Innovation and Regional Cooperation. The MSAR Government remains focused on new technologies related to mitigating climate change, including carbon capture and storage (CCS) technology and hydrogen energy technology. In 2021-2022, the Macao Science and Technology Development Fund (FDCT) approved 12 projects in the fields of environmental and energy science and technology, with funding exceeding MOP 15 million. Additionally, the FDCT, together with the National Natural Science Foundation of China, jointly funded the research project *Researches on metabolic mechanism of multisource solid waste and its optimization pathway of pollution and carbon reduction in Guangdong-Hong Kong-Macao Greater Bay Area*, working together to advance emission reduction technologies in the Greater Bay Area.

Promoting Low-Carbon Lifestyles Among the Public. For businesses and institutions, the MSAR Government promotes participation in energy-saving and emission reduction initiatives through various programs, such as the Macao Green Hotel Award, the Green School Partner Program, the Green Supermarket Commendation Program, and the Energy Efficiency Assessment Program for public departments and institutions. At the same time, the government encourages large enterprises to fulfill their social responsibilities by conducting carbon audits, formulating their own carbon neutrality plans, and disclosing low-carbon information to the public to promote a culture of carbon reduction among businesses and institutions. For individuals, the MSAR Government continues to strengthen environmental awareness and education, and has been formulating more incentive measures. These include integrating more low-carbon messages in various activities, enhancing the understanding of teachers and students about climate change and extreme weather, and promoting awareness through media and social platforms to guide citizens in fulfilling their obligations to save energy and reduce emissions.

(ii) Quantitative Assessment of Mitigation Policies and Actions

To better formulate greenhouse gas emission reduction targets and effective policies suited to the realities of the MSAR, the MSAR Government conducted the *Research on Macao's Determined Contribution on Climate Change and Long-Term GHG Low Emission Development Strategy*. Using evaluation model tools and considering China's autonomous emission reduction targets, this research simulated the emission reduction potential across various sectors in Macao, including electricity, transportation, construction, and tourism. The findings provide scientific evidence for the MSAR Government's planning and design of systems and mechanisms for greenhouse gas emission control, as well as for drafting the *Long-term Decarbonisation Strategy of Macao*.

Over the years, the MSAR Government has actively promoted the concepts of environmental protection, energy conservation, and green living. By increasing the proportion of imported electricity and implementing a series of emission reduction policies and measures, initial results have been achieved. The research report *MSAR Energy Efficiency Status 2021* shows that, due to the impact of the COVID-19 pandemic, overall energy consumption in MSAR decreased across some industries in 2021, although some sectors showed an increase compared to 2019. In terms of energy consumption, per capita annual energy consumption per square meter increased by 22.8% compared to 2019, in line with the increase in time spent at home during the pandemic (with 75.6% of respondents reporting more time spent at home). The energy consumption of non-governmental office units decreased by 2.1%, while schools' energy consumption decreased by 8.3%.

Details of quantified emission reduction measures and effects can be found in Table 6-12.

Table 6-12 Summary of Mitigation Actions and Their Effects

No.	Action	Objectives or Main Elements	Sectors and Gases Involved	Timescale	Nature	Regulatory Authorities	Status	Progress	Methodology and Assumptions/Base Year	Estimated Emission Reductions	Support Received
1	Increase the share of natural gas power generation	Natural gas power generation was introduced in 2008, with its share gradually increasing	Energy /CO_2	2008 to present	Government	DSPA	Under progress	Local power generation primarily relies on natural gas, while heavy oil units are maintained only for emergency backup purposes and undergo regular testing or dispatching.	Emission Reduction = Natural Gas Power Generation x (Heavy Oil Emission Factor – Natural Gas Emission Factor) Base Year: 2008	Total Emission Reductions from 2008 to 2022: 370 kt of CO_2	MSAR Government
2	Reduce carbon emissions per aircraft taking-off/ landing	Carbon emissions per aircraft landing and takeoff will be reduced by 30% in 2028 compared to 2018 Improving energy efficiency, replacing lighting systems and utilizing eco-friendly vehicles, implementing energy control in airport buildings, and enhancing waste management and recycling to reduce carbon emissions	Energy, Waste/ CO_2, CH_4, N_2O	2018 to present	Voluntary	AACM	Under progress	Carbon emissions per aircraft landing and takeoff decreased in 2019, but due to the significant reduction in aircraft landing and takeoff at Macau International Airport between 2020 and 2022, carbon emissions per aircraft landing and takeoff increased during 2020-2022	Carbon emission reductions per aircraft landing and takeoff = Carbon emissions per aircraft landing and takeoff in the current year - Carbon emissions per aircraft landing and takeoff in the base yearBase Year: 2018 Emission Boundary: Calculated based on direct and indirect emissions according to the requirements of Level 2 certification in the Airport Carbon Accreditation Program	Airport carbon emissions in 2022 decreased by 6.6% compared to 2018	Macau International Airport Co. Ltd.
3	Promoted the use of environme	Providing tax incentives for new vehicles that meet	Energy /CO_2	2012 to present	Government /Volu	DSPA	Under progress	Providing tax incentives for new vehicles that meet environmental emission	Emission Reductions = Fuel Savings x Gasoline Emission Factor	Total Emission Reduction from 2012 to 2022:	MSAR Government

No.	Action	Objectives or Main Elements	Sectors and Gases Involved	Timescale	Nature	Regulatory Authorities	Status	Progress	Methodology and Assumptions/Base Year	Estimated Emission Reductions	Support Received
	nt -friendly vehicle	environmental emission standards The main objective is to encourage citizens to use eco-friendly vehicles to reduce CO2 and exhaust pollutant emissions			ntary			standards in accordance with relevant laws	Base Year: 2012	130 kt of CO_2	
4	Urban gas distributio n network supply	Promoting Clean Energy Usage Through Urban Gas Introduction	Energy /CO_2	2013 to present	Gover nment	DSPA	Under progre ss	Further improving the natural gas pipeline network. In 2022, the undersea gas pipeline connecting Taipa and the Macao Peninsula was completed, extending the gas supply network to the southern part of the Macao Peninsula	Emission Reductions = Gas Consumption × Unit Calorific Value × (Petroleum Gas Emission Factor - Natural Gas Emission Factor) Base Year: 2013	Total emission reductions from 2013 to 2022: 33 kt CO_2	MSAR Governm ent
5	Energy efficient and energy saving plan for public sectors and institution s	Public sector/institutions manage daily energy consumption through self-developed energy-saving plans	Energy /CO_2	2007 to present	Gover nment /Volu ntary	DSPA	Under progre ss	As of 2022, a total of 46 departments participated, with approximately 80% of departments meeting the standards	Emission Reductions = Electricity Savings x Power Generation Emission Factor Base Year: 2007	Total Emission Reductions from 2008 to 2022: 17 kt CO_2	MSAR Governm ent
6	LED public	Replacing and installing LED street	Energy /CO_2	2010 to present	Gover nment	DSPA	Under progre	Completed the replacement of approximately 14,000	Emission reductions = Power savings × Power	Total emission reductions from	MSAR Governm

No.	Action	Objectives or Main Elements	Sectors and Gases Involved	Timescale	Nature	Regulatory Authorities	Status	Progress	Methodology and Assumptions/Base Year	Estimated Emission Reductions	Support Received
	outdoor lighting applications	lights					ss	high-pressure sodium street lights across Macao with LED lights, and new street lights are also LED lights	generation emission factor Base Year: 2010	2010 to 2022: 5 kt CO_2	ent
7	LED public local lighting applications	Replacing LED lighting fixtures for pedestrian overpass, parks and public toilets	Energy /CO_2	2015 to present	Government	IAM	Under progress	/	Emission reductions = Power savings × Power generation emission factor Base Year: 2015	Total emission reductions from 2015 to 2022: 10 kt CO_2	MSAR Government
8	Applications of solar PV technology	Application of solar PV technology in social housing and government departments	Energy /CO_2	2010 to present	Government	DSPA	Under progress	Solar PV systems will be installed in public housing and public building projects launched in Zone A of Macao New Urban Area In addition to setting an example, the government will also promote the use of green energy by facilitating inter-departmental cooperation, simplifying application and approval processes to encourage individuals and businesses to maximize their use of green energy.	Emission Reductions = Electricity Savings x Power Generation Emission Factor Base Year: 2010	Total emission reductions from 2010 to 2022: 596 tCO_2	MSAR Government

Chapter 3 Climate Change Impacts and Adaptation in the MSAR

I. Regional Circumstances and Institutional Arrangements

(i) Overview of MSAR's Situation Related to Climate Change Adaptation

The MSAR has a subtropical marine climate with prominent monsoons, resulting in mild weather. Climate data from 1991 to 2020 indicates that the annual average temperature in the MSAR was 22.8°C. January is the coldest month, with the monthly average temperature of approximately 15.2°C, while July is the hottest month, with the monthly average temperature of approximately 28.4°C. The annual average precipitation is about 1,966.6 mm, with significant seasonal variations. The rainy season from April to September accounts for over 84% of the total annual precipitation, with extreme heavy rainfall events during this period, where daily precipitation can exceed 300 mm.

The MSAR is considered a climate-vulnerable region, with frequent extreme weather and climate events such as tropical cyclones and associated storm surges, heavy rain, thunderstorms, and strong monsoons. Macao is affected by approximately 5-6 tropical cyclones per year, with 1-2 of them bringing winds of force 8 or above to the area. The high population density in the low-lying areas of MSAR further exacerbates the impacts of these climate events.

(ii) Institutional Arrangements Related to Climate Change Adaptation

The MSAR Government has long prioritized climate change adaptation, making it one of the key areas of focus for the Climate Change Group. The DSMG is responsible for climate change assessment and research, providing meteorological technical support to public departments and entities dealing with climate change. Other departments conduct work based on their respective functions to address the ecological, environmental, and socio-economic impacts of climate change. These responsibilities include: The Environmental Protection Bureau, which formulates policies and plans related to the ecological environment; the Civil Aviation Authority, which handles civil aviation infrastructure; the Housing Bureau (IH), which studies regulations and technical standards for public housing buildings; the Transport Bureau, which manages adaptation engineering for transport infrastructure and projects; the Marine and Water Bureau (DSAMA), which is responsible for docks and water resources; the Municipal Affairs Bureau, which oversees municipal public facilities and road drainage; the Macao Government Tourism Office (DST), which addresses tourism safety; the Education and Youth Development Bureau (DSEDJ), which is responsible for education related to climate change impacts and adaptation; the Economic and Technological Development Bureau (DSEDT), which researches economic policies; the Health Bureau (SS), which handles health-related matters.

II. Climate Change Impacts, Vulnerability Assessment, and Loss and Damage Status

The MSAR Government has organized relevant departments and research institutions to monitor and assess the impacts of climate change on water resources and terrestrial ecosystems to prepare for climate change mitigation and adaptation policies. In addition, historical climate observation data from the MSAR, along with global climate model simulation data, have been used to assess and predict climate change in the region.

(i) Characteristics and Trends of Climate Change

According to an analysis of daily average temperature and precipitation data from 1901 to 2022, the characteristics of climate change in the MSAR are as follows:

The temperature trends over the past 122 years in MSAR align closely with the global average temperature changes. The 100-year linear warming trend is 0.92°C, with an accelerated warming rate since the 1970s. Nine of the eleven warmest years in the past 122 years occurred in the 21st century. Temperatures have increased across all seasons, with the most significant rise in spring (approximately 0.108°C/decade), followed by winter (around 0.101°C/decade) and autumn (about 0.099°C/decade), with summer seeing the smallest increase (about 0.060°C/decade). There is a significant upward trend in both the daily maximum temperature and the daily minimum temperature, with notable inter-decadal changes in daily maximum temperature. Although the number of hot days (with daily maximum temperature over 33°C) has shown significant decadal variability, no substantial increase in hot days has been observed. However, cold nights (with daily minimum temperature of 12°C or below) and hot nights (with daily minimum temperature of 27°C or above) have shown a significant and sustained trend, with cold nights decreasing by approximately 1.5 days per decade and hot nights increasing by about 2.0 days per decade. The frequency of heavy rain (more than 50 mm per day) and torrential rain (more than 100 mm per day) has also increased, with 100-year linear trends of 3.6 days and 1.5 days, respectively.

Precipitation in the MSAR shows significant inter-decadal variations, with an overall increasing trend in the 20th century, with an average increase of approximately 38.1 mm per decade. The increase is most notable in summer, with less noticeable changes in other seasons. Based on the Expert Team on Climate Change Detection and Indices (ETCCDI) definitions, the DSMG calculated various climate change indices (see Table 6-13), which reflect an overall warming trend along with significant increases in precipitation intensity and the maximum consecutive 5-day precipitation.

Table 6-13 Climate Change Indices in MSAR (Based on Data from 1901 to 2022)

Index	Concept	Decadal Change
ID12	Cold Days	-0.149 days
CD12	Cold Nights	-1.52 nights
SU33	Hot Days	0.33 days
TR27	Hot Nights	2.01 nights
TXx	Annual Maximum Temperature	0.065℃
TNx	Annual maximum value of daily minimum temperature	0.053℃
TXn	Annual minimum value of daily maximum temperature	0.068℃
TNn	Annual Minimum Temperature	0.092℃
SDII	Daily simple precipitation intensity index	0.42 mm/day
Rx5day	Maximum Consecutive 5-Day Precipitation	8.57 mm

Based on Macao's historical climate data and simulation results of different GHG emission scenarios and climate models from the IPCC AR6, future climate change in Macao was assessed. The main conclusions are as follows: First, the average temperature in Macao will continue to show an upward trend. Under all scenarios, by the middle of this century (2041-2060), temperatures will rise by 1.18°C to 1.72°C compared to the average from 1995-2014; by the end of the 21st century (2081-2100), temperatures will increase by 1.28°C to 3.69°C (Table 6-14); seasonal temperatures will also show an upward trend by the end of this century (Table 6-15). Second, precipitation intensity in Macao is expected to increase by the middle and end of the 21st century, with the highest precipitation intensity during summer reaching up to 28.22% (Table 6-16).

Table 6-14 Multi-Model Assessment of Future Temperature Changes in MSAR (Relative to 1995–2014)

Temperature (°C)		
Greenhouse Gas Emission Scenarios	2041–2060	2081–2100
SSP1-2.6	1.18	1.28
SSP2-4.5	1.31	2.10
SSP3-7.0	1.26	2.80
SSP5-8.5	1.72	3.69

Table 6-15 Seasonal Temperature Changes in MSAR (Relative to 1995–2014)

Temperature (°C) (2081–2100)				
Greenhouse Gas Emission Scenarios	Spring	Summer	Autumn	Winter
SSP1-2.6	1.37	0.99	1.19	1.56
SSP2-4.5	2.19	1.82	2.12	2.27
SSP3-7.0	2.79	2.62	2.94	2.87
SSP5-8.5	3.66	3.37	3.85	3.89

Table 6-16 Seasonal Precipitation Intensity Changes in MSAR (Relative to 1995–2014)

Precipitation Intensity (%) (2081–2100)				
Greenhouse Gas Emission Scenarios	Spring	Summer	Autumn	Winter
SSP1-2.6	9.38	8.05	6.21	8.52
SSP2-4.5	2.78	16.14	12.04	11.32
SSP3-7.0	1.12	18.06	16.03	5.41
SSP5-8.5	8.23	28.22	21.09	5.24

(ii) Extreme Weather and Climate Events and Resulting Losses and Damages

In the New *Rainstorm Warning Signal System* effective from September 1, 2020, rainstorms are categorized into three levels - yellow, red, and black - based on different rainfall amounts. From September 1, 2020, to 2022, MSAR experienced three black-level and thirteen red-level rainstorm warnings. From 2020 to 2022, the MSAR Government activated its civil protection structure eight times in response to tropical cyclones and natural disasters. During Typhoon Higos in 2020, wind speeds exceeded force 8 in most areas of MSAR, with force 12 winds recorded on the cross-sea bridge. The highest 10-minute average wind speed reached 138.6 km/h, with peak gusts at 215.6 km/h, second only to the wind speeds recorded during Typhoon Hato in 2017.

During Typhoon Higos, 15 people were injured, with three suffering moderate injuries and the rest sustaining minor injuries. The Civil Protection Center received 99 inquiries, mainly related to customs and transportation issues, and recorded 274 incident reports. Additionally, three light rail stations (Pai Kok Station, Lotus Checkpoint Station, and West Cotai Station) suffered damage due to the storm. The Municipal Affairs Bureau conducted post-disaster cleanup and restoration and managed damaged trees.

(iii) Impacts of Climate Change on Natural Ecosystems and Vulnerability Assessment

1. Water resources

Over 98% of MSAR's water supply originates from the Xijiang River, a tributary of the Pearl River. The future state of water resources primarily depends on rainfall variations in the Pearl River Basin, upstream water usage, and changes in sea level in the South China Sea. According to national analysis, the southern rivers have shown little change in runoff over the past 30 years, while MSAR's rapid economic development has caused a sharp increase in water demand. By the end of the 21st century (2081–2100), the sea level around MSAR is expected to rise by 0.59 to 0.76 meters compared to the 1995–2014 average. Saltwater intrusion during low-water periods in the Pearl River estuary is anticipated, necessitating increased measures for water security.

2. Terrestrial ecosystems

In recent decades, tropical vines in MSAR's mountain forests have grown rapidly, covering large areas and gradually weakening or even killing trees due to lack of photosynthesis. Saplings under these canopies struggle to grow due to insufficient sunlight, preventing natural forest renewal. Invasive plant species have also disrupted forest structure and the growth of other plants. Additionally, forest pest issues have increased, with preliminary assessments suggesting that rising CO_2 levels and temperatures may be contributing factors. Disentangling the effects of climate change from urbanization remains challenging. Several super typhoons in recent years have also severely damaged MSAR's forests.

3. Oceans and coastal zones

As a coastal city, MSAR has its most vulnerable area along the west coast of the Macao Peninsula, where the low-lying terrain is highly susceptible to sea-level rise. When strong tropical cyclones approach or make landfall near the Pearl River estuary, storm surges can cause serious backflow and widespread flooding, especially if they coincide with astronomical tides. According to tide gauge data from 1925–2022, the average sea level in MSAR has been rising by approximately 1.6 mm per year, accelerating to about 1.9 mm per year in the past 20 years. From the 1970s to the present, MSAR has experienced 16 significant storm surge events, 11 of which occurred after 2000 and 6 after 2015.

In the future, both the extent and frequency of backflow flooding due to astronomical tides are expected to worsen, with an increased probability of severe storm surge impacts. Climate change will also significantly reduce areas suitable for mangroves, affecting mangrove growth in the region.

(iv) Impacts of Climate Change on Socioeconomic Systems and Vulnerability Assessment

1. Agriculture and food security

Not involved.

2. Health and public health

Climate disasters may make waste cleanup challenging, damage the living environment, and significantly increase the risk of infectious disease outbreaks in MSAR, especially digestive tract and mosquito-borne diseases.

3. Infrastructure and major projects

Typhoons and coastal flooding can cause severe flooding in low-lying areas, impacting infrastructure and major projects in these regions. During Typhoon Hato, flooding levels in Inner Harbor were between 1–2 meters, while the central area of Coloane reached nearly 1 meter. The cargo terminal in Inner Harbor and nearby businesses were completely flooded, damaging all goods. Flooding can also disrupt basic infrastructure like electricity, water, and communication, impacting residents' lives and making disaster response and recovery more challenging.

4. Urban and living environment

Meteorological disasters like typhoons can damage municipal facilities, cause tree collapse, and disrupt transportation, affecting daily life. During Typhoon Hato, about 9,000 trees in MSAR were toppled, and municipal facilities like parks, recreational areas, libraries, and exhibition venues suffered severe damage. Around 80 flights were canceled, 30 flights were delayed, and 440 passengers were stranded at the airport.

5. Sensitive secondary and tertiary industries

Tourism, a pillar industry in MSAR, is highly sensitive to climate change. Typhoons and coastal flooding can directly halt tourism and indirectly cause industry losses. During Typhoon Hato, power outages and varying degrees of flooding impacted many parts of MSAR, affecting large tour groups and closing some hotels and gaming venues, causing significant economic losses.

As a city with numerous cultural heritage sites, MSAR's traditional buildings are also vulnerable to climate and related secondary disasters, with some buildings exhibiting salt damage, condensation, and biological growth. Indoor environmental conditions in some actively used buildings will be increasingly challenging to maintain.

III. Actions and Challenges in Adapting to Climate Change

(i) Progress and Effects of Strategies, Policies, Goals and Actions for Adapting to Climate Change

1. Strengthening Climate Change Monitoring and Early Warning Capabilities

The MSAR government has been actively exploring technology for climate change monitoring and early warnings. MSAR has an extensive atmospheric and marine observation network, which includes 17 automatic weather stations, 1 climate observation station, 2 atmospheric radiation monitoring stations, 6 air quality monitoring stations, and 2 tide monitoring stations. Due to issues of storm surges and astronomical tide backflows, MSAR increased the number of automatic water level monitoring stations in low-lying western coastal areas to 20 in 2020, allowing for monitoring of coastal water levels and flooding conditions. The DSMG has optimized its flood warning services, focusing on rainfall, astronomical tides, and storm surges, and introduced AI to enhance early warning capabilities.

2. Enhancing the assessment of climate change impacts and risks

The bureau is developing capabilities according to the *Meteorological Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area (2020 – 2035)*, According to the planning requirements, by 2025 MSAR will establish a modern meteorological service system, cooperative framework, technological innovation system, and comprehensive disaster prevention and mitigation system in partnership with the Greater Bay Area (GBA). By 2035, this collaborative framework will develop into a world-leading modern system for meteorological services, innovation, and management across the GBA. The establishment of the relevant system will help Macao to better cope with the frequent extreme weather events in the future and reduce its impact.

3. Strengthening Adaptation Actions for SAR to Climate Change

MSAR has strengthened its emphasis on climate adaptation in high-level planning documents. The *Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area* released in 2019 emphasized proactive adaptation to climate change and outlined specific measures for water security, disaster prevention, and ecosystem protection. The *Macao's Urban Development Master Plan (2020-2040)* released in 2022aims to strengthen MSAR's resilience to increasingly complex and variable environmental challenges, such as climate and economic changes. It emphasizes the need to improve the city's shelter and rescue systems to enhance disaster prevention, mitigation, and response capabilities in extreme climate events.

4. Enhancing the climate resilience of natural ecosystems

In water resource security, the *Specialized Plans on Ensuring the Safety of the Water Supply to Macao and Zhuhai*, approved by the State Council in 2008, has led to cooperation between MSAR and Zhuhai, resulting in projects like the Zhuyin Reservoir, Zhuzhoutou Pump Station, and the Pinggang-Guangchang raw water supply security project. These facilities have significantly stabilized Zhuhai's water supply to MSAR and improved resilience. The MSAR-Zhuhai Water Resource Security Project is also planning additional infrastructure, including phase two of Zhuyin Reservoir, Qianwu Reservoir expansion, and the new Bainikeng Reservoir, designed to withstand a 100-year flood, with a total capacity increase of 101 million cubic meters.

In ecosystem protection, the *Macao Environmental Protection Plan (2021–2025)* focuses on ecological restoration, urban greening, marine protection, and coastal area management. In 2018, the Municipal Affairs Bureau began mountain forest restoration after typhoon damage, targeting a restoration area of at least 120 hectares by 2024. The third phase in 2022 included 15 hectares at Hac Sa Reservoir Natural Park and Taipa Grande Natural Park, where 15,000 seedlings were planted. Regular monitoring and protection of mangroves have improved the growth environment of mangroves along the coastal beaches , ensuring the species diversity of the beach ecosystem. Between 2020 and 2022, forest restructuring covered four hectares, with 4,000 seedlings planted, over 12,000 mangrove seedlings added, and 6,000 city trees planted. Monitoring of extreme events' effects on ecosystems is to be strengthened. Before a severe typhoon, trees are rapidly inspected, and after Typhoon Higos in 2020, post-storm assessments were conducted to gauge wild plants' damage levels. Tree species that are drought-, wind-, or flood-resistant are prioritized for planting, and support structures are installed and regularly adjusted for trees in coastal or high-wind locations.

5. Strengthening the climate resilience of economic and social systems

The MSAR Government has improved the urban drainage system through upgrades, expansions, and new construction projects, effectively mitigating waterlogging issues. The Inner Harbor North Pump Station and box culvert were completed in 2021. From 2020 to 2023, the government implemented the optimisation plan of the drainage network in San Kio district for flood relief in stages and continues to plan similar projects in other regions. Mechanisms for flood pump station staffing and coordination during extreme weather have been established to ensure pump stations function effectively. Greenbelts are being created along public streets and walkways to assist with water drainage and storage.

Considering that the post-disaster environment is conducive to the occurrence and spread of infectious diseases, the Macau Health Bureau has prepared contingency plans for the monitoring and prevention of food- and waterborne diseases after natural disasters, as well as a response plan for dengue fever outbreaks, which are regularly reviewed and updated.In the *Requirements of Basic Academic Attainments of Local Education System*, students are required to understand the impacts of climate change and disaster responses. Since 2019, the MSAR government has offered a Financial Support Plan for Subscription of Property Insurance against Major Disasters for Small and Medium-sized Enterprises to provide coverage for commercial property losses caused by severe weather.

6. Strengthening Disaster Reduction and Post-Disaster Recovery Efforts

In 2019, the MSAR Government announced the *10-Year Plan for Disaster Prevention and Mitigation of the Macao Special Administrative Region (2019-2028)*, which assessed the primary risks and challenges MSAR faces in areas such as natural disasters, accidents, public health events, and social security incidents. This plan identified priority areas for future emergency response capacity building in MSAR, setting 9 key objectives and 37 indicators to reflect improvements in disaster prevention, mitigation, and emergency response capabilities over the next decade. Key priorities include enhancing infrastructure resilience, improving emergency management systems, strengthening risk management and early warning capabilities, and improving social coordination in emergency response. These measures aim to address potential exacerbations in extreme weather and water resource shortages due to climate change, and to strengthen MSAR’s overall climate resilience.

The *Second Five-Year Plan for Economic and Social Development of the Macao Special Administrative Region (2021–2025)*, released in 2021, highlights the need for orderly implementation of the disaster prevention and mitigation plan, emphasizing the creation of a robust urban safety management system. This involves establishing a civil protection system led by the government with active social participation to improve disaster response efficiency. The plan also emphasizes periodic reviews and revisions to the *Civil Protection General Plan*. System functionalities of the “Emergency Command Application Platform” are to be upgraded, and efforts will continue to stockpile disaster preparedness supplies. The *Storm Surge Evacuation Plan in Low-lying Areas during Typhoon* will continue to be implemented, along with recruiting and training civil protection volunteers. Public awareness campaigns will be conducted to raise risk awareness and encourage disaster self-help among residents. Additionally, MSAR hosts an annual large-scale civil protection exercise, Crystal Fish Civil Protection Drill, to strengthen departmental disaster response coordination and enhance the general public’s disaster preparedness and emergency response awareness.

The *Macao's Urban Development Master Plan (2020-2040)* released in 2022 aims to strengthen MSAR’s resilience to increasingly complex and variable environmental challenges, such as climate and economic changes. It emphasizes the need to improve the city’s shelter and rescue systems to enhance disaster prevention, mitigation, and response capabilities in extreme climate events.

(ii) Challenges in Climate Change Adaptation

Currently, research on climate change impacts and adaptation strategies for the MSAR is relatively limited, especially in assessing future vulnerabilities. Current studies are primarily based on the Greater Bay Area or the Pearl River Basin, resulting in limited directly applicable scientific support for MSAR’s decision-making. There is a need to encourage more research, especially from local researchers, on related issues. Due to the diverse range of departments involved in climate adaptation, the MSAR established a cross-departmental working group on climate change, which has already yielded some progress. However, there remains a need for further improvements in cross-departmental coordination on climate adaptation.

IV. International Cooperation, Experiences, and Lessons Learned in Climate Change Adaptation

(i) Cooperation in Climate Change Adaptation

MSAR actively participates in climate change-related governance activities. MSAR has long been a member of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)/World Meteorological Organization (WMO) Typhoon Committee, participating in various committee working group meetings, exchanging the latest meteorological, hydrological, and disaster prevention technologies and application information. In 2022, MSAR received the Typhoon Committee’s 2022 Dr. Kintanar Award.

MSAR also participates in the World Meteorological Congress, the Forum on Regional Climate Monitoring-Assessment-Prediction for Asia, Meeting of the Asia-Pacific Regional Meteorological Subgroup on Air Navigation Planning and Implementation and other international forums. Through international exchanges, MSAR strengthens its capacity for weather and disaster monitoring and early warning.

MSAR serves as a platform for establishing a regular exchange mechanism between China and Portuguese-speaking countries' meteorological agencies. According to the *Meteorological Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area (2020 – 2035)*, MSAR will sign meteorological science and technology cooperation agreements with Portuguese-speaking countries. This cooperation, supported by the ESCAP/WMO Typhoon Committee Secretariat, aims to establish long-term strategic partnerships, promoting collaborative projects in numerical weather forecasting, severe weather early warning, and public meteorological services with Portuguese-speaking countries, fostering innovation in science and technology, and supporting talent development to advance meteorological technology and services.

(ii) Lessons and Insights in Climate Change Adaptation

Following the 2017 Typhoon Hato, MSAR collaborated closely with experts from China's National Disaster Reduction Committee to form the *Commission for Reviewing and Monitoring the Improvements of the Response Mechanism to Major Disasters*. Based on lessons learned from Typhoon Hato, MSAR is working to establish a modernized disaster prevention and reduction system led by the SAR Government and involving diverse societal participation. MSAR continues to strengthen cooperation with neighboring regions in Chinese mainland, updating emergency plans, improving infrastructure, and enhancing early warning systems. Through these efforts, MSAR has significantly reduced losses caused by typhoons. Comparing MSAR's three strongest typhoons since 1968 - Typhoon Hato (2017), Typhoon Mangkhut (2018), and Typhoon Higos (2020) - the economic loss from Typhoon Hato reached MOP 8.31 billion with an indirect loss of MOP 3.16 billion, resulting in 10 deaths and 244 injuries. After implementing response measures, losses from Typhoon Mangkhut the following year decreased to a direct economic loss of MOP 691 million and an indirect loss of MOP 1.045 billion, with 40 people injured. When Typhoon Higos hit, further reductions in losses occurred, with 15 people injured.

Chapter 4 MSAR's Finance, Technology and Capacity Building Needs and Support Received

I. Regional Circumstances and Institutional Arrangements

The MSAR Government has established a Climate Change Group responsible for coordinating work related to commitments under the *United Nations Framework Convention on Climate Change (UNFCCC)*, including developing measurable, reportable, and verifiable mitigation actions. The goal is to promote climate change mitigation and adaptation efforts within both private institutions and the general public, encouraging widespread participation in climate change action.

This chapter outlines the financial, technical, and capacity-building requirements for climate response in MSAR, covering both mitigation and adaptation aspects. Financial requirements relate primarily to future investments in projects aimed at mitigating and adapting to climate change in MSAR, with estimates based on the overall investment scales of similar existing projects. Technical needs are identified based on the technologies required to support MSAR's future low-carbon transformation. Capacity-building needs to involve developing institutional capacities to formulate and implement national policies effectively, advancing climate change objectives through specific actions, which may include capacity building for institutions, human resource development, education, and training.

II. Financial Needs and Support Received for Addressing Climate Change

(i) Financial Needs for MSAR's Climate Change Response

The MSAR Government's *Long-term Decarbonisation Strategy of Macao* outlines six key strategies: building a low-carbon power system, green transformation of land transport, energy conservation and clean energy substitution, waste reduction and waste-to-energy, community-wide low-carbon practices, and technological innovation with regional cooperation. A summary of project costs within MSAR's low-carbon transition pathway can be found in Table 6-17. These costs primarily cover energy, construction, and transportation sectors. Findings indicate that from 2021 to 2030, cumulative funding needs for projects listed in the table will be approximately CNY 3.847 billion, with an annual average of CNY 385 million. Of this, mitigation funding needs are estimated at CNY 2.902 billion, or about CNY 290 million per year. The table lists project funding needs primarily for the energy, construction, and transportation sectors; adaptation funding needs amount to CNY 945 million, with an average annual need of approximately CNY 94.48 million. As climate change risks grow, adaptation funding for MSAR is expected to increase.

Building a Low-Carbon Power System. For local power generation, the MSAR Government will further increase the proportion of natural gas generation in local power plants, aiming for 100% eventually. The government is also exploring carbon capture and storage (CCS) technologies to achieve deep carbon reduction and is assessing the feasibility of hydrogen power generation in the long term. Additionally, more photovoltaic systems will be installed in suitable locations, waste-to-energy technologies will be promoted, and the development of smart grids will be supported, continuously optimizing MSAR's energy supply structure. Regarding purchased electricity, the supplementary agreement on the electricity cooperation framework between the Macau SAR Government and China Southern Power Grid will expire in 2026. The two parties will renegotiate the electricity costs and the proportion of non-fossil energy in purchased electricity generation before the supplementary agreement expires, with the goal of achieving 100% non-fossil energy power generation by 2050 or earlier.

Building a green land transportation network. The MSAR Government is prioritizing public transport. Measures include enhancing public transport and pedestrian systems, advancing the light rail network, encouraging green travel, and reducing private vehicle use. To promote the adoption of electric vehicles (EVs), multiple measures have been proposed, such as replacing conventional vehicles with EVs, enhancing charging infrastructure, and ensuring long-term support for EV adoption. By 2035, MSAR aims for 100% zero-emission registration for new light vehicles and motorcycles (using electric or other clean technologies).

Energy conservation and clean energy substitution are also emphasized. In the short to medium term, the government plans to increase the use of natural gas in commercial, industrial, and residential areas, expanding the gas pipeline network to replace LPG for heating and cooking. MSAR will also advocate for high-efficiency appliances in commercial and residential sectors and raise the electrification rate of user equipment. The MSAR Government is starting from public projects, adding green building elements to new buildings, and studying the pilot plan of energy-saving renovation of existing buildings, aiming at improving the energy efficiency of buildings through better insulation and high-efficiency products, providing practical experience for the industry, and will continue to encourage all kinds of public and private buildings to obtain green building certification.

Waste Reduction and Energy Recovery. The MSAR Government is expanding food waste reduction and recycling and is constructing an organic resource recovery center to scale up energy recovery from waste. The center, expected to begin operations in 2027, will have an initial daily processing capacity of 150 tons of food waste, enabling energy recovery for its own use and potential distribution.

Encouraging Low-Carbon Lifestyles. The government will continue to engage businesses and institutions through programs like the MSAR Green Hotel Award, Green School Partnership Program, Green Supermarket Award Program, and Energy Efficiency Assessment Program for Public Departments and Agencies, encouraging the industry to participate in energy conservation and emission reduction. Large enterprises will be further encouraged to fulfill social responsibilities by conducting carbon audits, developing carbon-neutral plans, and publicly disclosing low-carbon information to foster a low-carbon culture among businesses and institutions. For individuals, MSAR will strengthen environmental education, explore incentive measures, and use media and social platforms to promote awareness and encourage responsible actions for energy conservation, emission reduction, waste separation and recycling.

Technological Innovation and Regional Cooperation. The government is also exploring new technologies, including the feasibility of applying CCS technology to local power generation units and researching hydrogen energy applications in land transport and power generation. Large enterprises or qualified organizations will be encouraged to lead by adopting low-carbon or green technologies. Given MSAR's limited land resources and skilled technical personnel, the government will actively pursue collaboration with international and regional partners to leverage advanced practices and technology to enhance local resilience to climate challenges. The private sector is also encouraged to draw on global best practices in green transformation, introduce innovative mechanisms and technologies, conduct carbon audits for key enterprises, and capitalize on transition opportunities.

Climate Change Adaptation. MSAR is considering expanding recycled water usage to reduce water consumption. There is also a need to predict and monitor sea-level rise and assess its potential threats to MSAR. Enhanced flood control infrastructure and an upgraded drainage system will be necessary in certain areas to mitigate flooding from climate change-related disasters In addition, the government is exploring the impact of climate change on MSAR's native plant life to strengthen biodiversity protection.

(ii) Climate Finance Support Received by MSAR

Not involved.

III. Technology Development and Transfer Needs and Support Received for Addressing Climate Change

(i) Technical Needs for MSAR's Climate Change Response

In terms of climate change mitigation, MSAR is exploring CCS technology, hydrogen energy generation, offshore wind power, smart grids, improved building insulation, low-carbon building, urban waste recycling and reuse, and other technologies. For adaptation, as a climate-vulnerable city, MSAR's key technological needs include recycled water utilization, sea-level rise prediction, high-efficiency flood defense technology, ecosystem restoration, and disaster risk assessment methods specific to climate change impacts. Additional technical requirements are outlined in Table 6-19.

(ii) Technical Support for Climate Change Response in MSAR

Not involved.

(iii) Case Study Analysis

Not involved.

IV. Capacity-Building Needs and Support Received for Addressing Climate Change

(i) Capacity-Building Needs for MSAR's Climate Change Response

For capacity-building efforts, MSAR continues to focus on extreme weather early warning and risk management, with ongoing regional and international cooperation in climate risk and disaster response coordination. It is essential to improve climate change coordination and information sharing mechanisms and to enhance the skills of government officials in climate response. Regular educational and outreach programs will raise climate awareness among government staff and the public, fostering broad social engagement for the accelerated development of a low-carbon economy. Additional capacity-building needs are listed in Table 6-21.

(ii) Support for Capacity Building in Climate Change Response

Not involved.

V. Needs and Support Received for Enhancing Transparency in

Compliance Efforts

(i) Transparency Needs for Compliance Efforts

The MRV work of the MSAR Government is still in its initial stages. MSAR has established a preliminary statistical and accounting system for its greenhouse gas inventory. Improving transparency in compliance work. First, it is necessary to continuously improve MSAR's basic statistical and accounting systems, including statistics on energy activities, industrial processes and product use, land use, land-use changes and forestry, and waste management, closely aligning with international compliance standards. A mechanism for routine data collection and inventory compilation is needed. Second, carbon auditing for key enterprises should be expanded, and guidelines for carbon audits across different enterprise types should be developed to support enterprises in building robust statistical systems. This will ensure MSAR's compliance work meets national and international MRV (monitoring, reporting, verification) standards. Lastly, conducting regular assessments of climate policy effectiveness will provide a foundation for refining and optimizing policy directions.

(ii) Support MSAR Received for Enhancing Transparency in Compliance Efforts

No information.

Table 6-17 Financial Needs for MSAR's Climate Change Response

Responsible Entity	Project name	Description	Estimated total funding requirement (CNY)	Estimated allocation of funds to the climate change fields (CNY)	Estimated period	Funding nature	Support areas	Project Department	Sub-sectors	Whether technology transfer is involved	Whether capacity-building is involved	Expected effects
DSPA	Local Power Generation[75]	Development of Smart Grid	This includes the power concession company investing around CNY 160 million in smart meter replacement	This includes the power concession company investing around CNY 160 million in smart meter replacement	2021-2024	Funded by the power concession company investment	Mitigation	Energy	None	None	None	with smart meter replacement expected by 2025.
DSPA	Waste Reduction at Source and Waste Sorting	Continued improvement of the recycling network, increasing public awareness and participation in recycling	CNY 39 million	CNY 39 million	2022–2025	Funded by the government	Adaptation	Environmental Protection	None	None	None	Raise public awareness on waste reduction and recycling
DSPA	Waste-to-energy	Construction of Organic Resource Recovery Center	Approximately CNY 1.01 billion	Approximately CNY 1.01 billion	2023–2027	Funded by the government	Mitigation	Environmental Protection, Energy	None	Yes	None	Improve organic waste recycling capacity
DSPA	Low-carbon lifestyles	Environmental education activities aimed at the public, businesses, and schools	CNY 6 million	CNY 6 million	2022–2025	Funded by the government	Adaptation	Environmental Protection	None	None	None	Increase awareness about emission reduction among society and the public
DSPA	Green Transportation Transition	Plan to grant financial support for the scrapping of obsolete motorbikes and their replacement with new electric motorbikes	Around CNY 16.9 million	Around CNY 16.9 million	2022–2025	Funded by the government	Mitigation	Transport	None	None	None	Accelerate the phasing out of high-pollution vehicles and promote electric vehicle use

[75] The project cycle is expected to be from 2020 to 2024, with an estimated total funding requirement of 200 million, and an equal allocation of funds to climate change fields. The table data represents average allocations.

Responsible Entity	Project name	Description	Estimated total funding requirement (CNY)	Estimated allocation of funds to the climate change fields (CNY)	Estimated period	Funding nature	Support areas	Project Department	Sub-sectors	Whether technology transfer is involved	Whether capacity-building is involved	Expected effects
DSPA	Local Power Generation	Install photovoltaic systems at suitable locations	Approximately CNY 9.1 million	Approximately CNY 9.1 million	2022–2024	Funded by the government	Mitigation	Energy, Construction	None	None	None	Increase the share of renewable energy to reduce carbon emissions
DSPA	Local Power Generation and Waste-to-Energy[76]	Construct Phase III Facilities at Macao Incineration Center	Approximately CNY 1.496 billion	Approximately CNY 1.496 billion	2021-2024	Funded by the government	Mitigation	Energy	None	None	None	Enhance waste processing and waste-to-energy capabilities
DSPA	Local Power Generation[77]	Install Photovoltaic Systems at the New Administrative Building of the Macao Incineration Center	Approximately CNY 16 million	Approximately CNY 16 million	2021-2024	Funded by the government	Mitigation	Energy, Construction	None	None	None	Support green buildings and renewable energy utilization
IH	Add flood barriers	Add flood barriers at entrances and facilities	CNY 2.6 million	CNY 2.6 million	2021–2030	Funded by the government	Adaptation	Construction	None	None	None	Prevent seawater backflow or rainwater accumulation damage to buildings
DSMG	Industry Carbon Auditing Study	Research on standards and systems for industry-specific carbon auditing applicable to MSAR	CNY 1 million	CNY 1 million	2022–2027	Funded by the government	Mitigation	Energy, Industry, Transportation, Construction	None	None	Yes	Support the development of future industry carbon auditing systems

[76] The project cycle is expected to be from 2020 to 2024, with an estimated total funding requirement of 1.87 billion, and an equal allocation of funds to climate change fields. The table data represents average allocations.

[77] The project cycle is expected to be from 2020 to 2024, with an estimated total funding requirement of 20 million, and an equal allocation of funds to climate change fields. The table data represents average allocations.

Responsible Entity	Project name	Description	Estimated total funding requirement (CNY)	Estimated allocation of funds to the climate change fields (CNY)	Estimated period	Funding nature	Support areas	Project Department	Sub-sectors	Whether technology transfer is involved	Whether capacity-building is involved	Expected effects
DSAT	Green Transport Network[78]	Guided by a "public transport first" approach, enhancing public transportation and pedestrian systems, advancing light rail construction	CNY 193 million	CNY 193 million	2022–2030	Funded by the government	Mitigation	Transport	None	None	None	Promote green transportation
DSAMA	Promote Recycled Water Use[79]	Utilize recycled wastewater, with infrastructure, operational management, and technical specifications to be established for expanding recycled water supply areas	Approximately CNY 879 million	Approximately CNY 879 million	2022–2030	Funded by the government	Adaptation	Water Resources	None	Yes	None	Enhance water resource recycling
IAM	Wildlife Monitoring in Macau	Long-term monitoring of wild plants in selected areas, study the impacts of climate change and the environment on MSAR's wild plants	Approximately CNY 1 million	Approximately CNY 1 million	2022–2025	Funded by the government	Adaptation	Forestry and grassland	None	None	None	Assess plant phenology types and the effects of climate on plant phenology
IAM	Forest Regeneration	Plant resilient native trees to enhance MSAR's forest ecosystem functionality	Approximately CNY 2.4 million	Approximately CNY 1.2 million	2021-2024	Funded by the government	Adaptation	Forestry and grassland	None	None	None	Improve the resilience of forests to extreme weather
IAM	Forest Restoration	Restore forest areas damaged by typhoons in MSAR	Approximately CNY 32 million	Approximately CNY 16 million	2021-2024	Funded by the government	Adaptation	Forestry and grassland	None	None	None	Improve the resilience of forests to extreme weather

[78] The project cycle is expected to be from 2022 to 2035, with an estimated total funding requirement of 300 million, and an equal allocation of funds to climate change fields. The table data represents average allocations.
[79] The project cycle is expected to be from 2022 to 2034, with an estimated total funding requirement of 1.27 billion, and an equal allocation of funds to climate change fields. The table data represents average allocations.

Responsible Entity	Project name	Description	Estimated total funding requirement (CNY)	Estimated allocation of funds to the climate change fields (CNY)	Estimated period	Funding nature	Support areas	Project Department	Sub-sectors	Whether technology transfer is involved	Whether capacity-building is involved	Expected effects
Public Works Bureau	Inner Harbor Rainwater Pump Station and Drainage Project	Large box culvert channels, rainwater pump station construction, and sewer system restructuring to alleviate flooding in southern Inner Harbor during heavy rain events, with completion expected by the first half of 2025	No data	No data	2021-2025	Funded by the government	Adaptation	Construction	None	None	None	Mitigate the impact of heavy rains, typhoons, and sea-level rise on the area
Public Works Bureau	New Urban Zone Area A Levee Optimization Project	Raise levees in Zone A to enhance flood resilience, minimize the impact of seawater overflow from storm surges. Construction divided into three phases, with phase one scheduled for completion by the first half of 2024	No data	No data	2021-2024	Funded by the government	Adaptation	Construction	None	None	None	Mitigate the impact of heavy rains, typhoons, and sea-level rise on the area

Table 6-18 Financial Support MSAR Received for Climate Change Response

Responsible Entity	Project name	Description	Source of Support	Domestic Project Implementing Agency	Funding Support Received Total Amount (CNY)	Climate-Related Amount (CNY)	Project implementation period	Funding nature	Funding status	Support areas	Support sectors	Sub-sectors	Whether technology transfer is involved	Whether capacity-building is involved	Project status	Project effects	Additional Information
None																	

Table 6-19 Technical Transfer Support Needs for MSAR’s Climate Change Response

Responsible Entity	Project name	Description	Support areas	Support sectors	Sub-sectors	Technology Needed	Estimated period	Expected effects
DSPA	Construction of Organic Resource Recovery Center	Biomass Recovery and Power Generation	Mitigation	Energy, Waste Utilization	None	Biomass Power Generation Technology	2023–2027	Reduce organic waste and increase the share of clean power
DSAMA	Recycled Water Utilization Technology	Reclaimed Water Recycling	Adaptation	Water Resources	None	Water Recycling	2024–2030	Reduce water consumption
DSAMA	Sea-Level Rise Prediction and Assessment Technology	Assess threats from sea-level rise	Adaptation	Coastal Areas	None	Sea-level monitoring	2024–2030	Reduce risks posed by rising sea levels
DSAMA	High-Efficiency Flood Defense Technology	Prevent flood disaster	Adaptation	Coastal Areas	None	Flood Disaster Prevention	2024–2030	Prevent flood disasters

Table 6-20 Technical Transfer Support MSAR Received for Climate Change Response

Responsible Entity	Project name	Description	Project implementation period	Source of Support	Domestic Project Implementing Agency	Support areas	Support sectors	Sub-sectors	Project status	Project effects	Additional Information
None											

Table 6-21 Capacity-Building Needs for MSAR's Climate Change Response

Responsible Entity	Project name	Description	Support areas	Support sectors	Sub-sectors	Estimated period	Expected effects
DSMG	Training in Climate Change Governance for Government Agencies	Training of key personnel in government departments on climate change governance to improve managerial capacity	Adaptation	Energy, Industry, Environment	None	2024–2025	Over 100 personnel trained, with at least five lectures held
DSMG	Industry Carbon Auditing Study	Research on standards and systems for industry-specific carbon auditing applicable to MSAR	Mitigation	Energy, Industry, Transportation, Construction	None	2022–2027	Develop at least one carbon audit guide for industries, with at least five lectures held

Table 6-22 Capacity-Building Support MSAR Received for Climate Change Response

Responsible Entity	Project name	Description	Source of Support	Domestic Project Implementing Agency	Project implementation period	Support areas	Support sectors	Sub-sectors	Project status	Project effects	Additional Information
None											