LAO PEOPLE'S DEMOCRATIC REPUBLIC

PEACE INDEPENDENCE DEMOCRACY UNITY AND PROSPERITY

THE THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

Ministry of Natural Resources and Environment

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February 2024

FORWARD

This Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC), prepared by the Ministry of Natural Resources and Environment (MONRE) on behalf of the National Focal Point for the UNFCCC, the Kyoto Protocol and the Paris Agreement. This national communication reaffirms the Lao PDR's commitment and effort to cope with climate change. The TNC was prepared in accordance with UNFCCC guidelines, including the Articles 4 and 12 of the UNFCCC, technical guidelines on the National Communication, stakeholders' consultations and requirements.

The key elements of the TNC are (i) Introduction; (ii) National circumstances; (iii) National greenhouse gas inventory; (iv) programmes containing measures for adequate climate change adaptation; (v) programmes containing measures to mitigate climate change; (vi) Other information relevant to the achievement of the objectives of the convention including transfer of technologies, research and systematic observation, education and capacity building, information and public awareness on climate change, networking and mainstreaming climate change issues into the national socio- economic development plans; and (vii) Constraints and gaps, and related financial, technical and capacity needs.

The TNC document is considered to have important implications for policy and technical practices to develop solutions to climate change in Lao PDR and will be implemented in conjunction with the Nationally Indented Determined Contribution (NDC) and the National Strategy on Climate Change, among others.

The Ministry of Natural Resources and Environment, on behalf of the government of the Lao PDR, would like to take this opportunity to express our appreciation to the steering committee, secretariat, line ministries, development partners, and international organizations for their considerable and invaluable contributions and also thank to the Global Environment Facility and the United Nations Environment Programme for your supporting such as financial and technical assistance to this TNC. I strongly encourage each of us and also look forward for cooperation and working with stakeholders on the implementation and continual improvement of the next national communication on climate change.

Minister
Ministry of Natural Resources and Environment

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LIST OF ACRONYMS, ABBREVIATIONS

ADB	Asian Development Bank
BUR	Biennial Update Report
CliPAD	Climate Protection through Avoided Deforestation
COP	Conference of the Parties
DCC	Department of Climate Change
EIA	Environmental Impact Assessment
EPF	Environmental Protection Fund
FAO	Food and Agriculture Organization (of the United Nations)
FCPF	Forest Carbon Partnership Facility
FIM	Forest Information Management
FIP	Forest Investment Programme
FIPD	Forest inventory and Planning Division
GCF	Green Climate Fund
GEF	Global Environment Facility
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaftffs Internationale Zusammenarbeit (German Agency for International Cooperation)
GOL	Government of Lao PDR
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
kfW	Kreditanstalt fur Wiederaufbau (German Development Bank)
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Energy and Mines
MOF	Ministry of Finance
MONRE	Ministry of Natural Resource and Environment
MPI	Ministry of Planning and Investment
MRV	Measuring/Monitoring, Reporting and Verification
NC	National Communication on Climate Change
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NGOs	Non-Government Organizations
ODA	Official Development Assistance
OECD	The Organization for Economic Co-operation and Development
PAREED	Participatory Land and Forest Management Project
PLUP	Participatory Land-use Planning
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions from Deforestation and forest Degradation plus the conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks
REL	Reference Emissions Level
R-PP	Readiness Preparation Proposal
SESA	Strategic Environmental and Social Assessment
SFM	Sustainable Forest Management
SIDA	Swedish International Development Agency

SNC	The Second National Communication on Climate Change
SNV	Netherland Development Organisation
SUFORD	Sustainable Forestry and Rural Development
TNC	The Third National Communication on Climate Change
TWGs	Technical Working Groups
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WCS	World Conservation Society
WREA	Water Resources and Environmental Administration
WRI	World Resource Institute
WWF	Worldwide Fund for Nature

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

Lao PDR, since becoming a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1995, submitted the First and Second National Communication (FNC and SNC) to the UNFCCC's secretary in 2000 and 2013, respectively. The Third National Communication (TNC) is the continuity of the effort of the Lao PDR to communicate climate change situation and management in the country. The TNC includes the national circumstances, greenhouse gas (GHGs) inventory, programmes containing climate change adaptation and mitigation measures, other information, financial and technical constraints, support needs.

The TNC was supported by the Global Environment Facility (GEF) and United Nations Environment Programme (UNEP). The Ministry of Natural Resources and Environment (MONRE), on behalf of the government of Lao PDR, implemented the project as well as preparation of the TNC. MONRE coordinated relevant sectors and stakeholders and set up a team, especially Technical Working Group (TWGs) to implement the project and develop the TNC. The institutional arrangement for the TNC is as described in the section 1.2 below. The national circumstances, GHGs inventory, programmes containing climate change adaptation and mitigation measures, other information, financial and technical constraints, support needs are in Chapter 2 to Chapter 7, respectively.

1.2 INSTITUTIONAL ARRANGEMENTS FOR THE DEVELOPMENT OF THE TNC

TNC was prepared based on the following institutional arrangement shown in the Figure 1 below.

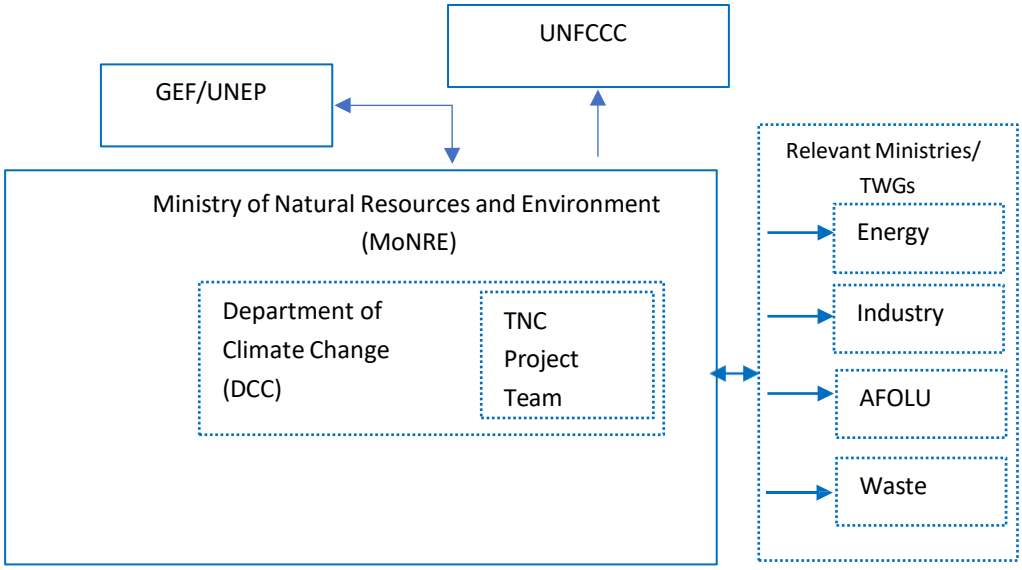


Figure 1 Institutional Arrangement for TNC

The TNC development process (Figure 2) was under MoNRE's supervision and leadership. Department of Climate Change (DCC) represented MONRE as well the government to ensure effectiveness and efficiency of the TNC project implementation, quality and compliance of TNC development, including communication and consultation with stakeholders including UNEP and submission of to the UNFCCC in a timely manner. To achieve the objective, the TNC team including the project steering committee (PSC), the technical thematic working groups (TWGs) and national consultants were established to support DCC, MONRE and coordination with relevant sectors on the TNC development including data collection, assessment and reporting, validation as well as quality assurance/control (QA/QC).

The PSC and the TWGs were the governmental decision making and technical body, respectively, who nominated by relevant sectors such as Ministry of Energy and Mines, Agriculture and Forestry, Public Work and Transport, Industry and Commerce, Public Health, Education, Lao Women Union, etc. to coordinate the TNC development, especially GHG inventory, assessment and identification of measures for climate change adaptation and mitigation, constraints and support needs. In addition, the PSC and TWG were also responsible for reviewing the TNC, including data and assessment results.

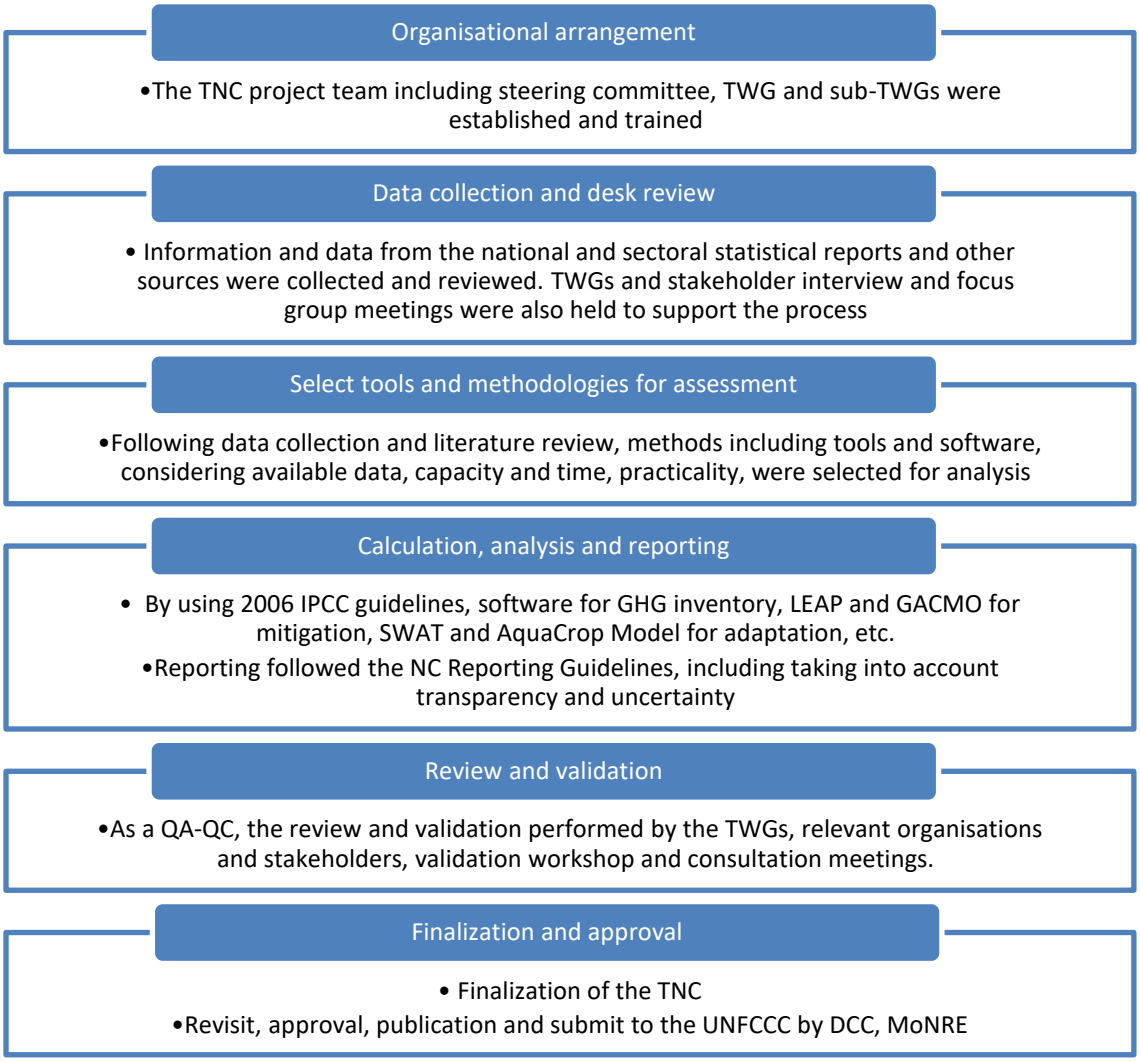


Figure 2 TNC Development Process

CHAPTER 2 NATIONAL CIRCUMSTANCES

2.1 GEOGRAPHICAL LOCATION AND ENVIRONMENT

2.1.1 Geographical location

Lao PDR is situated in Southeast Asia region, sharing border with China to the north, Vietnam to the East, Cambodia and Thailand to the South and Southwest, and Myanmar to the Northwest (Figure 3). The country's total land area is 236,800 squares kilometres. Of which, about 80% of the total land area is mountainous, and the rest is flat land area along the Mekong River. The elevation ranges from 200 to 2,880 meters above sea level. The country, administratively and or geographically divided into three regions: the north, central and south.

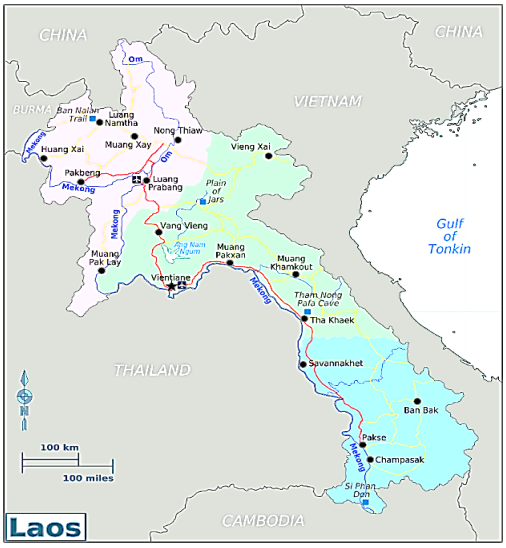


Figure 3 Map of the Lao PDR

2.1.2 Climate

Lao PDR has a tropical and monsoonal climate, which is characterized into two seasons. Raining season starts from May to ends in September. The average rainfall of the rainy season is approximately 1,900 millimetres per year and accounts for about 80% of a rainfall during a year. Dry season is between October and April. This season has little rainfall, and is influenced by cold wind from the northeast, which causes the low temperature, especially between November and January. Annual average temperature is around 29° C, while average temperature in the north is around 20° C, and 25-27° C in the rest of the regions.

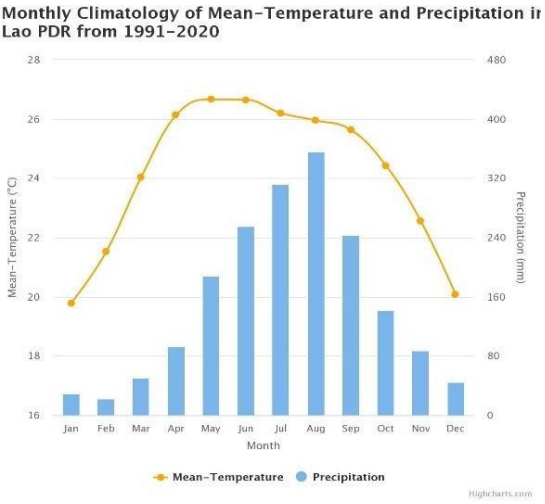


Figure 4 Overall climate of the Lao PDR

2.1.3 Land

Land includes forest, cropland, grassland, settlement, other land, and wetland including water. The forest and land use inventory 2019 revealed that about half of the land area of the country is forest, followed by cropland (19%), and the rest is other lands. However, based on the national land use master plan (2018), Lao PDR aims to increase conservation land and forest cover to 70% of the country area, and the rest (30%) are allocated for developments, including agriculture and industries (Table 1).

Table 1 Planned Land Use in Lao PDR[1]

No	Land Categories	Total areas	
		Hectares (ha)	Percent (%)
I	**Conservation land for forest cover**	**16,576,500**	**70**
1	Conservation forest	4,718,000	**20**
2	Protection forest	8,247,000	23
3	Production forest	3,110,000	13
4	Industrial tree plantation	501,500	2
II	**Land utilization and Economic development**	**7,102,500**	30
1	Agriculture	4,502,500	19
1.1	Paddy field	2,000,000	8,4
1.2	Biennial plants and Short live plants	1,000,000	4,2
1.3	Fruit tree cultivation	802,500	3,4
1.4	Pasture	700,000	3
2	Building up and other usage	2,600,000	11
2.1	Transportation	180,000	0,8
2.2	Construction	370,000	1,6
2.3	Others	2,050,000	8,6
Total		**23,680,000**	**100**

2.1.4 Water Resources

Lao PDR has abundant fresh water resources including river network, among others. As mentioned, the average rainfalls are approximately 1,900 millimetres per year. Surface water is about 332,5 kilo cubic meters or about 55,000 cubic meter per capita per year, on average. The largest source of water is from the Mekong River and its tributaries. The annual water consumption in the country is 4,260 million cubic meters, accounting for 1.3% of the freshwater resources. Most of the water use is in agriculture sector including irrigation, which accounts for about 93%. The rest is industrial sector including hydropower (4%) and household use (3%). The river network provides great hydropower potentials. Total development potential is around 23,000 megawatts, and thus far, only about 5% of the potential is exploited.

[1] MONRE (2018). National Land-use Master plan

2.1.5 Forest Resources

The forest inventory in 2015[2] showed that Lao PDR had forest area of about 13.7 million hectares (ha), which covered approximately 58% of the total land area of the country. Forest consisted of tropical and subtropical moist evergreen, dry dipterocarp forest and mixed breaded leave and coniferous forest. Based on the forest law, forest is divided into three main forest types: production, conservation, and protection forest. In 2015, the production forest covered 3.1 million hectares. Of which, 2.2 million ha (70.8%) of the production forest was forest and the rest were other land uses. The protection forest was 7.9 million hectares and 4.8 million ha (59.8%) was forest and the rest were other land uses. Conservation forest, 4.8 million ha, consisted of and 3.5 million ha (73.4%) was forest. In addition, there were other forest land (7.8 million ha, including 3.2 million ha of forest) that have not been categorised (Table 2).

Table 2 Forest type and areas in 2015[3]

Forest categories	Areas (Mha)	Forest cover (Mha)	Forest cover (%)
Production forests	3.1	2.2	70.8
Protection forests	7.9	4.8	59.8
Conservation forests	4.8	3.5	73.4
Forests have not categorized yet	7.8	3.2	42.5

Lao PDR used to have very high proportion of forest cover. However, as report in the first Biennial Update Report (2021), forest cover decreased from time to time over past five decades. The national forest inventory for the year 1982-2010 showed that the forest cover dropped from 70% in 1940 to 41.5% in 2002. In 2015, the inventory conducted again to assess forest and land change from 2005 to 2015 and the result show forest cover was 60.2% or equivalent to 14.3 million hectares in 2005, and then it decreased to 59.3% (14 million hectares) in 2010, and the 58% (13.7 million hectares) in 2015 (Figure 5). The decrease of forest cover was due deforestation and forest degradation resulted from commercial and household use logging, shifting cultivation and agriculture expansion, mining, hydropower, infrastructure, settlement area. development and expansion.

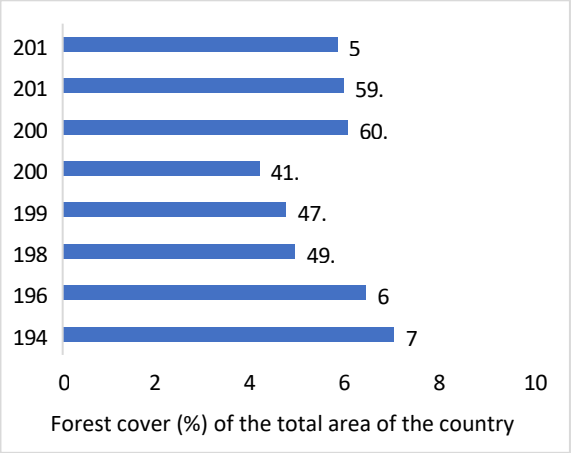


Figure 5 Forest cover in the Lao PDR 1940-2015[4]

[2] MAF (2018). Lao People's Democratic Republic Forest Reference Emission Level and Forest Reference Level for REDD+ Results Payment under the UNFCCC.
[3] Footnote 2
[4] Modified by TNC Team

2.1.6 Biodiversity

Lao PDR is situated in the global biodiversity hot-spots and one of the biological richest countries. There are 166 species of reptiles and amphibians, 700 species of birds, 90 species of bats and more than 247 species of mammals reported to exist in the country. In addition, there are thousands of species of aquatics and fishes. Of which, approximately 500 species of the indigenous fish are found in the Mekong River and its tributaries. Plant biodiversity consists of 8-11,000 species of flowering plants, and many of them are economically valuable. However, several species might be endangered (Table 3 and 4), while new species are still being discovered, and reptiles, insects, and rodents are not well-known and documented[5].

Table 3 Threatened species by taxonomic group[6]

	Mammals	Birds	Reptiles	Amphi-bians	Fishes	Molluscs	Other Inverte-brates	Plants	Fungi and Protists	Total
Lao PDR	47	29	28	6	56	16	5	62	0	249

Table 4 Number of species in IUCN's Red List Category[7]

Taxonomic Group	EX	EW	Subtotal	CR	EN	VU	Subtotal	NT	LR/cd	DD	LC	Total
Animals	1	0	1	33	52	102	187	95	0	222	1,517	2,022
Plants	0	0	0	5	29	28	62	18	0	37	606	723

Notes
EX - Extinct; EW - Extinct in the Wild; CR - Critically Endangered; E – Endangered; VU – Vulnerable; Near Threatened; LR/cd - Conservation Dependent; Data - Deficient, LC - Least Concern.

Biodiversity is crucial to the Lao economy, livelihood improvement and poverty reduction, among others. Approximately 67 percent of the Lao population is in rural area, and 75-80 percent of the rural population depend on the forests and harvesting wild plant and animal products for their day-to-day subsistence and income. About 90 percent of the over 1,400 species of wild animals are used for protein by local people[8].

[5] MONRE, 2020. The Lao People's Democratic Republic: State of Environment Report, March 2020.
[6] Footnote 5
[7] Footnote 5
[8] MONRE, 2016. The National Biodiversity Strategy and Action Plan for Lao PDR 2016-2025. Department of Forest Resource Management. Vientiane Lao PDR

2.1.7 Mineral Resources

Apart from the existing operations (Figure 6), there are more than 500 intact resources and locations. Those minerals include gold, diamond, coal, oil, metal, copper, salt, lead, zinc and gypsum. The minerals production has been remarkably increased. Lignite coal production, for example, has been largely increased since the operation of the first coal-fired power plant in the country in 2015. Limestone is the second largest minerals that has been mined for years. In addition, in recent year, excavation of iron ores has also been increased.

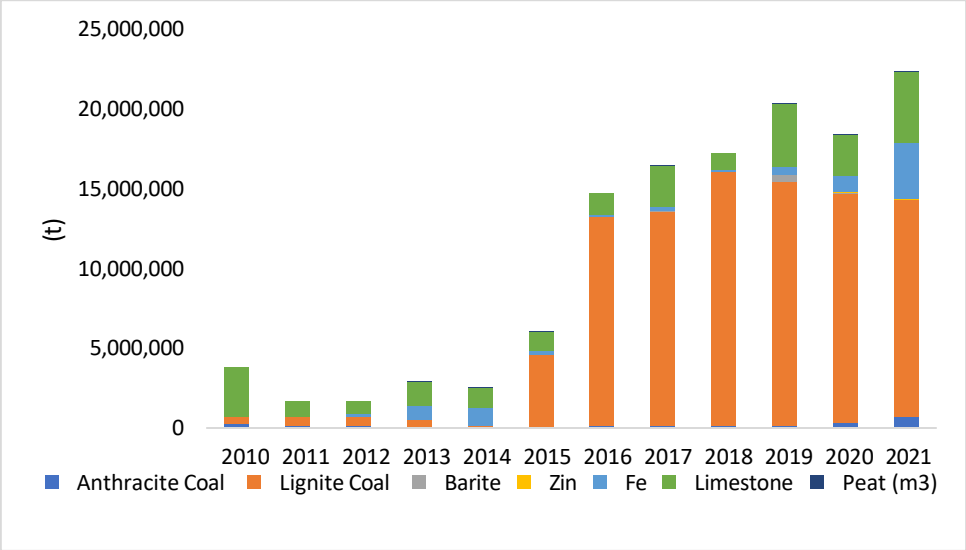


Figure 6 Minerals explored in Lao PDR from 2010 to 2021[9]

Minerals is one of the main income sources of the Lao PDR. In the year 2011 – 2015 mining industrial have a total revenue of 66,746.83 billion-kip, on average of 6.97% per year, compare to the revenue in the year 2006 – 2010 increase 184.18%[10]. However, the contribution to GPD from mining sector is 6.6%, for the year 2010 and 2012 is 8% and 7% respectively[11].

2.1.8 Pollutions

In general, Lao PDR still has good air quality. However, the increase of agricultural expansion including forest and grassland burning, urbanization and increase of transportation, industries have gradually worsened air quality. Some aspects as well as parameters of air quality were sometimes below the national standards, fine particulate matter (PM-2.5), for example, became an issue of many provinces in the country in recent years (Table 5).

[9] Lao National Statistics Bureau (2022). National statistical report.
[10] Ministry of Energy and Mining (2015). Energy and Mining Report 2015
[11] National Bank of Laos (2013). National Bank Report 2013

Table 5 Air quality in Lao PDR 2018-2021[12]

Air Quality Monitoring Station		Standard value						
		O_3	**CO**	**SO_2**	**NO_2**	**PM-10**	**STP**	**PM-2.5**
		mg/m^3	ppm	ppm	ppm	mg/m^3	mg/m^3	mg/m^3
Ambient Air Quality National Standards		0.20	30	0.13	0.11	0.12	0.33	0.05
Vientiane Capital (The National Assembly Hall Lak6)	2018	0.027	0.330	0.002	0.035	0.102	0.178	**0.116**
Vientiane Capital (NUOL)	2018	0.025	0.951	0	0.014	0.087	0.11	**0.073**
Vientiane Capital (Chao Anouvong Park)	2018	0.044	3.925	0.001	0.032	**0.145**	0.177	**0.125**
Vientiane Capital (Vita Industrial Farm)	2018	0.057	0.664	0.003	0.014	**0.189**	0.122	**0.081**
Vientiane Province	2018	-	0.469	**0.344**	0.038		0.084	**0.125**
Bolikhamxay Province	2018	0.014	0.54	0.006	0.004	0.014	0.033	-
Khammouane province	2018	0.012	0.272	0.004	0.003	0.039	0.041	-
Savannakhet Province	2018	0.048	0.477	0.001	0.003	0.013	0.029	-
Champasak Province	2018	0.009	0.042	0.002	0.008	0.037	0.041	-
Saiyabuli Province	2018	-	0.473	0	0	-	0.04	0.016
Luang Prabang Province	2018	-	0.604	0	0	0	0.121	0.027
Phongsaly Province	2019	-	0.335	0	0	0	0.172	**0.121**
Bokeo Province	2019	-	0.606	0	0	0	0.174	**0.139**
Luang Namtha Province	2019	-	0.357	0	0	0	0.202	**0.133**
Oudomxay Province	2019	-	0.603	0	0	0	0.165	**0.145**
Houaphanh Province	2021	-	0.273	0	0	-	0.081	**0.056**

Notes: [-] Not measured; [0] Not detected

Solid waste generation was about 1.71 million tons per year in 2010, and increased to about 1.31 tons per year in 2016 (Table 6), and estimated to increase to 1.48 million tons per year in 2020 (Table 7). Meanwhile, some sources reported solid waste generation, especially in secondary town was about 0.65 kg/capita/day[13, 14] or ranged from 0.276 to 0.639 kg/capita/d in 2010[15] and 0,59-0,691 kg/capita/d in 2011[16]. More than 50% of the solid waste was wood and organic waste (Figure 7).

[12] MONRE (2021). The National Air Quality Monitoring Report.
[13] GGGI, 2019. Solid Waste Management in Vientiane, Lao P.D.R: Situation assessment and opportunities for waste-to-resource.
[14] MONRE, 2020. Lao PDR State of Environment Report 2020.
[15] Phonekeo and Inthavong, 2010. Solid Waste Management in Laos.
[16] LPPE Newsletter, 2012. Baseline Survey on Urban Environment in the 3 Cities.

Table 6 Solid Waste Generation in Lao PDR 2010-20016[17]

Year	2010	2011	2012	2013	2014	2015	2016
Solid waste disposed to landfill (Tone/Year)	369,106	386,095	406,406	423,637	433,191	431,637	445,942
Solid waste disposed to Landfill (%)	31.5	31.6	32.9	32.6	32.1	34.1	34.1
Total[1]	1,171,765	1,221,820	1,235,277	1,299,500	1,349,505	1,265,798	1,307,748

Notes

1, estimated data based on data from Department of Urban Planning and Housing, MPWT (2017). This was slightly different from those estimated and reported in Lao PDR State of Environment Report 2020 (Table 7)

Table 7 Estimated Solid Waste Generation in Laos 2005-2020[18]

	Population 2005[6]	Population 2015[7]	Waste Generation 2005 Tonnes/year	Waste Generation 2015 Tonnes/year	Estimated Waste Generation 2020 Tonnes/year
Urban areas	1,523,557	2,135,943	361,464	506,752	617,119
Rural with roads	2,895,321	3,843,399	528,396	701,420	824,032
Rural without roads	1,197,482	512,886	131,124	56,161	41,841
Total	5,621,982	6,492,228	1,020,984	1,264,334	1,482,992

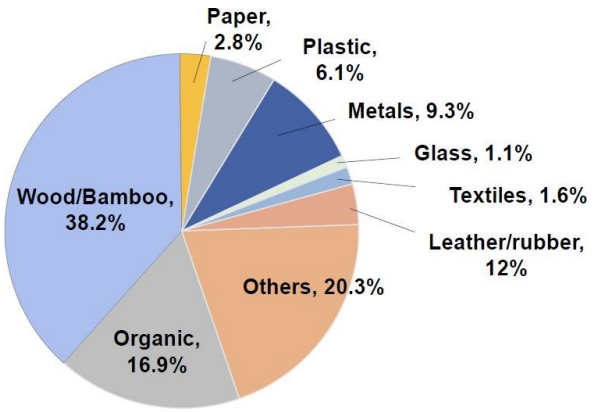


Figure 7 Solid Waste Composition in 2010[19]

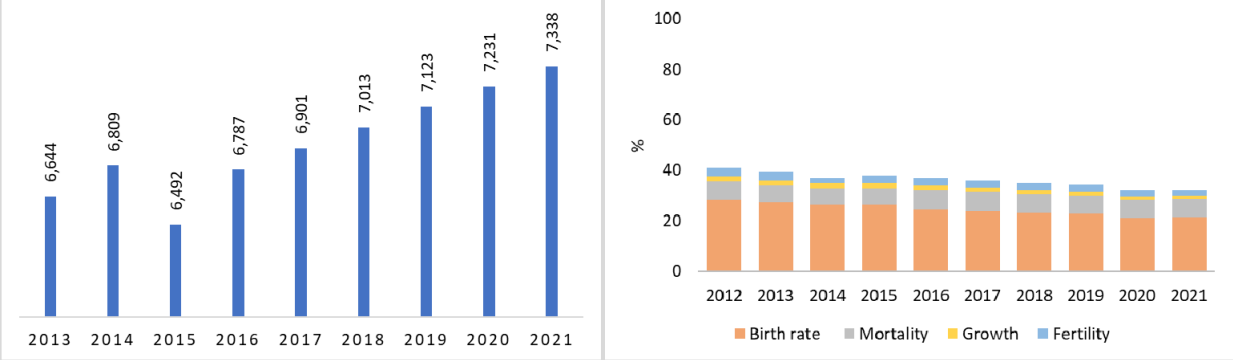
[17] Department of Urban Planning and Housing, MPWT (2017). Solid production statistics (unpublished).

[18] GGGI (2019) Solid Waste Management in Vientiane, Lao P.D.R: Situation assessment and opportunities for waste-to-resource

[19] GGGI (2019) adopted data from CCA (2015), who cited Phonekeo and Inthavong (2010).

2.2 SOCIOECONOMIC DEVELOPMENT

Lao PDR had a population of about 7.3 million people in 2021 and population density of about 27 people per square kilometre. Population is increasing at a high rate, 1.45% per year (Figure 8a), although birth rate tended to decline between 2012-2021(Figure 8b). The ratio of the increment ratio can be divided into the age group which show a huge difference especially the population in the age of 5 – 14 will decrease about 3.7%, however, the population with employment will increase 10.6% and the elderly will increase 10.1%. The structure change of the age group especially the increase in teenager population will positively contribute to the growth of the country population (national population and household report, 2015)



(a) (b)

Figure 8 (a) Population (1,000) and (b) Population Growth Rate (%) 2013-2021.[20]

Population who lives under poverty line is relatively high. A poverty analysis showed that 20% of the population are still under poverty line or poor in 2015. In 2014, the poor were 1,736 villages and 76,604 household, which accounted for 23.09% of the total number of villages through the country. These ratios decreased from 27.6% in 2007-2008 and 23.2% in 2012-2013, when the fourth and fifth survey on consumption and expenditure (LECS IV and V) were conducted. The ratio of the use of clean water reached 84.71% and the ratio the use of toilet reached 67.92% in 2014.

From the year 2010 to 2018 the economy of Lao PDR has been continuously and steadily growing at average of 7.5% per year, a large proportion of the growth mostly come from Service and Industrial sectors (Table 6). Total GDP per capita has continuously increasing due to the result of the implementation of social economic development plan from the year 2011 to from the total of 1,217 USD in the year 2010 - 2011 to 1,970 USD in the year 2014 - 2015 and 2,558 USD in the year 2017 – 2018 (Figure 9). In the year 2011, Lao PDR has GNI of 1,010 USD per capital and increased to 1,232 USD in the year 2015 and 2,209 USD. The continuously growing of the economy due the government mechanism and the suitable macroeconomic management measures; the nation is peaceful, and the society is courteous; political and economic stability; increasing the international and regional integration. From the growth of the economic has reduced the poverty rate from 27.6% in 2008 to 23.2% in 2012-2013 (LECS V).

[20] Lao National Statistics Bureau, Laos Statistical Information Service (LaoSIS) (2022). National statistical report 2013-2021.

Table 8 GDP growth rate from 2011 to 2018[21]

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
GDP growth	8,1	8,3	8,0	7,8	7,5	6,9	6,8	6,5
Agriculture and Forest	2,9	2,8	3,1	3,0	3,0	3,0	2,8	2,5
Industry	15,8	14,4	7,4	8,5	8,9	9,0	9,5	7,7
Service	7,8	8,1	9,7	9,3	9,1	8,5	6,2	7,6
Taxes	-	-	-	-	-	3,8	6,9	3,7

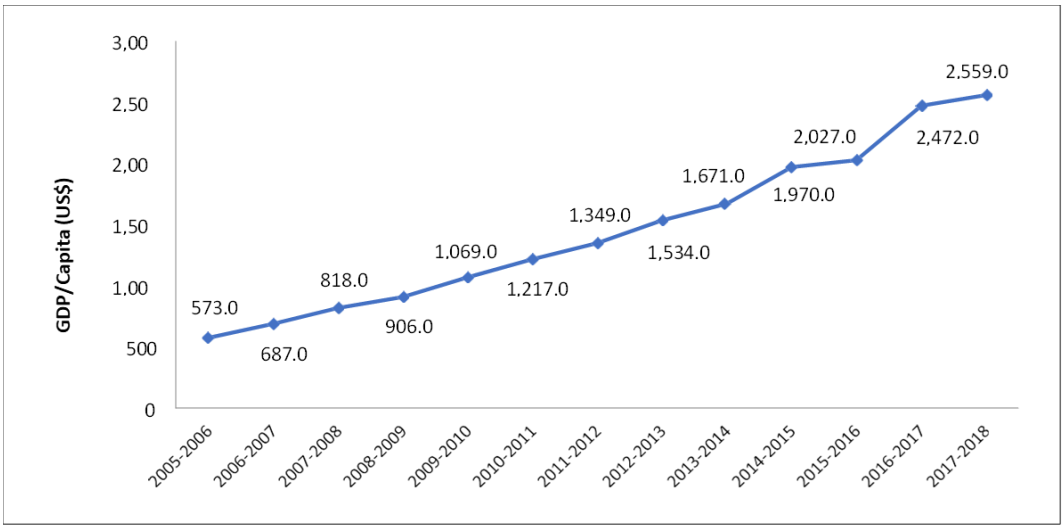


Figure 9 Average GDP growth rate/person/year, 2005-2016 and 2018-2019[22]

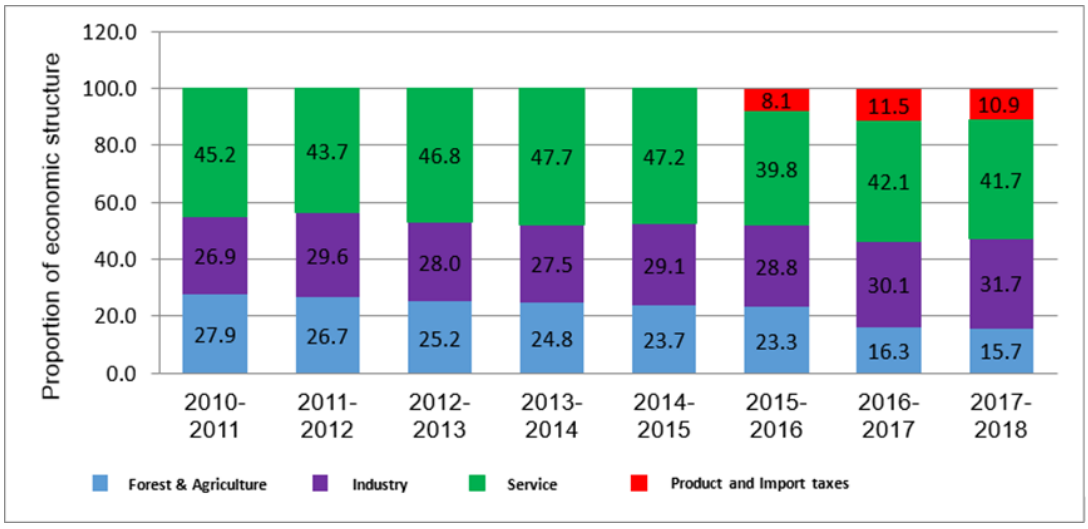


Figure 10 Proportion of economic structure[23]

[21] MPI (2020). Socio-economic development summary annual report 2010-2011 and 2018-2019
[22] Footnote 21
[23] Footnote 21

The economic structure has changed according to the changed of the industrial and modern: the ratio of agriculture and forestry sectors in the economic structure has reduced from 27.9% in 2010–2011 to 23.7% in 2014–2015 and in the year 2017 – 2018 reduced to 15.7%; in the industrial sector has increase from 26.9% in 2010 – 2011 to 29.1% and 31.7% in 2014 – 2015 and 2017 – 2018 respectively; in the service sector has the bigger ratio than any other sectors in the economy structure has increased 2% in 2013 – 2015 and 2014 – 2015 compared to 2010 – 2011: increased from 45.2% in 2010 – 2011 to 47.7% in 2013 – 2014 and 47.2% in 2014 – 2015 of GDP. However, the trend seems to be reduced starting from 2016 – 2017 onward after the product and import tax has been separated from each other inside the economy structure (Figure 10).

Agriculture sector is an important sector for the implementation of the government policy and social economic development plan, after the introduction of the new policy which agriculture sector is the main target and identify the suitable path from the normal economy to commercial economy. From the said policy, stepwise improvement of agriculture infrastructure, for instance: litigation system, reservoir and water pumping stations has been implemented in many areas which improved the number of rice planting seasons; Technical infrastructure, for instance research, demonstration and technical service provider centres or stations has been established and developed, which lead to Lao PDR self-sufficiency on food productions, especially from 2000 onward and part of the food productions also has been exported (Agriculture Strategic Development Plan 2025 and The Vision 2030, Ministry of Agriculture and Forestry, 2015). Furthermore, agriculture and wood industrial sectors, especially the commercial plants: corn, job's tears, sugarcane, beans, coffee, rubber, cottons, vegetables, and fruits are continuously expanding and capable of export to both local and international markets. Animal husbandry and fishery sectors area growing well due to the push for a change in new animal husbandry techniques, new equipment and production factors, technical training on animal husbandry techniques, storage of fodder, grass cultivation, animal vaccination which improve the growth rate of the animal at the ratio of 5% per year.

Forestry sector is another important sector that contribute to social economic development of Lao PDR, especially to the livelihood improvement of rural people that depend on the NTFPs for household consumption and generate revenue. Estimated revenue generate from NTFP is about 320 USD per household especially in the rural area and total revenue for the whole country is about 183.7 million USD per year (Ministry of Agriculture and Forestry, 2015).

Energy sector is the basic infrastructure of the social economic development, the transition from agriculture society to industrial society, which focused more on the unitization of the technology in the day to day leaving. Energy sector is one of the many sectors that drive the social economic to grow. Nowadays, Lao PDR have total of 45 electricity related projects with the total capacity of 6.437 MW, able to produce electricity up to 34.357 million GWh per year. Among those there are power stations which produce electricity more than or equal to 15 MW in total of 29 projects, has the capacity of 6.365 MW can produce the electricity up to 33.957 GWh per year; power stations which can produce electricity more than 15 MW in total 14 projects, has the capacity of 72 MW, can produce electricity up to 400 GWh per year. (National Social Economic Report for the year 2011 – 2015). The mining sector is another important factor that contribute to the social economic development, in the year 2011 mining sector contribute to the total GDP up to 10.3%.

In the year 2011 – 2015 the production from the sector had an average growth of 9.97% per year (total revenue produced is 66,746.83 billion kip) compared to the year 2006–2010 increase 184.14% (Ministry of Energy and Natural Resources, 2018).

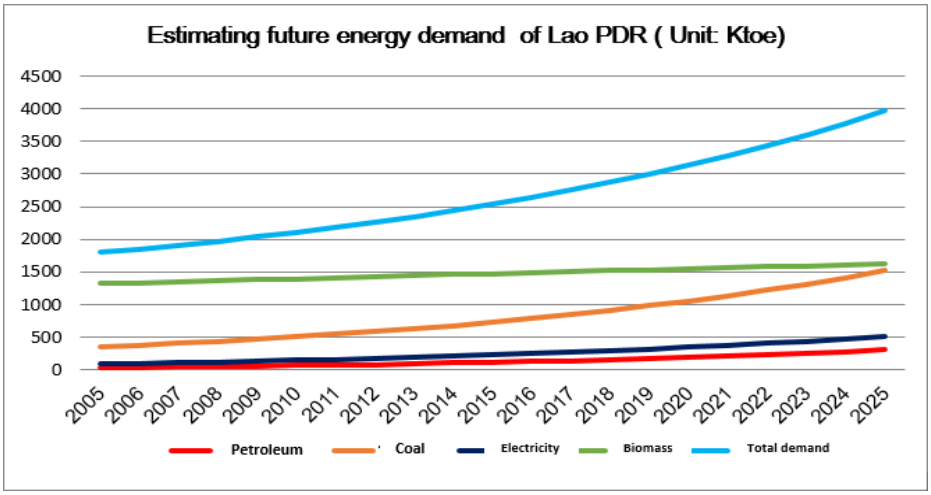


Figure 11 Estimated future energy demand in Lao PDR

The total need of energy for the whole country increases about 3.6% per year, which increase from 1.8 million tons compare to petrol (MTOE) in the 2005 to 3.9 million tons in the year 2025, but there is an indication that the demand from the household decreasing from 77.8% in the year 2005 to 48.5% in the year 2025. At the same time the demand from industrial sector is increasing from 6.1% in the year 2005 to 16.9% in the year 2025. The energy production from hydroelectricity will increase about 11% in the year 2005 – 2025, but about 10% is for the country consumption and 90% will be exported, for the need of electricity inside the country will increase about 8.3% per year until 2025 (Figure 11)

CHAPTER 3 NATIONAL GREENHOUSE GAS INVENTORY

3.1 INTRODUCTION

GHG inventory, in general, was conducted in accordance with Article 4.1(a) and Article 12 of the of the NFCCC, namely inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. Specifically, the TNC included:

1) Inventories of emissions and removals for four sectors, namely Energy, Industrial Process and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste. Emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and other gases, however, were not estimated due to inadequate data and resources. So did emissions of NO_X, CO, NMVOCs, and SO2; they were not estimated due to inadequate data and resources. So, only CO2, CH_4, and N_2O were estimated in the inventory. However, emissions of those gases were possibly be negligible in 2010;
2) Unit of GHG emissions and removal expressed in CO_2 equivalents (CO_{2e}), and for

consistency with the previous GHG inventories, Global Warming Potential (GWP) in the IPCC Second Assessment Report (2RA) were used for the conversion of the unit;

3) Estimation of emissions by sources and removals by sink using 2006 IPCC Guidelines and software for National Greenhouse Gas Inventories for the inventories, including sectoral approach, quality assurance and quality control (QA/QC) procedures, uncertainty management and key category analysis based on IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) and the IPCC Good Practice Guidance for Land Use Change and Forestry (2003). The reference approach was not used to estimate and report CO2 emissions from fuel combustion, and in comparison, with the result from sector approach due to time constraints and other reasons;
4) Using the year 2010 as the base year;
5) Tier 1 method and default emission factors (EFs) were used for estimation of GHGs since the country specific EFs were not available;
6) Transparency, Accuracy, Consistency, Completeness, and Comparability (TACCC) in the inventory. in addition, notation Keys including Not Estimated (NE), Included Elsewhere (IE), Confidential Information (C), Not Applicable (NA) and Not Occurring (NO) were used in the reporting.

GHG inventory process included (1) organisational arrangement including set up and capacity building for TWG on the inventory; (2) Data collection and analysis; (3) GHG calculation and analysis; (4) Reporting; (5) Review and validation of the GHG technical report; and (6) Finalization, incorporation GHG inventory in the TNC (Figure 12). As a part of or similar to the organisational arrangement for TNC, GHG inventory was oversaw by DCC, MONRE, who also formed the TNC project steering committee, TWGs and recruited consultant for GHG inventory. The PSC and the TWGs were the governmental decision making and technical body, respectively, who nominated by relevant sectors such as Ministry of Energy and Mines, Agriculture and Forestry, Public Work and Transport, Industry and Commerce, etc. DCC, PSC and TWG's main roles was to coordinate and ensure that GHG inventory was conducted in effective, efficient and timely manner, meeting a quality and the national and UNFCCC's requirements. In addition, they were also responsible for data provision and validation. The consultant's main roles was to coordinate with DCC, PSC, TWG and other stakeholders, calculation and analysis of GHGs using 2006 IPCC Guidelines and Software, and production of GHG technical report. Finally, the GHG inventory technical report was reviewed and validated by the PSC, the TWG and stakeholders including UNEP through consultations and endorsed by MONRE (Figure 12).

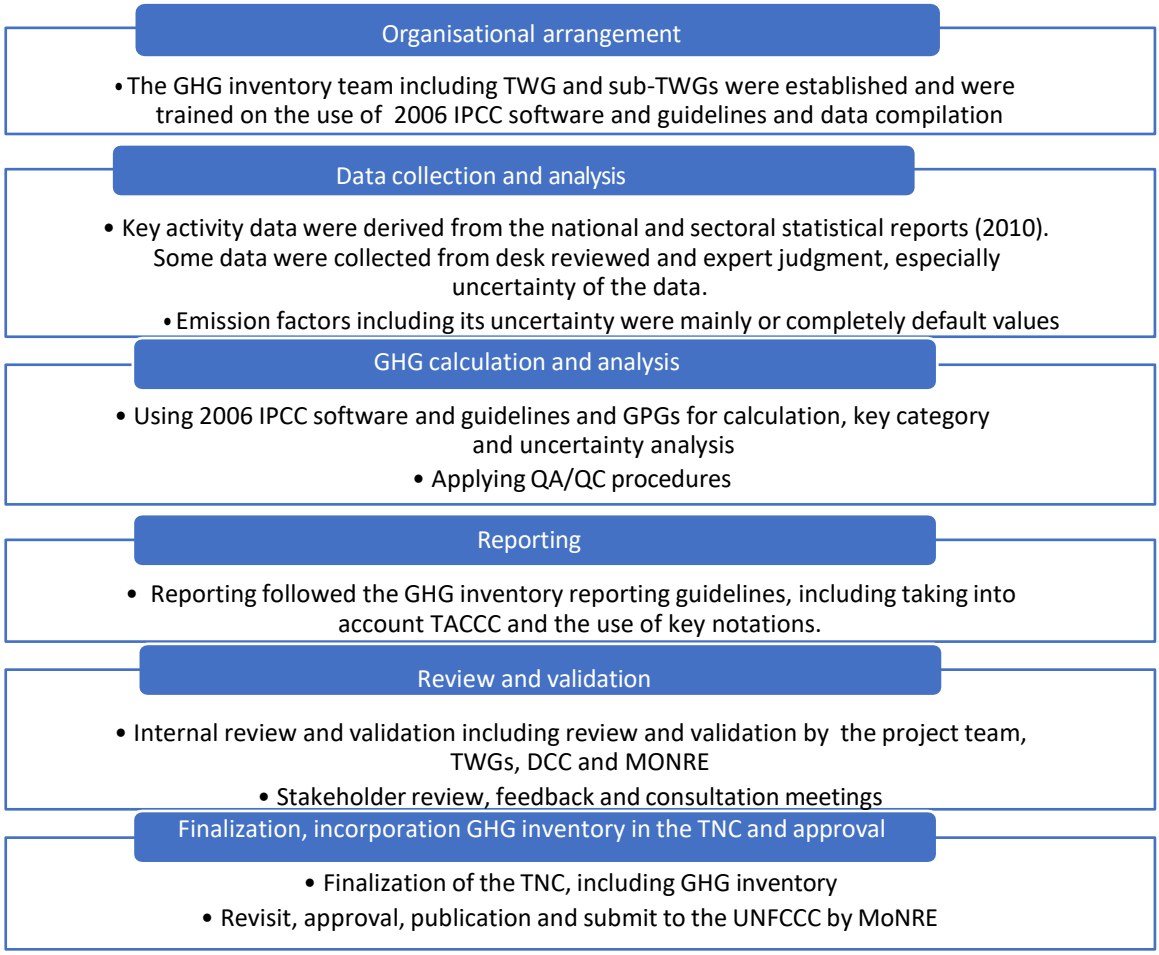


Figure 12 GHG inventory and reporting process

3.2 SUMMARY OF EMISSIONS IN 2010

The GHG inventory result showed that Lao PDR was net sink of 25,492.3 GgCO2eq in 2010. This derived from total removal of 36,171.28 GgCO2eq and total emissions of 10,678.96 GgCO2eq. AFOLU sector had the total removals (36,169.89 GgCO2eq) and total emissions of 6,570.47 GgCO2eq, leading to net sink of 26,900.8 GgCO2eq. Looking at the emissions side, AFOLU was the largest sources of emissions, accounting for about 62% of the total emissions. The second largest source of emissions was Energy Sector, which shared 27% of the total emissions. The rest were IPPU and Waste Sector which contributed 8% and 3% of the total emissions, respectively (Figure 13 and Table 9). By gas, there were CO2 emissions of 4,108.49 Gg; 270.10 Gg of CH4 (5,672.20 GgCO2eq) and 3.90 Gg of N2O (1,209.99 GgCO2eq) (Figure 14). In addition, there was emissions from international banker, particularly aviation, which emitted 111.74 GgCO2eq (Table 9).

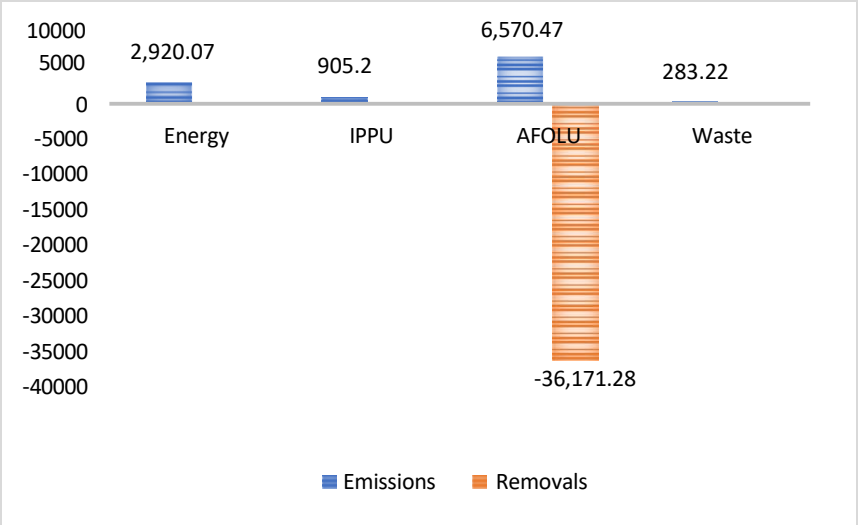


Figure 13 Total Emissions (tCO2e) in 2010 in Lao PDR[24]

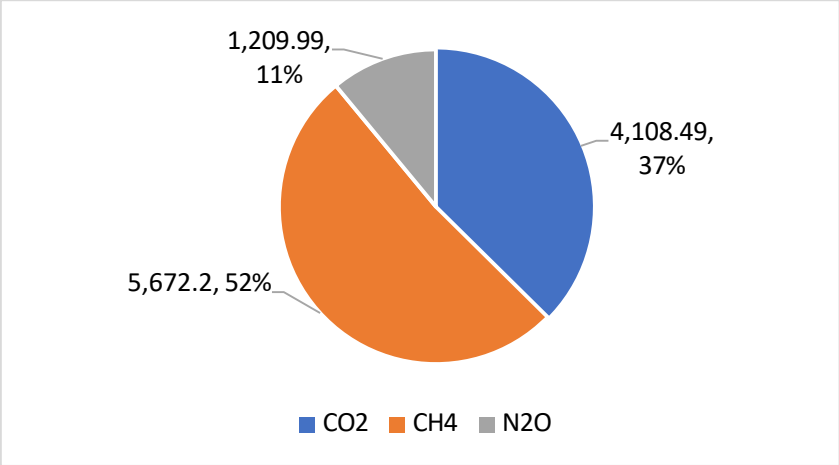


Figure 14 Total Emissions by Gas (GgCO2eq) in 2010[25]

There were totally 45 sources of emissions and a source of removal in 2010. Of which, there 12 key emission sources which accounted for about 95% of the total emissions and removals were summarized in Table 10. Based on trend analysis (Table 10), the majority of emissions were on the rising trend, so did the removals from forest land remaining forest land which increased in comparison with the removals in the year 2000 reported in SNC (-2,046.7 GgCO2eq), but lower than those in 1990 under FNC (-121,614 GgCO2eq).

Uncertainty analysis, based on uncertainty analysis tool/formula in 2006 software including default EFs uncertainty and activity data uncertainty derived by expert judgement, showed that there could be versions in total and sectoral emissions or by gases. The combined inventory uncertainty was about 43.16%. Improvement of inventory quality requires improvement of activity data and development of country specific EFs.

[24] TNC Team (2019). Technical report on national greenhouse gas inventory (unpublished).
[25] Footnote 24

In comparison with the emissions in the year 2000 reported in SNC (41,764 GgCO2eq) and those in 2014 reported in the first BUR (24,099.98 GgCO2eq), the emissions in the year 2010 under this TNC was much lower. Importantly, it was net sink in 2010, while Lao PDR was net emitter in the year 2000 and 2014. However, variable emissions could be caused by forest and land use change data and inventory method, among others. In the year 2000, forest area was only about 42%, while it was about 59% in the year 2010 and about 58% in 2014. In addition, 1996 revised guidelines and methodologies were used in the year 2000, while 2006 IPCC guidelines and methodologies were used for 2010 and 2014 GHG inventory.

In other words, emissions from AFOLU sector, especially forest and land use change were much different between the year 2010 and others, 2000 and 2014. Emissions from other sector such as Energy, IPPU and Waste in 3 years continuously increased from 2000 to 2010 and 2014, respectively.

Table 9 Total GHG emissions in 2010 in Lao PDR[26]

Categories	Net CO2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2eq conversion factors	Other halogenated gases without CO2eq conversion factors	NOx	CO	NMVOCs	SO2	Total (CO2e)
Total National Emissions and Removals	-32,374.49	270.10	3.90	NE	NE	NE	NE	NE	NE	NE	NE	NE	-25,492.3
1 - Energy	2,882.40	0.37	0.09	NE	NE	NE	NE	NE	NE	NE	NE	NE	2,920.07
1.A - Fuel Combustion Activities	2,877.03	0.37	0.09	NA	NA	NA	NA	NA	NE	NE	NE	NE	
1.B - Fugitive emissions from fuels	5.36	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
1.C - Carbon dioxide Transport and Storage	NE	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	
2 - Industrial Processes and Product Use	905.20	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	905.20
2.A - Mineral Industry	842.15	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
2.B - Chemical Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
2.C - Metal Industry	63.04	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
2.D - Non-Energy Products from Fuels and Solvent Use	NE	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
2.E - Electronics Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE	NE	
2.G - Other Product Manufacture and Use	NO	NO	NO	NE	NE	NE	NE	NE	NE	NE	NE	NE	
2.H - Other	NO	NO	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE	
3 - Agriculture, Forestry, and Other Land Use	-36,169.89	261.13	3.50	NO	NO	NO	NO	NO	NE	NE	NE	NE	-29,600.8
3.A - Livestock	NA	168.54	0.68	NA	NA	NA	NA	NA	NE	NE	NE	NE	
3.B - Land	-36,164	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
3.C - Aggregate sources and non-CO2 emissions sources on land	1.38	92.59	2.81	NA	NA	NA	NA	NA	NE	NE	NE	NE	
3.D - Other	-7.28	NO	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE	
4 - Waste	7.78	8.59	0.30	NO	NO	NO	NO	NO	NE	NE	NE	NE	283.22
4.A - Solid Waste Disposal	NA	1.10	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	
4.B - Biological Treatment of Solid Waste	NA	3.60	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
4.C - Incineration and Open Burning of Waste	7.78	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	

[26] Footnote 24

4.D - Wastewater Treatment and Discharge	NA	3.87	0.30	NA	NA	NA	NA	NA	NE	NE	NE	NE	
4.E - Other (please specify)	NO	NO	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE	
5 - Other	0	0	0	NO	NO	NO	NO	NO	NE	NE	NE	NE	
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NA	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
5.B - Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE	
Memo Items (5)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE	
International Bunkers	110.75	0.0008	0.0031	NO	NO	NO	NO	NO	NE	NE	NE	NE	111.73
1.A.3.a.i - International Aviation (International Bunkers)	110.75	0.0008	0.0031	NA	NA	NA	NA	NA	NE	NE	NE	NE	
1.A.3.d.i - International water-borne navigation (International bunkers)	NE	NE	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE	
1.A.5.c - Multilateral Operations	NE	NE	NE	NO	NO	NO	NO	NO	NE	NE	NE	NE	

Table 10 Key Sources Analysis Approach 1 Level Assessment [27]

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	Greenhouse gas	2010 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total of Column F
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	-45,598.94	45,598.94	0.6882	0.6882
3.B.2.b	Land Converted to Cropland	CARBON DIOXIDE (CO2)	6,803.67	6,803.67	0.1027	0.7909
3.A.1	Enteric Fermentation	METHANE (CH4)	3,003.25	3,003.25	0.0453	0.8362
3.B.6.b	Land Converted to Other land	CARBON DIOXIDE (CO2)	2,809.76	2,809.76	0.0424	0.8786
1.A.3.b	Road Transportation	CARBON DIOXIDE (CO2)	1,863.18	1,863.18	0.0281	0.9067
3.C.7	Rice cultivations	METHANE (CH4)	1,850.94	1,850.94	0.0279	0.9347
3.C.4	Direct N2O Emissions from managed soils	NITROUS OXIDE (N2O)	847.58	847.58	0.0128	0.9475
2.A.1	Cement production	CARBON DIOXIDE (CO2)	839.8	839.8	0.0127	0.9602

[27] Footnote 24

3.3 GREENHOUSE GAS EMISSIONS BY SECTOR

3.3.1 ENERGY SECTOR

Lao PDR, in general as well as the inventory year, 2010, uses all type of energy: solid, liquid and gas. Some such as fuel oils are mainly imported, while the rest or majority is domestically produced. Electricity used in the country in 2010 was totally produced from hydropower and there was no fossil-based electricity and heat production in that time. The first coal-fired power was operated in the country in 2015 (MEM, 2018). The import, production, and consumption of fuels such as fuel oils, gas, coals, and biomass in 2010 were summarized in the Table 11 below.

Table 11 Energy production, important and consumption in Lao PDR in 2010 [28]

Type of Fuels	Import (t)	Domestic producti-on (t)	Export (t)	Consumption (t)						Balance (t)	Sources
Liquid				**Transport**	**Industry**	**Agriculture**	**Commercial**	**Reside-ntial**	**Others**		
Gasoline	187,755.27	-		152,885.10	-	-	-	-		34,870.17	Lao Fuel and Gas Association, 2017 and MEM,2018
Jet Kerosene[2]	13,359	-		13,359	-	-	-	-		0.066	
Diesel Oil[3]	688,907.148	-		654,122	34,462	323.31	-	-		0.15	
Fuel Oil	10,067.350	-		-	9,717	-	-	-		350.35	
Lubricants[4]	2,551.78	-		2,551.78	-	-	-	-		0	
Biodiesel(B100)[5]	-	127		-	-	127	-	-		0	IREP,2016
Gas											
LPG[6]	2,314	-		-	-	-	1,431	883		512	MEM,2018
Solid[7]											
Anthracite	-	212,000		-	114,000	-	-	-	98,000	0	MEM,2018
Lignite	-	501,600	445,000	-	47,000	-	-	-	37,000	0	
Fuelwood[8]		3,628			155		2,946	527			
Charcoal[9]		186			-		95	91			

Notes:

1. *Gasoline consisted of the Gasoline GR 91 and GR 95, which were 210,367.873 tonnes and 2,581.705 tonnes respectively (LFGA,2017). Based on expert judgment; 30% of gasoline was used by the passenger cars, 10% by light-duty trucks and 60% by motorbike.*
2. *Based on expert judgment; 40% of diesel was used by the passenger cars, 25% by light-duty trucks and 35% by heavy-duty trucks and buses.*
3. *Based on expert judgment; all jet kerosene was used in the aviation industry, 50% international and 50% domestic aviation.*
4. *Lao Fuel and Gas Association (2017) reported 1,594.126 tonnes of lubricants imported, while MEM (2017) reported 2,551.78 tonnes. MEM (2017) data was used for the inventory. Based on expert judgment; 50% of the lubricants was used by the passenger cars and motorbikes, 25% by light-duty trucks and 25% by heavy-duty trucks and buses.*
5. *Assumed that 100% of the biodiesel was used in the agriculture sector since the biodiesel was only useable by tractors.*
6. *MEM (2018) reported that in 2010 the imported LPG was 1,510 tonnes, but consumption in the commercial and residential sector were 1,431 tonnes and 883 tonnes, respectively. This inventory assumed that the imported LPG would be 2,314 tonnes.*
7. *The production and consumption of anthracite and lignite are different from what were reported in MEM (2018), which reported that anthracite and lignite production in 2010 were 212,000 tonnes and 522,000 tonnes, respectively. Export of lignite production in 2010 were 445,000 tonnes, it means only 77,000 tonnes of lignite were consumed in the country in 2010. Data from Lao Statistics Bureau (2010) reported that anthracite and lignite production in 2010 were 217,000 tonnes and 501,600 tonnes, respectively but it was unclear whether there was any export of the coal or not. However, based on consultations with stakeholders, the data in MEM (2018) were used in the updated inventory. in addition, based on expert judgment, it was assumed that 100% of the anthracite and lignite were used in the industrial sector.*
8. *MEM (2018) reported that fuelwood production was 2,101 kt but reported its consumption were in the commercial 2,946 kt, residential 527 kt and industrial sector 155 kt in 2010. It was assumed that total charcoal production was 3,628 kt in the year 2010.*
9. *MEM (2018) reported that charcoal production was 95 kt but reported its consumption were 95 kt in the commercial and 91 kt in residential sector in 2010. It was assumed that total charcoal production was 186,000 tonnes in the year 2010.*

[28] Ministry of Energy and Mines (2018). Energy Statistics 2018

GHG inventory of the Energy Sector covered estimation of emissions from 1) Fuels Combustion (1A) in all sectors and 2) Fugitive Emissions from the fuels (1B). The emissions from the Carbon Dioxide Transportation and Storage (1C) were not estimated due to it is applicable.

Based on the data above and the use of 2006 IPCC software including default emission factors for estimation, the energy sector including fuels production and consumption emitted 2,882.40 Gg of CO_2, 0.375Gg CH_4 and 0.096Gg NO_2 or 2,920.04 Gg CO_{2eq}, which was equivalent to 27 % of the national total GHG emissions in 2010, as mentioned in section 3.2. Of which, emissions from fuel combustion accounted for about 99.94% and the rest was from fugitive emissions from coal mining. By sector, fuel combustion in transportation was the largest source of emissions, which accounted for approximately 6,685% (or 1,922.87 Gg CO_{2eq}), followed by fuel combustion in manufacturing and construction sector, which accounted for about 34% (981.26 Gg CO_{2eq}). Emissions from fuel combustion in energy industry and other sectors, which shared less than 0.1% (Figure 15). As mentioned in the section 3.2, there was emissions from international banker as well, particularly aviation, which emitted 111.74 GgCO2eq (Table 12).

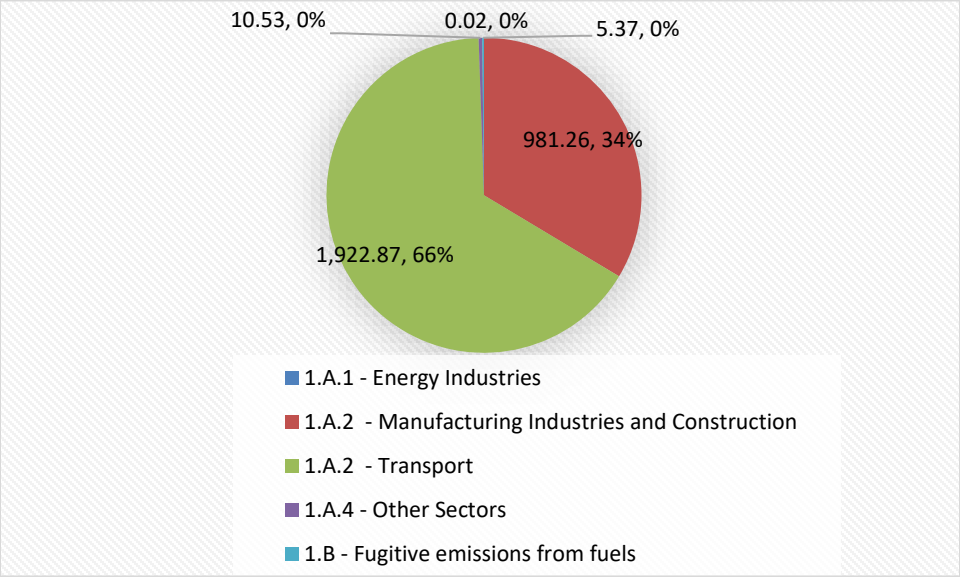


Figure 15 Emissions from Energy Sector[29]

[29] Footnote 24

Table 12 Emissions from Energy Sector[30]

Categories	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
1 - Energy	2,882.402	0.375	0.096	0	0	0	0
1.A - Fuel Combustion Activities	2,877.037	0.375	0.096	0	0	0	0
1.A.1 - Energy Industries		0.001	0.000	0	0	0	0
1.A.1.a - Main Activity Electricity and Heat Production				0	0	0	0
1.A.1.a.i - Electricity Generation	NA	NA	NA	IE	IE	IE	IE
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	NA	NA	NA	NO	NO	NO	NO
1.A.1.a.iii - Heat Plants	NA	NA	NA	NO	NO	NO	NO
1.A.1.b - Petroleum Refining	NA	NA	NA	NO	NO	NO	NO
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries		0.001	0.000	0	0	0	0
1.A.1.c.i - Manufacture of Solid Fuels	NA	0.001	0.000	NE	NE	NE	NE
1.A.1.c.ii - Other Energy Industries	NA	NA	NA	NO	NO	NO	NO
1.A.2 - Manufacturing Industries and Construction	975.56	0.079	0.013	0	0	0	0
1.A.2.a - Iron and Steel	NA	NA	NA	NE	NE	NE	NE
1.A.2.b - Non-Ferrous Metals	NA	NA	NA	NE	NE	NE	NE
1.A.2.c - Chemicals	NA	NA	NA	NE	NE	NE	NE
1.A.2.d - Pulp, Paper and Print	NA	NA	NA	NE	NE	NE	NE
1.A.2.e - Food Processing, Beverages and Tobacco	NA	NA	NA	NE	NE	NE	NE
1.A.2.f - Non-Metallic Minerals	NA	NA	NA	NE	NE	NE	NE
1.A.2.g - Transport Equipment	NA	NA	NA	NE	NE	NE	NE
1.A.2.h - Machinery	NA	NA	NA	NE	NE	NE	NE
1.A.2.i - Mining (excluding fuels) and Quarrying	NA	NA	NA	NE	NE	NE	NE
1.A.2.j - Wood and wood products	NA	NA	NA	NE	NE	NE	NE
1.A.2.k - Construction	NA	NA	NA	NE	NE	NE	NE
1.A.2.l - Textile and Leather	NA	NA	NA	NE	NE	NE	NE
1.A.2.m - Non-specified Industry	975.56	0.079	0.013	NE	NE	NE	NE
1.A.3 - Transport	1,891.32	0.27	0.083	NE	NE	NE	NE
1.A.3.a - Civil Aviation	8.96	0.000	0.000	NE	NE	NE	NE
1.A.3.a.i - International Aviation (International Bunkers) (1)	IE	IE	IE	IE	IE	IE	IE
1.A.3.a.ii - Domestic Aviation	8.96	0.000	0.000	NE	NE	NE	NE
1.A.3.b - Road Transportation	1,863.19	0.27	0.083	NE	NE	NE	NE
1.A.3.b.i - Cars	559.44	0.11	0.028	NE	NE	NE	NE
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	559.44	0.11	0.028	NE	NE	NE	NE
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	NA	NA	NA	NE	NE	NE	NE
1.A.3.b.ii - Light-duty trucks	604.23	0.052	0.032	0	0	0	0
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	NA	NA	NA	NE	NE	NE	NE
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	NA	NA	NA	NE	NE	NE	NE
1.A.3.b.iii - Heavy-duty trucks and buses	487.85	0.003	0.013	NE	NE	NE	NE
1.A.3.b.iv - Motorcycles	211.65	0.101	0.010	NE	NE	NE	NE
1.A.3.b.v - Evaporative emissions from vehicles	NA	NA	NA	NE	NE	NE	NE
1.A.3.b.vi - Urea-based catalysts (3)	NO	NA	NA	NO	NO	NO	NO
1.A.3.c - Railways	NA	NA	NA	NE	NE	NE	NE
1.A.3.d - Water-borne Navigation	19.16	0.002	0.000	NE	NE	NE	NE
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	IE	IE	IE	IE	IE	IE	IE
1.A.3.d.ii - Domestic Water-borne Navigation	19.168	0.002	0.000	NE	NE	NE	NE

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1.A.3.e - Other Transportation	NA	NA	NA	NE	NE	NE	NE
1.A.3.e.i - Pipeline Transport	NA	NA	NA	NO	NO	NO	NO
1.A.3.e.ii - Off-road	NA	NA	NA	NE	NE	NE	NE
1.A.4 - Other Sectors	10.14	0.018	0.000	NE	NE	NE	NE
1.A.4.a - Commercial/Institutional	4.27	0.003	0.000	NE	NE	NE	NE
1.A.4.b - Residential	5.13	0.015	0.000	NE	NE	NE	NE
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	0.73	0.000	0.000	NE	NE	NE	NE
1.A.4.c.i - Stationary	NA	NA	NA	NE	NE	NE	NE
1.A.4.c.ii - Off-road Vehicles and Other Machinery	0.739	0.000	0.000	NE	NE	NE	NE
1.A.4.c.iii - Fishing (mobile combustion)	NA	NA	NA	NE	NE	NE	NE
1.A.5 - Non-Specified	NA	NA	NA	NE	NE	NE	NE
1.A.5.a - Stationary	NA	NA	NA	NE	NE	NE	NE
1.A.5.b - Mobile	NA	NA	NA	NE	NE	NE	NE
1.A.5.b.i - Mobile (aviation component)	NA	NA	NA	NE	NE	NE	NE
1.A.5.b.ii - Mobile (water-borne component)	NA	NA	NA	NE	NE	NE	NE
1.A.5.b.iii - Mobile (Other)	NA	NA	NA	NE	NE	NE	NE
1.A.5.c - Multilateral Operations (1)(2)	NO	NO	NO	NO	NO	NO	NO
1.B - Fugitive emissions from fuels	5.36	NO	NA	NE	NE	NE	NE
1.B.1 - Solid Fuels	5.36	NO	NA	NE	NE	NE	NE
1.B.1.a - Coal mining and handling	5.36	NO	NA	NE	NE	NE	NE
1.B.1.a.i - Underground mines	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.1 - Mining	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.2 - Post-mining seam gas emissions	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.3 - Abandoned underground mines	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.i.4 - Flaring of drained methane or conversion of methane to CO2	NO	NO	NA	NO	NO	NO	NO
1.B.1.a.ii - Surface mines	5.36	NO	NA	NE	NE	NE	NE
1.B.1.a.ii.1 - Mining	2.68	NO	NA	NE	NE	NE	NE
1.B.1.a.ii.2 - Post-mining seam gas emissions	2.68	NO	NA	NE	NE	NE	NE
1.B.1.b - Uncontrolled combustion and burning coal dumps	NA	NA	NA	NE	NE	NE	NE
1.B.1.c - Solid fuel transformation	NA	NA	NA	NE	NE	NE	NE
1.B.2 - Oil and Natural Gas	NA	NA	NA	NO	NO	NO	NO
1.B.2.a - Oil	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.i - Venting	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.ii - Flaring	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii - All Other	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii.1 - Exploration	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii.2 - Production and Upgrading	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii.3 - Transport	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii.4 - Refining	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii.5 - Distribution of oil products	NA	NA	NA	NO	NO	NO	NO
1.B.2.a.iii.6 - Other	NA	NA	NA	NO	NO	NO	NO
1.B.2.b - Natural Gas	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.i - Venting	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.ii - Flaring	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.iii - All Other	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.iii.1 - Exploration	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.iii.2 - Production	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.iii.3 - Processing	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.iii.4 - Transmission and Storage	NA	NA	NA	NO	NO	NO	NO
1.B.2.b.iii.5 - Distribution	NA	NA	NA	NO	NO	NO	NO

1.B.2.b.iii.6 - Other	NA	NA	NA	NO	NO	NO	NO
1.B.3 - Other emissions from Energy Production	NA	NA	NA	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NE	NA	NA	NE	NE	NE	NE
1.C.1 - Transport of CO2	NE	NA	NA	NE	NE	NE	NE
1.C.1.a - Pipelines	NE	NA	NA	NO	NO	NO	NO
1.C.1.b - Ships	NE	NA	NA	NO	NO	NO	NO
1.C.1.c - Other (road)	NE	NA	NA	NE	NE	NE	NE
1.C.2 - Injection and Storage	NO	NA	NA	NO	NO	NO	NO
1.C.2.a - Injection	NO	NA	NA	NO	NO	NO	NO
1.C.2.b - Storage	NO	NA	NA	NO	NO	NO	NO
1.C.3 - Other	NO	NA	NA	NO	NO	NO	NO
Memo Items (3)							
International Bunkers	110.75	0.0008	0.0031	NE	NE	NE	NE
1.A.3.a.i - International Aviation (International Bunkers) (1)	110.75	0.0008	0.0031	NE	NE	NE	NE
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	NA	NA	NA	NE	NE	NE	NE
1.A.5.c - Multilateral Operations (1)(2)	NE	NE	NE	NE	NE	NE	NE
Information Items							
CO2 from Biomass Combustion for Energy Production	7.56	NE	NE	NE	NE	NE	NE

3.3.2 INDUSTRIAL PROCESS AND PRODUCT USE

2006 IPCC guideline and software for GHG inventory covers eight industrial process and product use (2A to 2H), namely mineral, chemical, metal, non-energy products from fuels and solvent, electronics, product uses as substitutes for ozone depleting substances, other product manufacture and use, and other. In Laos, particularly in 2010, there were only two industries that were relevant to the GHG emissions, the mineral industry including cement and lime, and metal industry including iron rod production processes. Industrial products that possibly emit HFCs, PFCs and SF6 such as freezers, fridge, and electronic appliance, etc. were imported and used in Laos, but it lacked data about the quantity of products and HFCs, PFCs and SF6 uses. So, only emissions from cement, lime, iron production processes were reported.

Cement, lime, iron rod production in 2010 were 1,700,000 tones, 3,140 tonnes and 46,701.9 tonnes, respectively[31], without capture and storage of emissions. Based on these production data and default emission factors (EFs) of cement (clinker fraction in cement, 95% and 0.52 tonne CO2/tonne clinker), lime (0.75 tonne CO2/tonne produced), and iron-steel production (1.35 tonne CO2/tonne produced), total emissions from the industries would be 905.20 Gg CO_2 in the inventory year, 2010. Cement industry emitted 839.8 Gg CO2, which accounted for 94.93% of the total emissions. The rest were emissions from lime and iron production, which were about 2.36 Gg CO2 (0.26%) and 63.05 Gg CO2 (5.25%), respectively (Table 11).

The IPPU and emissions increased significantly in comparison with the previous inventory, the 2000, when the emissions from industrial sector as well as cement, lime and iron-steel production was only 48.4 Gg CO2eq However, it was noted that, apart from the amount of the industrial production, the method used in the previous inventory (the revised 1996 IPCC guidelines and UNFCCC software including default emission factors), could slightly contribute to the difference.

[31] Lao Department of Statistics (2011). The Statistical Yearbook 2010. Ministry of Planning and Investment. Vientiane

Table 13 Emissions from IPPU Sector[32]

Categories	(Gg)			CO2 Equivalents(Gg)				(Gg)				
	CO2	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors (1)	Other halogenated gases without CO2 equivalent conversion factors (2)	NOx	CO	NMVOCs	SO2
2 - Industrial Processes and Product Use	905.20	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.A - Mineral Industry	842.15	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.A.1 - Cement production	839.8	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.2 - Lime production	2.35	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.3 - Glass Production	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.4 - Other Process Uses of Carbonates	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE
2.A.4.a - Ceramics	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.4.b - Other Uses of Soda Ash	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.4.c - Non Metallurgical Magnesia Production	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.4.d - Other (please specify) (3)	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.A.5 - Other (please specify) (3)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE
2.B.1 - Ammonia Production	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.2 - Nitric Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.3 - Adipic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	NA	NA	NO	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.5 - Carbide Production	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.6 - Titanium Dioxide Production	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.7 - Soda Ash Production	NE	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.8 - Petrochemical and Carbon Black Production	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE
2.B.8.a - Methanol	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.8.b - Ethylene	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.8.c - Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE

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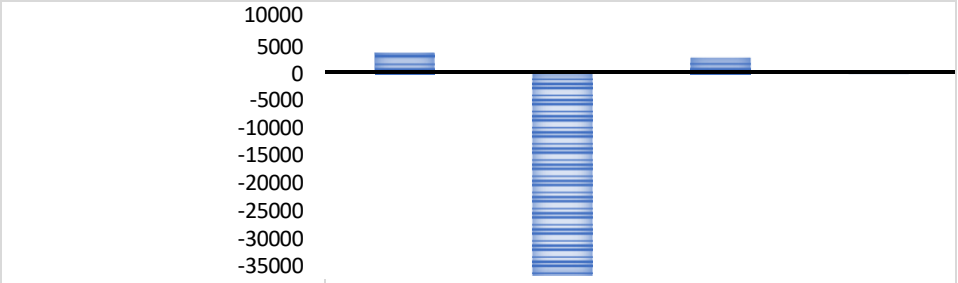
2.B.8.d - Ethylene Oxide	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.8.e - Acrylonitrile	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.8.f - Carbon Black	NO	NO	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.9 - Fluorochemical Production	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE
2.B.9.a - By-product emissions (4)	NA	NA	NA	NE	NA	NA	NA	NA	NE	NE	NE	NE
2.B.9.b - Fugitive Emissions (4)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.B.10 - Other (Please specify) (3)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.C - Metal Industry	63.04	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.C.1 - Iron and Steel Production	63.04	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.C.2 - Ferroalloys Production	NO	NE	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.C.3 - Aluminium production	NO	NA	NA	NA	NO	NA	NA	NA	NE	NE	NE	NE
2.C.4 - Magnesium production (5)	NO	NA	NA	NA	NA	NO	NA	NA	NE	NE	NE	NE
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.C.6 - Zinc Production	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.C.7 - Other (please specify) (3)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.D - Non-Energy Products from Fuels and Solvent Use (6)	NO	NO	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE
2.D.1 - Lubricant Use	NE	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.D.2 - Paraffin Wax Use	NO	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.D.3 - Solvent Use (7)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.D.4 - Other (please specify) (3), (8)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.E - Electronics Industry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.E.1 - Integrated Circuit or Semiconductor (9)	NA	NA	NA	NO	NO	NO	NA	NE	NE	NE	NE	NE
2.E.2 - TFT Flat Panel Display (9)	NA	NA	NA	NA	NO	NO	NA	NE	NE	NE	NE	NE
2.E.3 - Photovoltaics (9)	NA	NA	NA	NA	NO	NA	NA	NA	NE	NE	NE	NE
2.E.4 - Heat Transfer Fluid (10)	NA	NA	NA	NA	NO	NA	NA	NA	NE	NE	NE	NE
2.E.5 - Other (please specify) (3)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.F.1 - Refrigeration and Air Conditioning	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.F.1.a - Refrigeration and Stationary Air Conditioning	NA	NA	NA	NE	NA	NA	NA	NA	NE	NE	NE	NE
2.F.1.b - Mobile Air Conditioning	NA	NA	NA	NE	NA	NA	NA	NA	NE	NE	NE	NE

2.F.2 - Foam Blowing Agents	NA	NA	NA	NE	NA	NA	NA	NE	NE	NE	NE	NE
2.F.3 - Fire Protection	NA	NA	NA	NE	NE	NA	NA	NA	NE	NE	NE	NE
2.F.4 - Aerosols	NA	NA	NA	NE	NA	NA	NA	NE	NE	NE	NE	NE
2.F.5 - Solvents	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE	NE
2.F.6 - Other Applications (please specify) (3)	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE	NE
2.G - Other Product Manufacture and Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.1 - Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.1.a - Manufacture of Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE
2.G.1.b - Use of Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE
2.G.1.c - Disposal of Electrical Equipment	NA	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE
2.G.2 - SF6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.2.a - Military Applications	NA	NA	NA	NA	C	C	NA	NA	NE	NE	NE	NE
2.G.2.b - Accelerators	NA	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE
2.G.2.c - Other (please specify) (3)	NA	NA	NA	NA	NE	NE	NA	NA	NE	NE	NE	NE
2.G.3 - N2O from Product Uses	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.G.3.a - Medical Applications	NA	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.G.3.b - Propellant for pressure and aerosol products	NA	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.G.3.c - Other (Please specify) (3)	NA	NA	NE	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.G.4 - Other (Please specify) (3)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H - Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2.H.1 - Pulp and Paper Industry	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.2 - Food and Beverages Industry	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE
2.H.3 - Other (please specify) (3)	NA	NA	NA	NA	NA	NA	NA	NA	NE	NE	NE	NE

2.3.4 AGRICULTURE, FORESTRY AND OTHER LAND USE

This GHG inventory emissions from the Agriculture, Forestry and Other Land Use (AFOLU) sector, in accordance with the 2006 IPCC guidelines and software, covered (1) emissions from livestock (3A), (2) emissions and removals due to land use and land use change (3B), (3) aggregate sources and non-CO2 emission from land (3C), and (4) other (3D).

AFOLU sector had a negative or removal of 36,169.89 Gg of CO_2, but released about 261.14 Gg CH_4 and 3.50 Gg NO_2 , resulting net sink of 26,900.8 GgCO2eq in 2010. Total removals of the sector, as mentioned, were 36,169.89 GgCO2eq, while its total emissions were 6,570.47 GgCO2eq. The removals were mainly from land remaining forest land, other lands converted to forest land and cropland remaining cropland (Table 14). Emissions from livestock including enteric fermentation and livestock manure management were 168.55Gg CH4 and 0.68 GgN2O or 3,750.83 GgCO2eq. Emissions from aggregate sources including open burning of biomass 2,819.64 Gg. (Figure 16).



	3.A Livestock	3.B Land	3. C Aggregate source and non-CO2 emissions sources on land	3.D Other (Harvested Wood Products)
Emissions (+)/Removals (-)	3,750.8	-36,164	2,819.64	-7.28

Figure 16 Net emissions from AFOLU sector in 2010.[33]

[33] Footnote 24

Table 14 Emissions from AFOLU sector in 2010[34]

Categories	(Gg)					
	Net CO2 emissions / removals	Emissions				
		CH4	N2O	NOx	CO	NMVOCs
3 - Agriculture, Forestry, and Other Land Use	- 36,169.89	261.13	3.50	NE	NE	NE
3.A - Livestock	NO	168.54	0.68	NE	NE	NE
3.A.1 - Enteric Fermentation	NO	143.01	NO	NE	NE	NE
3.A.1.a - Cattle	NO	73.35	NO	NE	NE	NE
3.A.1.a.i - Dairy Cows	NA	4.08	NA	NE	NE	NE
3.A.1.a.ii - Other Cattle	NA	69.27	NA	NE	NE	NE
3.A.1.b - Buffalo	NA	65.06	NA	NE	NE	NE
3.A.1.c - Sheep	NA	NE	NA	NE	NE	NE
3.A.1.d - Goats	NA	1.83	NA	NE	NE	NE
3.A.1.e - Camels	NA	NO	NA	NE	NE	NE
3.A.1.f - Horses	NA	0.006	NA	NE	NE	NE
3.A.1.g - Mules and Asses	NA	NO	NA	NE	NE	NE
3.A.1.h - Swine	NA	2.75	NA	NE	NE	NE
3.A.1.j - Other (please specify)	NA	NO	NA	NE	NE	NE
3.A.2 - Manure Management (1)	NO	25.53	0.68	NE	NE	NE
3.A.2.a - Cattle	NO	3.33	0.25	NE	NE	NE
3.A.2.a.i - Dairy cows	NA	1.86	0.04	NE	NE	NE
3.A.2.a.ii - Other cattle	NA	1.47	0.21	NE	NE	NE
3.A.2.b - Buffalo	NA	2.36	0.13	NE	NE	NE
3.A.2.c - Sheep	NA	NO	NO	NE	NE	NE
3.A.2.d - Goats	NA	0.08	0.017	NE	NE	NE
3.A.2.e - Camels	NA	NO	NO	NE	NE	NE
3.A.2.f - Horses	NA	0.001	0.000	NE	NE	NE
3.A.2.g - Mules and Asses	NA	NE	NE	NE	NE	NE
3.A.2.h - Swine	NA	19.27	0.06	NE	NE	NE
3.A.2.i - Poultry	NA	0.48	0.20	NE	NE	NE
3.A.2.j - Other (please specify)	NA	NO	NO	NE	NE	NE
3.B - Land	- 36,164	NE	NE	NE	NE	NE
3.B.1 - Forest land	- 4,5691.78	NE	NE	NE	NE	NE
3.B.1.a - Forest land Remaining Forest land	- 45,598.94	NA	NA	NE	NE	NE
3.B.1.b - Land Converted to Forest land	-92.83	NE	NE	NE	NE	NE
3.B.1.b.i - Cropland converted to Forest Land	-130.81	NA	NA	NE	NE	NE
3.B.1.b.ii - Grassland converted to Forest Land	38.64	NA	NA	NE	NE	NE
3.B.1.b.iii - Wetlands converted to Forest Land	-0.32	NA	NA	NE	NE	NE
3.B.1.b.iv - Settlements converted to Forest Land	-0.11	NA	NA	NE	NE	NE
3.B.1.b.v - Other Land converted to Forest Land	-0.23	NA	NA	NE	NE	NE
3.B.2 - Cropland	6,641.51	NE	NE	NE	NE	NE
3.B.2.a - Cropland Remaining Cropland	-162.15	NA	NA	NE	NE	NE
3.B.2.b - Land Converted to Cropland	6,803.67	NE	NE	NE	NE	NE
3.B.2.b.i - Forest Land converted to Cropland	6,699.14	NA	NA	NE	NE	NE
3.B.2.b.ii - Grassland converted to Cropland	104.03	NA	NA	NE	NE	NE
3.B.2.b.iii - Wetlands converted to Cropland	0.54	NA	NA	NE	NE	NE

[34] Footnote 24

3.B.2.b.iv - Settlements converted to Cropland	NO	NA	NA	NE	NE	NE
3.B.2.b.v - Other Land converted to Cropland	-0.05	NA	NA	NE	NE	NE
3.B.3 - Grassland	-13.26	NE	NE	NE	NE	NE
3.B.3.a - Grassland Remaining Grassland	0	NA	NA	NE	NE	NE
3.B.3.b - Land Converted to Grassland	-13.26	NE	NE	NE	NE	NE
3.B.3.b.i - Forest Land converted to Grassland	1.30	NA	NA	NE	NE	NE
3.B.3.b.ii - Cropland converted to Grassland	-14.55	NA	NA	NE	NE	NE
3.B.3.b.iii - Wetlands converted to Grassland	NO	NA	NA	NE	NE	NE
3.B.3.b.iv - Settlements converted to Grassland	NO	NA	NA	NE	NE	NE
3.B.3.b.v - Other Land converted to Grassland	-0.01	NA	NA	NE	NE	NE
3.B.4 - Wetlands	NE	NE	NE	NE	NE	NE
3.B.4.a - Wetlands Remaining Wetlands	NE	NE	NE	NE	NE	NE
3.B.4.a.i - Peatlands remaining peatlands	NE	NA	NE	NE	NE	NE
3.B.4.a.ii - Flooded land remaining flooded land	NA	NA	NA	NE	NE	NE
3.B.4.b - Land Converted to Wetlands	NE	NE	NE	NE	NE	NE
3.B.4.b.i - Land converted for peat extraction	NA	NA	NE	NE	NE	NE
3.B.4.b.ii - Land converted to flooded land	NE	NA	NA	NE	NE	NE
3.B.4.b.iii - Land converted to other wetlands	NA	NA	NA	NE	NE	NE
3.B.5 - Settlements	89.76	NE	NE	NE	NE	NE
3.B.5.a - Settlements Remaining Settlements	NO	NA	NA	NE	NE	NE
3.B.5.b - Land Converted to Settlements	89.76	NE	NE	NE	NE	NE
3.B.5.b.i - Forest Land converted to Settlements	45.20	NA	NA	NE	NE	NE
3.B.5.b.ii - Cropland converted to Settlements	40.20	NA	NA	NE	NE	NE
3.B.5.b.iii - Grassland converted to Settlements	4.33	NA	NA	NE	NE	NE
3.B.5.b.iv - Wetlands converted to Settlements	0.01	NA	NA	NE	NE	NE
3.B.5.b.v - Other Land converted to Settlements	NO	NA	NA	NE	NE	NE
3.B.6 - Other Land	2,809.76	NE	NE	NE	NE	NE
3.B.6.a - Other land Remaining Other land	NA	NA	NA	NE	NE	NE
3.B.6.b - Land Converted to Other land	2,809.76	NE	NE	NE	NE	NE
3.B.6.b.i - Forest Land converted to Other Land	2,705.65	NA	NA	NE	NE	NE
3.B.6.b.ii - Cropland converted to Other Land	25.96	NA	NA	NE	NE	NE
3.B.6.b.iii - Grassland converted to Other Land	78.05	NA	NA	NE	NE	NE
3.B.6.b.iv - Wetlands converted to Other Land	NO	NA	NA	NE	NE	NE
3.B.6.b.v - Settlements converted to Other Land	0.09	NA	NA	NE	NE	NE
3.C - Aggregate sources and non-CO2 emissions sources on land	1.38	92.592	2.819	NE	NE	NE
3.C.1 - Emissions from biomass burning	NE	4.45	NE	NE	NE	NE
3.C.1.a - Biomass burning in forest lands	NA	4.43	NE	NE	NE	NE
3.C.1.b - Biomass burning in croplands	NA	0.01	NE	NE	NE	NE
3.C.1.c - Biomass burning in grasslands	NA	0.003	NE	NE	NE	NE
3.C.1.d - Biomass burning in all other land	NA	0.001	NE	NE	NE	NE
3.C.2 - Liming	1.38	NA	NA	NE	NE	NE
3.C.3 - Urea application	0.007	NA	NA	NE	NE	NE
3.C.4 - Direct N2O Emissions from managed soils	NA	NA	2.734	NE	NE	NE
3.C.5 - Indirect N2O Emissions from managed soils	NA	NA	NE	NE	NE	NE
3.C.6 - Indirect N2O Emissions from manure management	NA	NA	0.085	NE	NE	NE
3.C.7 - Rice cultivations	NA	88.14	NA	NE	NE	NE
3.C.8 - Other (please specify)	NA	NA	NA	NE	NE	NE
3.D - Other	-7.28	NE	NE	NE	NE	NE
3.D.1 - Harvested Wood Products	-7.28	NA	NA	NE	NE	NE
3.D.2 - Other (please specify)	NA	NA	NA	NE	NE	NE

2.3.5 WASTE SECTOR

GHG inventory in waste sector covered four main sources of emissions from waste sector: solid waste disposal (4A), biological treatment of solid waste (4B), incineration and open burning of solid waste (4C), wastewater treatment and discharge (4D). Other source (4E) was estimated since there was no other source of emissions apart from above. First Order Decay (FOD) method used for estimation of emissions, and GHGs included. Time series data, from 2000 to 2010, which were used in the inventory were mainly collected from urban and housing department as well as urban administration and development agency, ministry of public work and transport.

Solid waste production in Laos has been increased overtime. In 2003, solid waste about 1.268 million tonnes, and then it went up to about 1.647 million tonnes in 2014. Solid waste disposal at site, however, was relatively low. It ranged from about 16% to 31% only, between 2003 and 2014. The rest were dumped, burned, and disposed elsewhere. The recycling was possibly less than 10%. Biological treatment of solid waste, especially compost was small scale and unorganised. Incineration of solid waste was also small scale since there was only a clinical incinerator in the country. Open burning of solid waste still occurred elsewhere. However, it was estimated that only about 0.1% of the unmanaged solid waste was burned in the inventory year, 2010.

Waste sector released 7.79 Gg of $CO_{2,}$ 8.59 Gg CH_4 and 0.31 Gg NO_2 or about 283.22 GgCO2eq in total. Most of the emissions were from wastewater treatment and discharge (176.48 GgCO2eq), which contributed to almost 62% of the total emissions. Solid waste disposal, based on First Order Decay method, could generate 23.25 GgCO2eq in the inventory year. The rest were emissions from biological treatment and solid waste incineration and open burning, which generated 75.70 GgCO2eq (26.72%) and 7.79 GgCO2eq (2.75%), respectively (Figure 17).

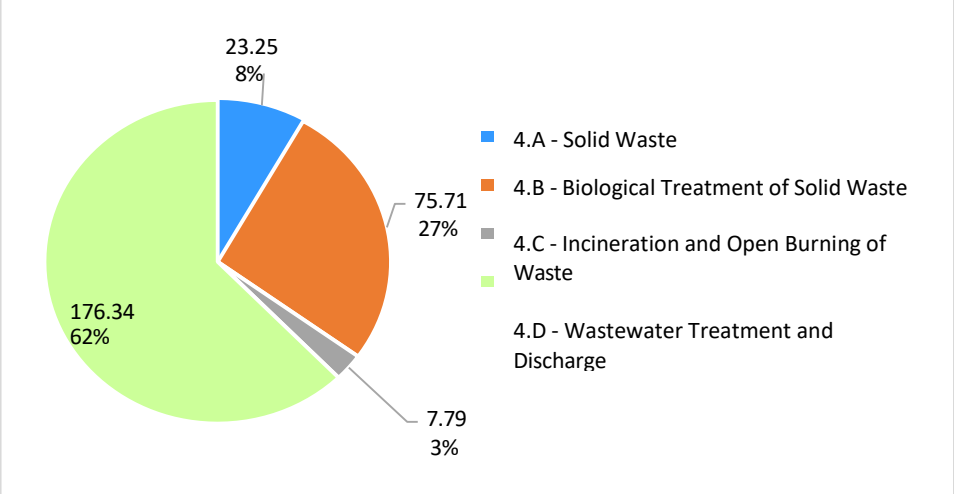


Figure 17 Emissions from Waste Sector[35]

[35] Footnote 24

Table 15 Emissions from Waste Sector[36]

Categories	Emissions [Gg]						
	CO2	CH4	N2O	NOx	CO	NMVOCs	SO2
4 - Waste	7.79	8.59	0.30	NE	NE	NE	NE
4.A - Solid Waste Disposal	NO	1.10	NE	NE	NE	NE	NE
4.A.1 - Managed Waste Disposal Sites	NA	NA	NA	NE	NE	NE	NE
4.A.2 - Unmanaged Waste Disposal Sites	NA	NA	NA	NE	NE	NE	NE
4.A.3 - Uncategorized Waste Disposal Sites	NA	NA	NA	NE	NE	NE	NE
4.B - Biological Treatment of Solid Waste	NA	3.60	NE	NE	NE	NE	NE
4.C - Incineration and Open Burning of Waste	7.79	NE	NE	NE	NE	NE	NE
4.C.1 - Waste Incineration	6.38	NE	NE	NE	NE	NE	NE
4.C.2 - Open Burning of Waste	1.41	NE	NE	NE	NE	NE	NE
4.D - Wastewater Treatment and Discharge	NO	3.88	0.30	NE	NE	NE	NE
4.D.1 - Domestic Wastewater Treatment and Discharge	NA	3.12	0.30	NE	NE	NE	NE
4.D.2 - Industrial Wastewater Treatment and Discharge	NA	0.75	NA	NE	NE	NE	NE
4.E - Other (please specify)	NA	NA	NA	NE	NE	NE	NE

CHAPTER 4 PROGRAMMES CONSTAINING MEASURES TO FACILITATE ADEQUATE ADAPTATION

4.1 INTRODUCTION

Information on climate change vulnerability and adaption was not provided in the First National Communication (FNC) (2000), but the Second National Communication (SNC) highlighted that Laos is particularly at risk of floods and drought. Recent assessment and findings indicated that Lao PDR, as an LDC with limited adaptive capacities, is highly vulnerable to the impacts of climate change. Moreover, it is predicted that future climate phenomenon and risks would be even worse, and without adequate capacity development capacity to manage the current and projected risks, the country will be exposed to even higher climate risks and impacts in the future. To enhance adaptive capacity and reduce impacts, Lao PDP has put in place adaption plans, while capacity and the implementation remains limited.

This chapter provides an updated climate change assessment, vulnerabilities including assessment of climate change impacts on water resources and agriculture sector. In addition, it also revisited and updated measures for climate change adaption. Constraints, gaps and support needs are identified and described Chapter 7.

4.2 CLIMATE CHANGE VULNERABILITY AND IMPACTS

[36] Footnote 24

Climate change vulnerability depends on climate phenomenon, hazards and exposure, sensitivity and capacity of the country. It has been observed that Lao PDR experiences climate change and variability, increase of exposure and sensitivity, while adaptive and resilient capacity remains low, as described in the following sections (Figure 18). The vulnerability assessments reported under TNC were mainly derived by desk review.

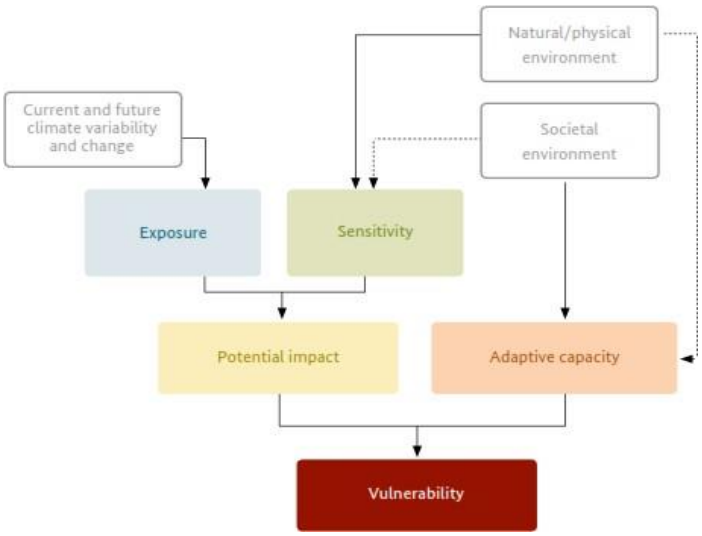


Figure 18 Vulnerability Assessment Conceptual Framework

Studies on climate change impacts or risks under TNC included desk review and case studies of the climate change impacts on agriculture and water resources sector as it is the most vulnerable sectors, which were selected by consultation within TNC team and key stakeholders. So did the tools such as framework, tools: AQUEDUCT Global Flood Analyser, the Soil & Water Assessment Tool (SWAT), and scenarios which were selected based on TNC team and key stakeholders, considering its applicability and availability of data, resources, capacity and time.

4.2.1 HISTORICAL CLIMATE

SNC (2013) provided an observation of climate change using a regression analysis showed that the annual mean temperature in the Lao PDR has increased with a rate of about 0.05 °C/year in the past 30 years, from 1970 to 2010.

An assessment conducted in 2016 found that that, in general, the temperature in Lao PDR consistently increased with a rate 0.022°C/year, with the maximum and minimum temperature increase of 0.017°C/year and 0.023°C/year, respectively, over the past 30 years (1976- 2005) (Figure 19). Spatial pattern of annual mean minimum and maximum temperature were similar, especially in the southern, where both minimum and maximum temperature substantially increased (Figure 20).

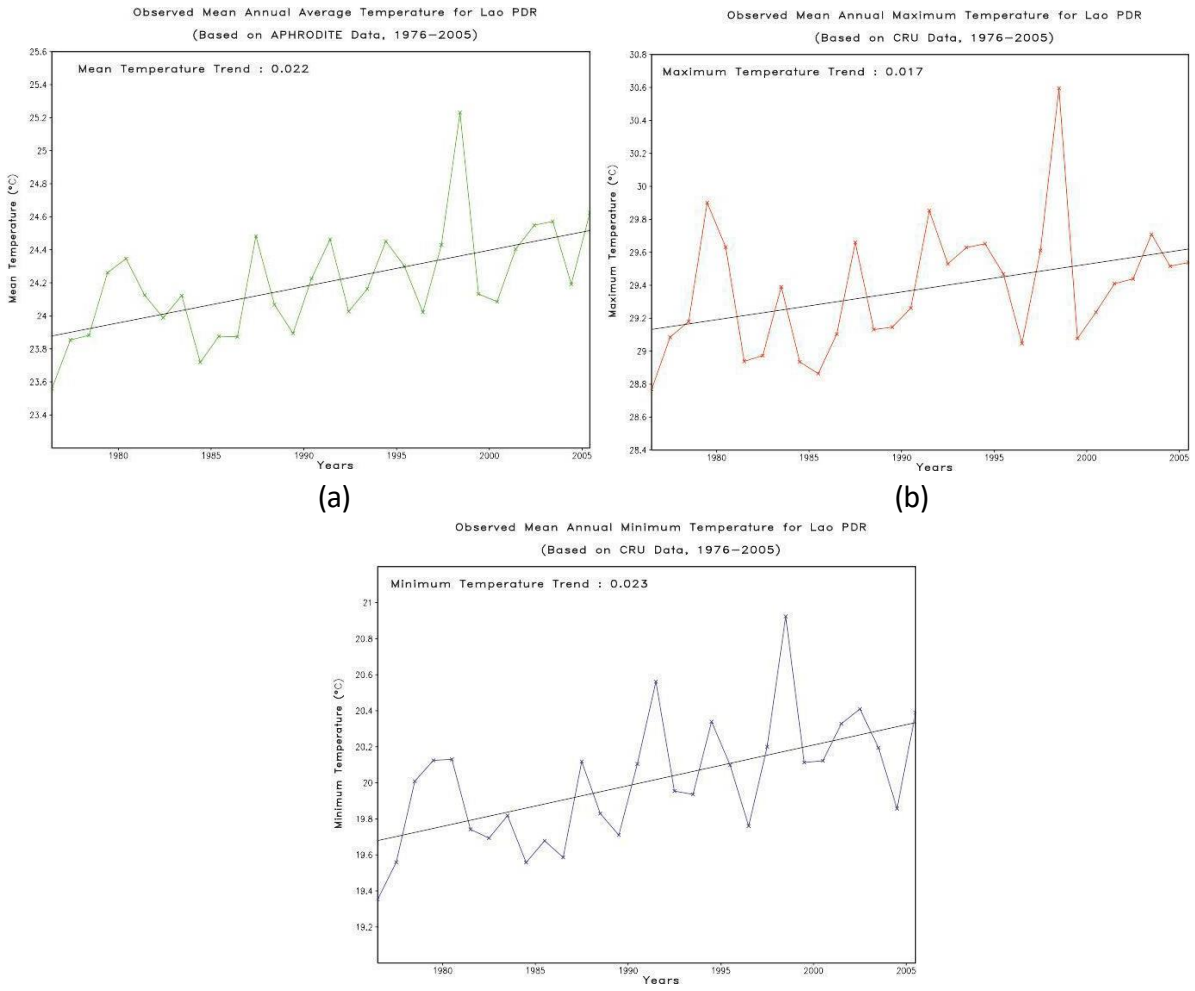


Figure 19 Mean Annual Average (a), The Minimum (b) and Maximum Temperature (c) 1976- 2005[37]

[37] The Department of Disaster Management and Climate Change, MoNRE (2016). Report on the Historical Climate Change, Climate Vulnerability and Climate Change Projection for Lao PDR

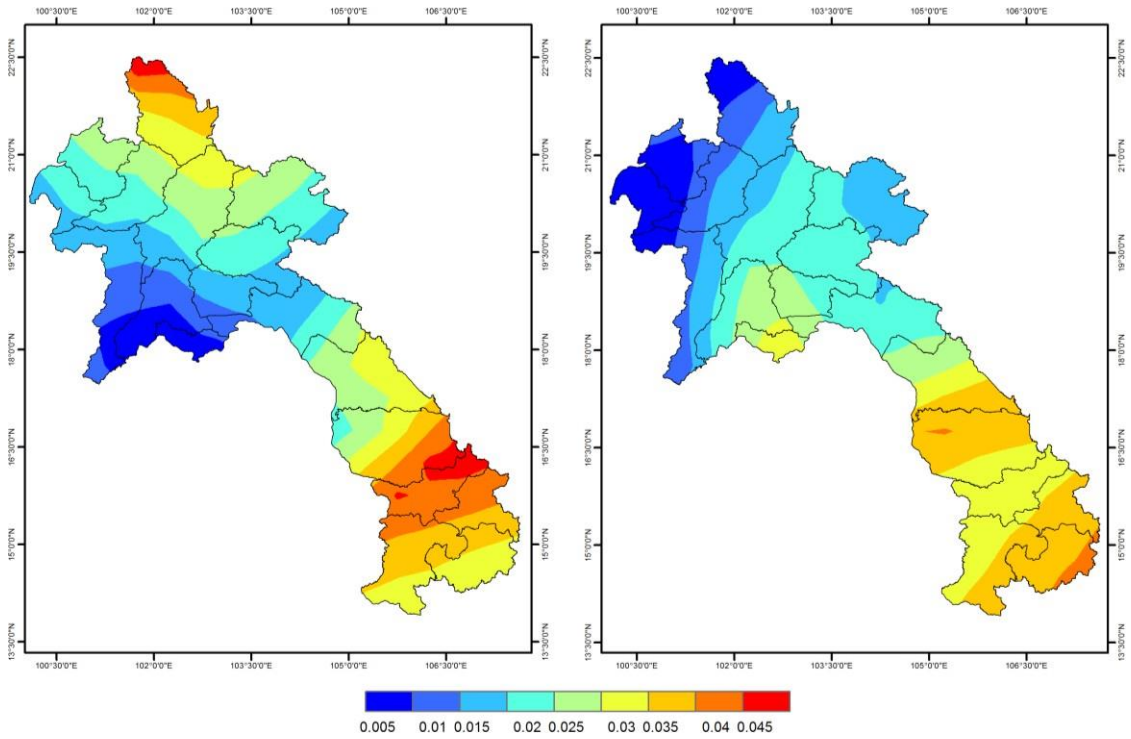


Figure 20 Figure 20 Spatial pattern of annual mean minimum (left) and maximum temperature trend (°) (right) cover Laos for the period 1976-2005 using CRU data[38]

Looking at the 10 years interval, both mean maximum and minimum temperature in each region and province remarkably varied. The mean maximum temperature tended to increase, while minimum temperature tended to decrease through the country.

Between 1976 and 1885, the mean maximum temperature of the country increased about 0.6°cm, while it ranged from -0.6 to 0.02 °c. The temperature trended to decrease in several provinces, especially the Northern provinces, while it increased in the central and a top northern province (Figure 21). Between 1986 and 1995, the difference in the mean maximum temperature ranged from -1 to 0.1°c, but increased in the south and decreased in the north. The difference in the mean maximum temperature between 1996 and 2005 ranged from -1 and 0.1°c like the 1986 and 1995 period (Figure 22), but it was in opposite direction, where the temperature in the north declined, but increased in the south between 1996 and 2005. (Figure 23).

[38] Footnote 37

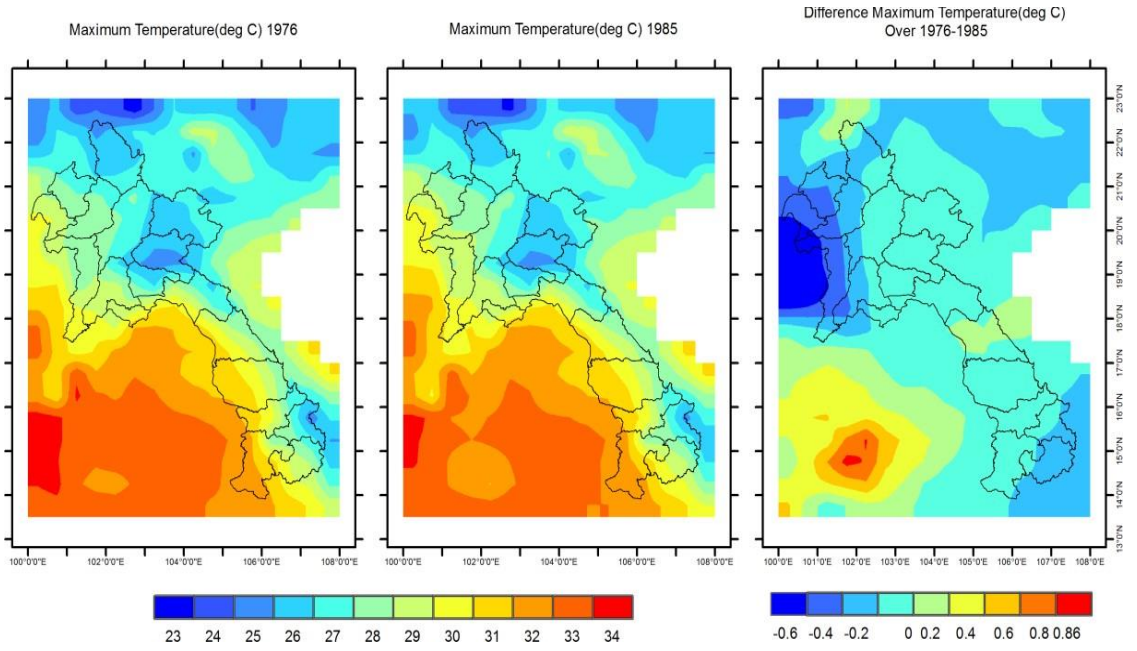


Figure 21 Figure 21 Changes in Maximum Temperature 1976-1985.[39]

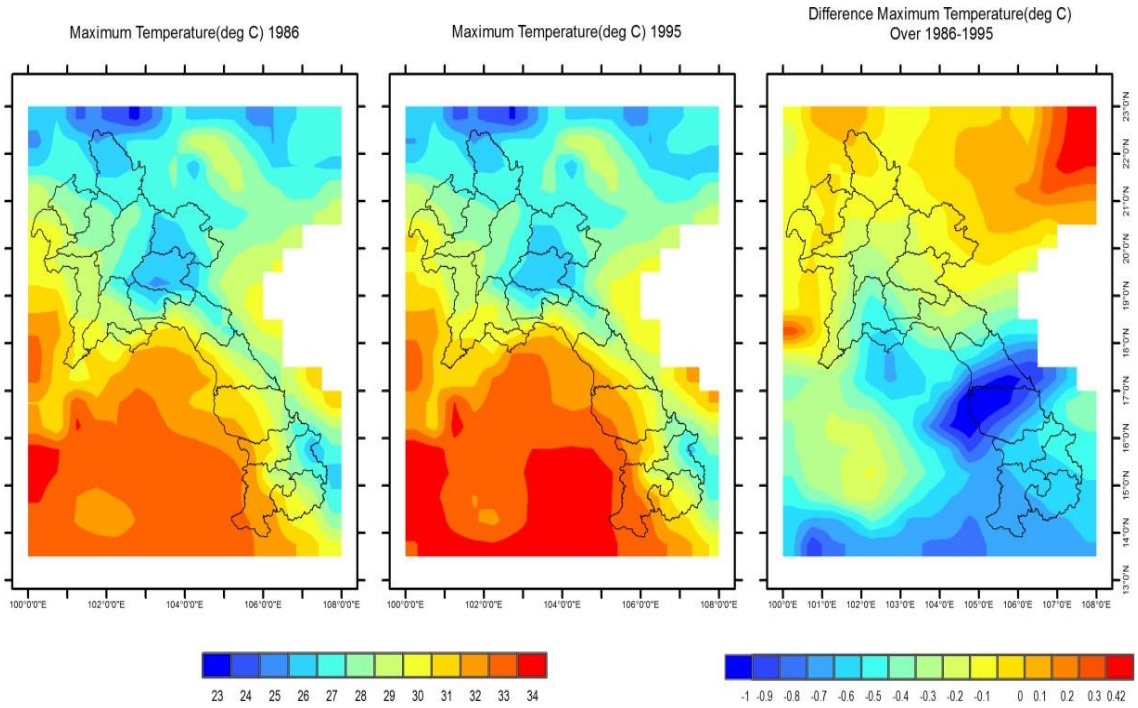


Figure 22 Figure 22 Changes in Maximum Temperature 1986-1995.[40]

[39] Footnote 37
[40] Footnote 37

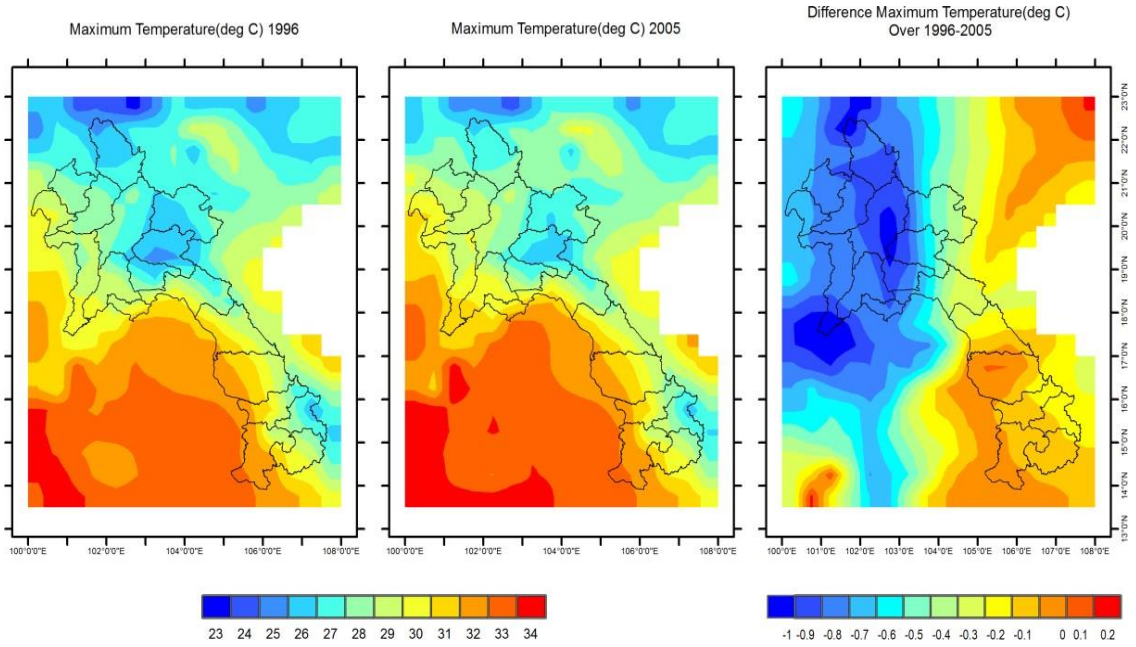


Figure 23 Figure 23 Changes in Maximum Temperature 1996-2005[41]

The difference in the mean minimum temperature between 1976 and 1985 ranged from -0.9 to 0.2 °c. (Figure 24) and the different minimum temperature between 1986 and 1995 ranged -0.8 to 0.1 °c. (Figure 25). Between 1995 and 2005, the different minimum temperature tended to decrease through the country. The lowest temperature was found in the western part of Khammuan and Savannakhet province, where the temperature was down to -0.9 °c (Figure 26).

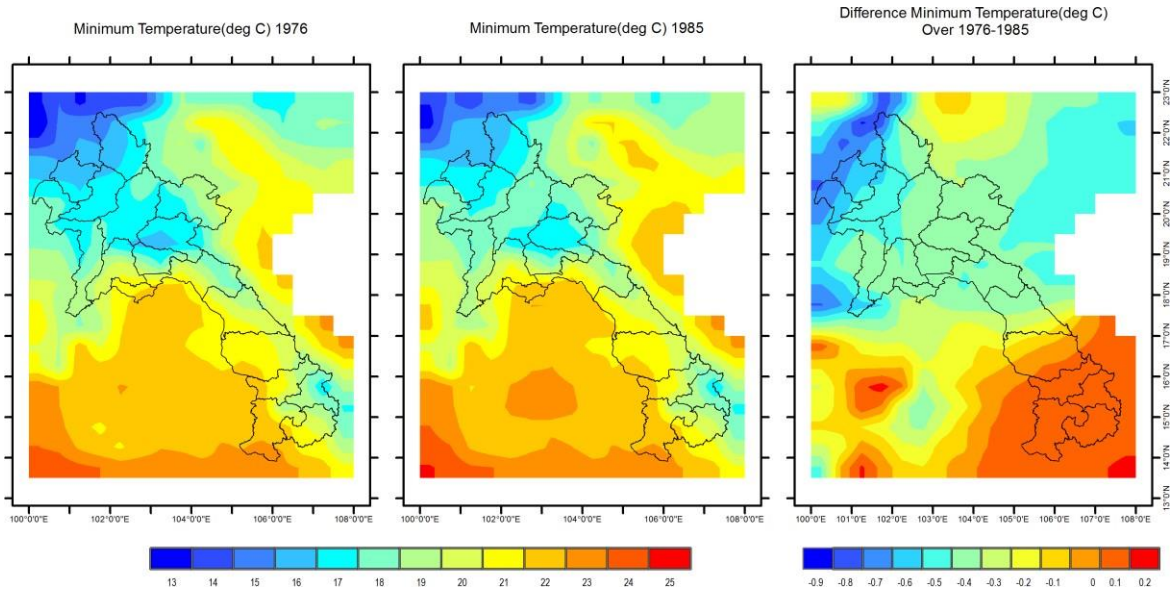


Figure 24 Changes in Minimum Temperature 1976-1985[42]

[41] Footnote 37
[42] Footnote 37

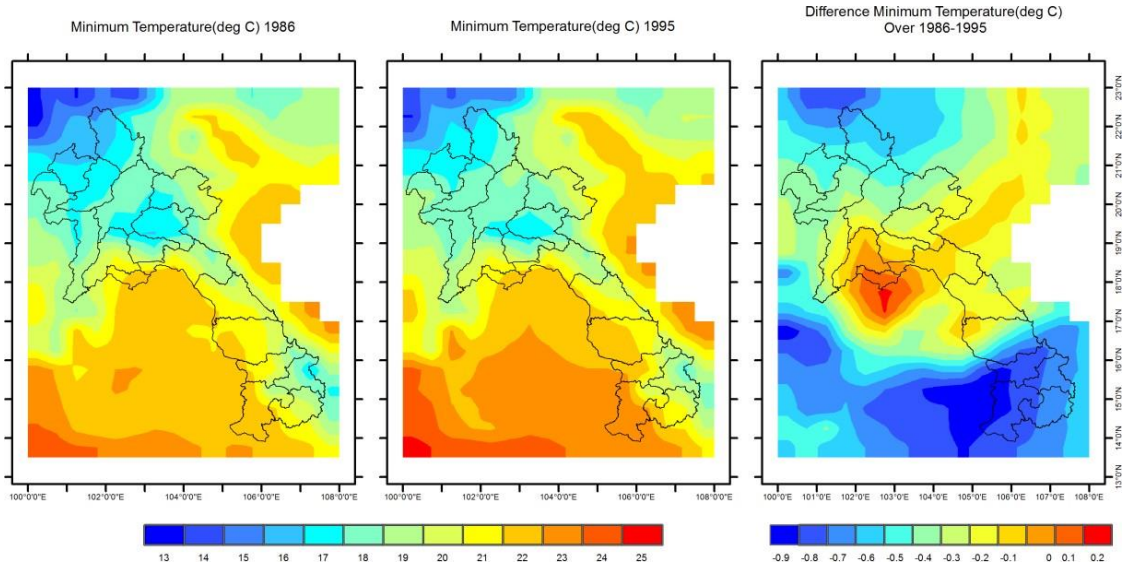


Figure 25 Changes in Minimum Temperature 1986-1995[43]

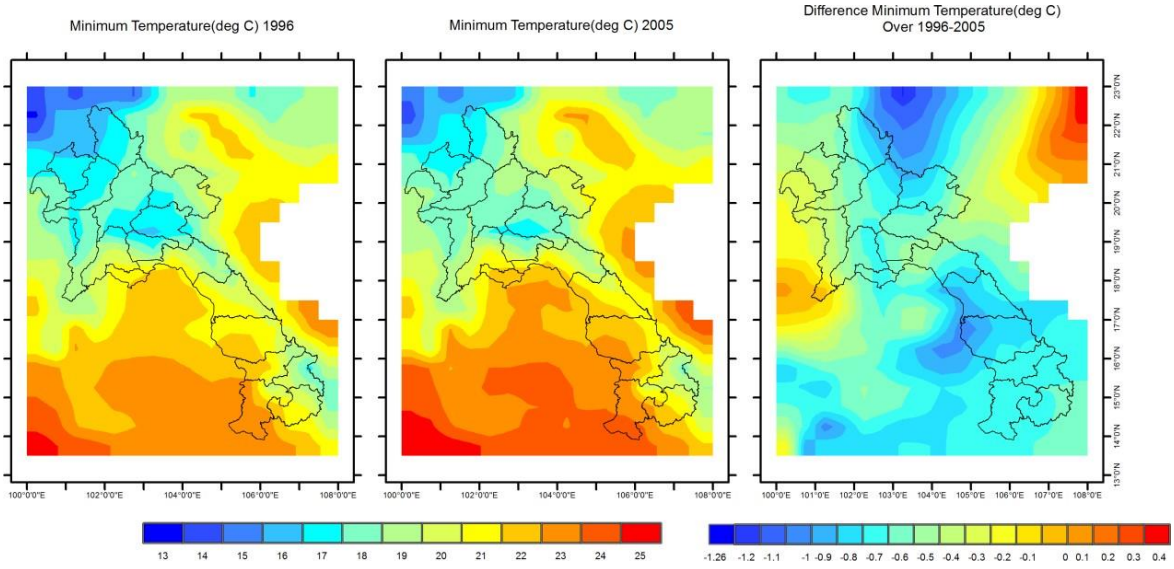


Figure 26 Changes in Minimum Temperature 1996-2005[44]

[43] Footnote 37
[44] Footnote 37

4.2.2 PROJECTED CLIMATE TRENDS

4.2.2.1 Temperature

In the future, based on the assessment in 2016 showed that, Lao PDR, especially the east part will experience increased temperature for both short-term (2021-2050) and long-term (2070- 2099) under both RCP 4.5 and RCP 8.5 scenario. Under RCP 4.5 scenario, for short-term (2021- 2050) or 2030s, the average maximum temperature will increase 0.98 to 1.35 °C, and the north part of the country will experience more increase of the temperature in comparison with the south part. For long-term (2070-2099) or 2080s, the average maximum temperature will increase
2.0 to 2.65 °C, and it will increase more in the north part of the country in comparison with the south part. Luang Prabang and Huaphan province, for example, the temperature could rise up to
2.65°C (Figure 27 and 28).

Under RCP 8.5 scenario, the average maximum temperature will increase 1.2 to 1.6 °C for short- term (2021-2050) or 2030s, and it could go up 1.6 °C for Phongsaly province, which is in top north of the Lao PDR. For long-term (2070-2099) or 2080s, the average maximum temperature will increase 3.55 to 4.5 °C, and it will increase more in the north part of the country in comparison with the south part. Phongsaly and Huaphan province, for example, the temperature could rise up to 4.5°C (Figure 29 and 30).

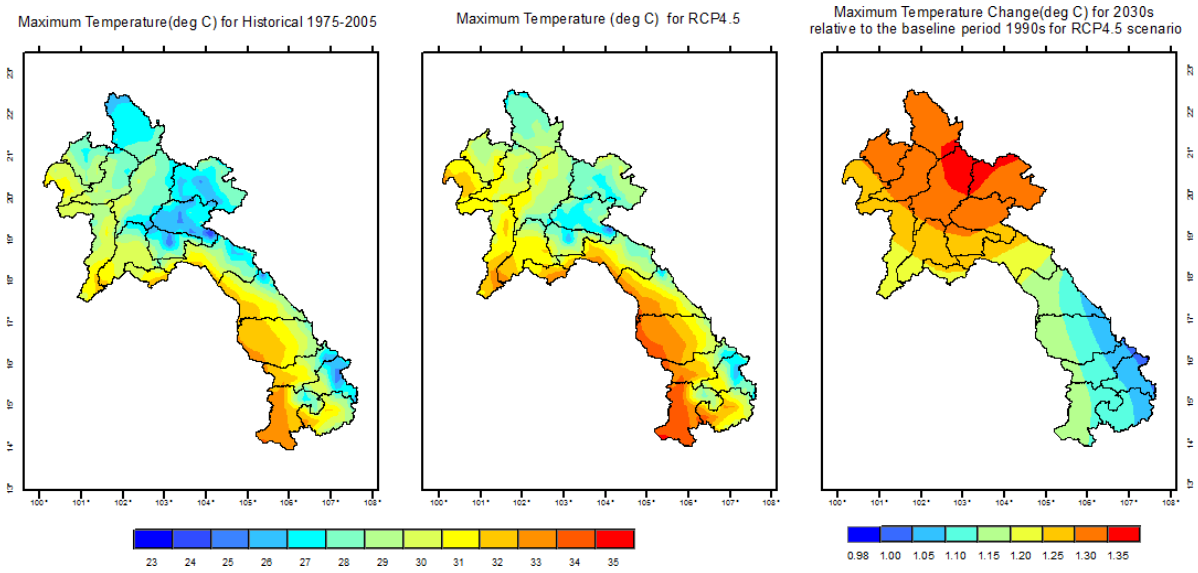


Figure 27 Change in Maximum temperature between Observed and Projected for short-term (2020-2050) under RCP 4.5[45]

[45] Footnote 37

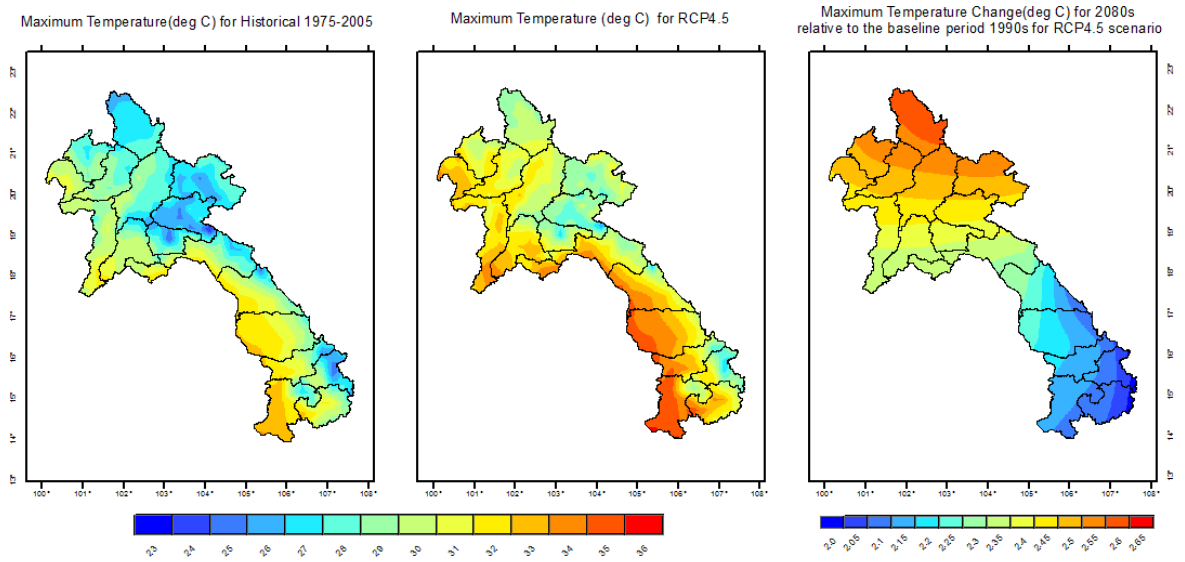


Figure 28 Change in Maximum temperature between Observed and Projected for long-term (2070-2099) under RCP 4.5[46]

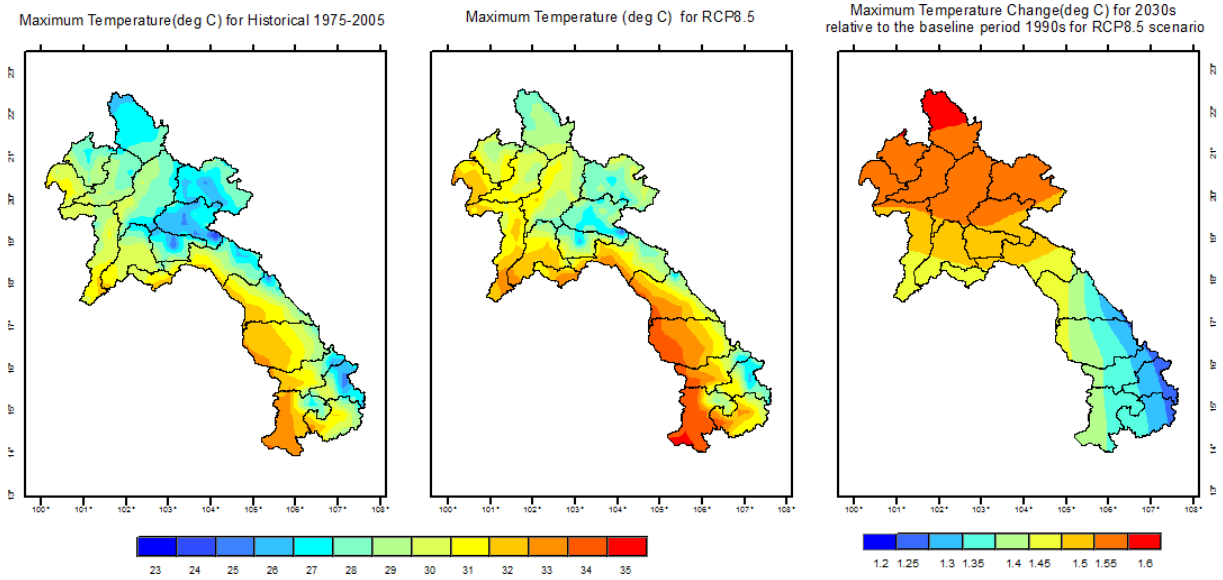


Figure 29 Change in Maximum temperature between Observed and Projected for short-term (2021-2050)-RCP 8.5[47]

[46] Footnote 37
[47] Footnote 37

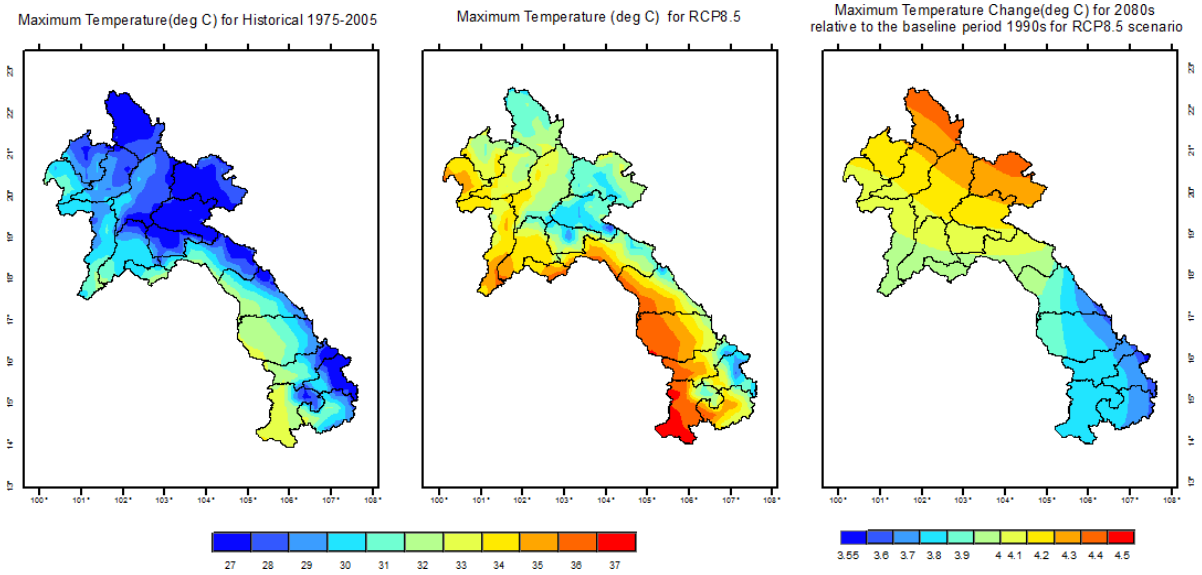


Figure 30 Change in Maximum temperature between Observed and Projected for long-term (2070-2099) RCP 8.5[48]

The projection of the minimum temperature under RCP 4.5 showed that the temperature increases around 1.05 °C to 1.4 °C in several provinces including Phongsaly, Luang Namtha, and Bokeo province for short-term (2021-2050) or 2030s in comparison with the baseline 1975-2005 or 1990s. Under RCP 8.5, the change of minimum temperature is between 1.45 °C to 1.55 °C for the north e.g., Phongsaly, Luang Namtha, Bokeo, Oudomxay, and Xayabouly province. And between 1.2 °C to 1.5 °C for the south (Saravan and Xekong province). For Long-term 2070-2099 or 2080s, the minimum temperature increases 2.4°C to 2.5 °C for the north part and 2°C to 2.2°C for the south part.

For short-term (2021-2050) or 2030s under RCP 8.5, the average minimum temperature increases around 2.0 °C to 2.5 °C in several provinces including Phongsaly, Luang Namtha, and Bokeo province. Under RCP 8.5, the change of minimum temperature is between 1.45 °C to 1.55°C for the north and between 1.2 °C to 1.5 °C for the south (Saravan and Xekong province). For long term RCP 8.5, 2070-2099 or 2080s, the temperature goes up to 4.4 °C, which occurs in Phongsaly and Huaphan province.

[48] Footnote 37

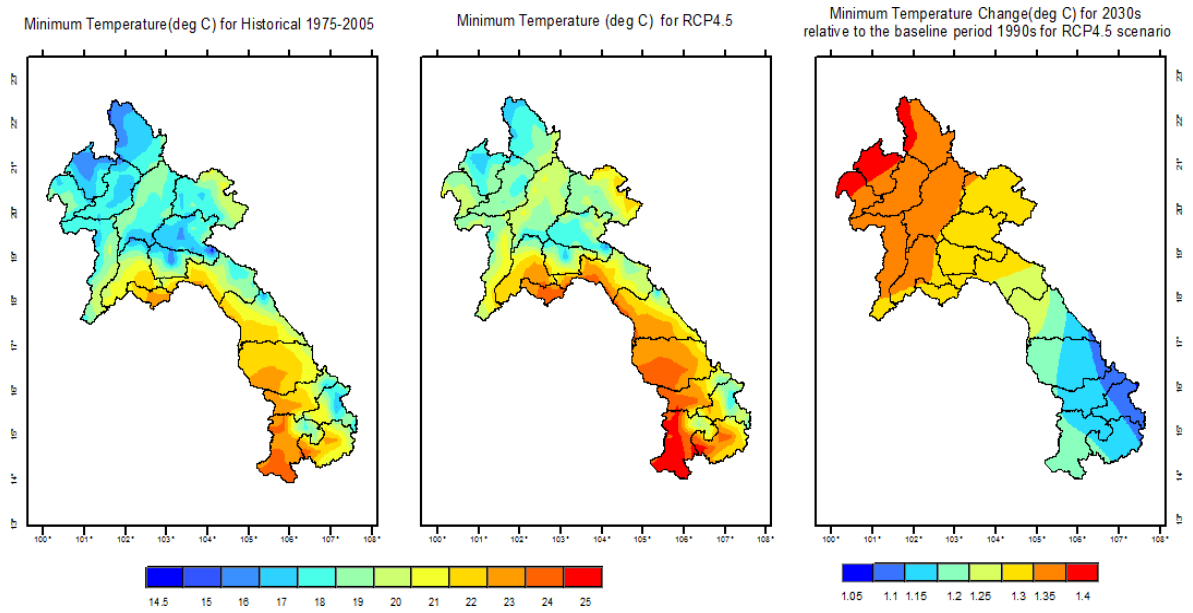


Figure 31 Change in Minimum temperature between Baseline, Observed, and Projected for short-term (2020-2050).[49]

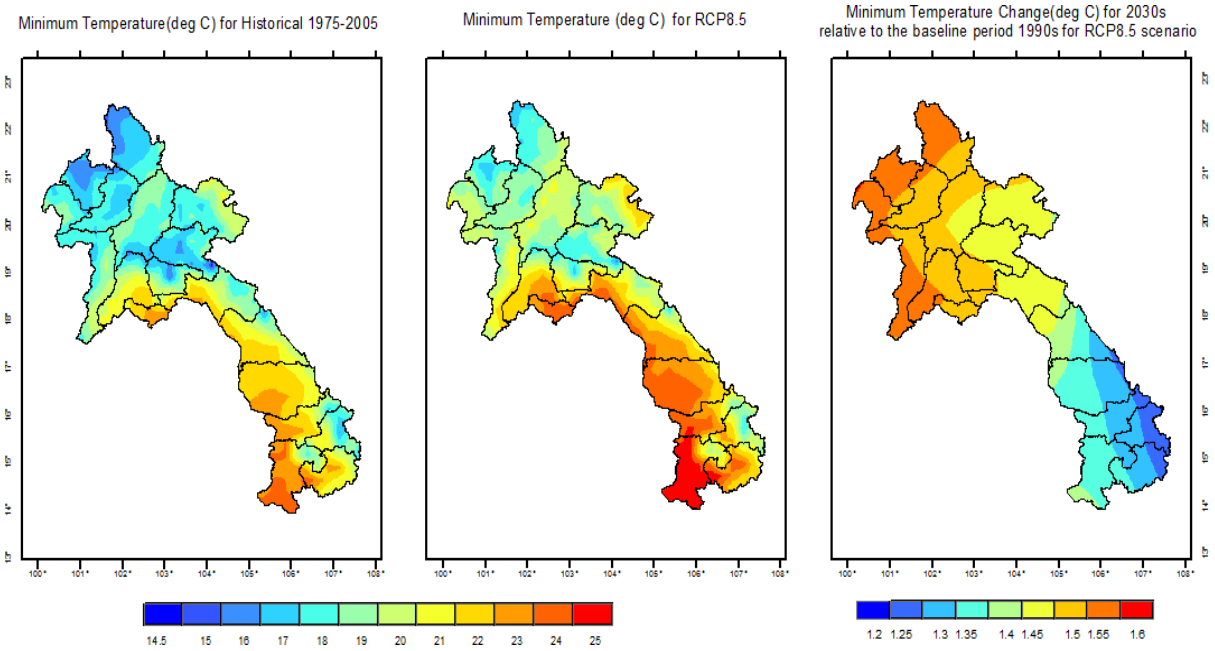


Figure 32 Change in Minimum temperature between Baseline, Observed, and Projected for short-term (2020-2050) RCP 8.5.[50]

[49] Footnote 37
[50] Footnote 37

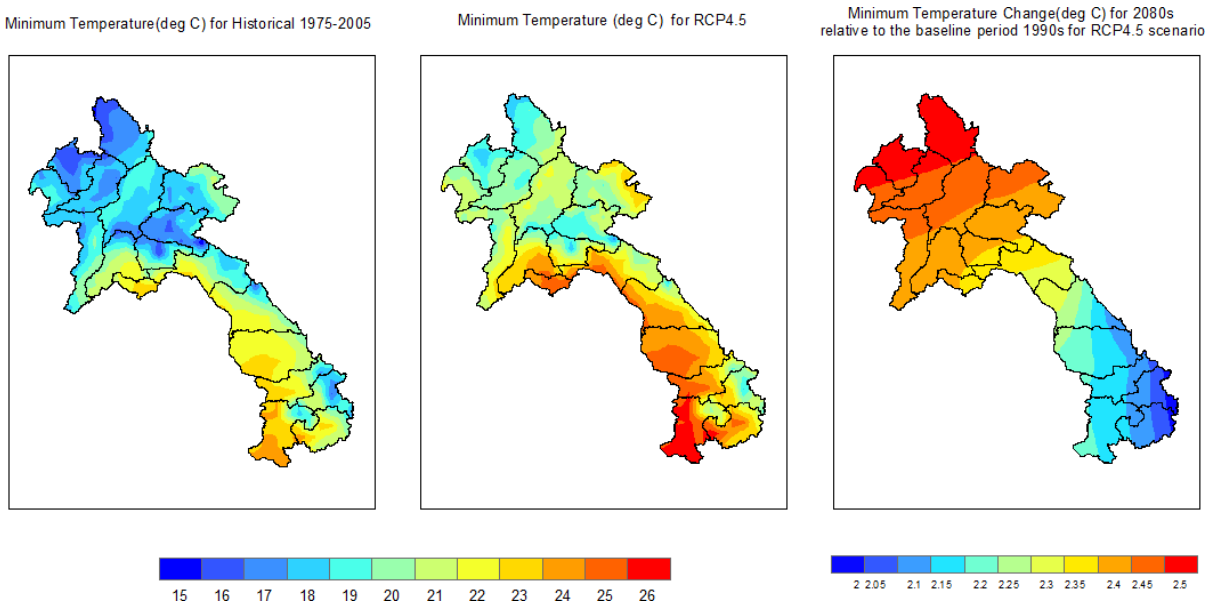


Figure 33 Change in Minimum temperature between Baseline, Observed, and Projected for long-term (2070-2099) RCP 4.5.[51]

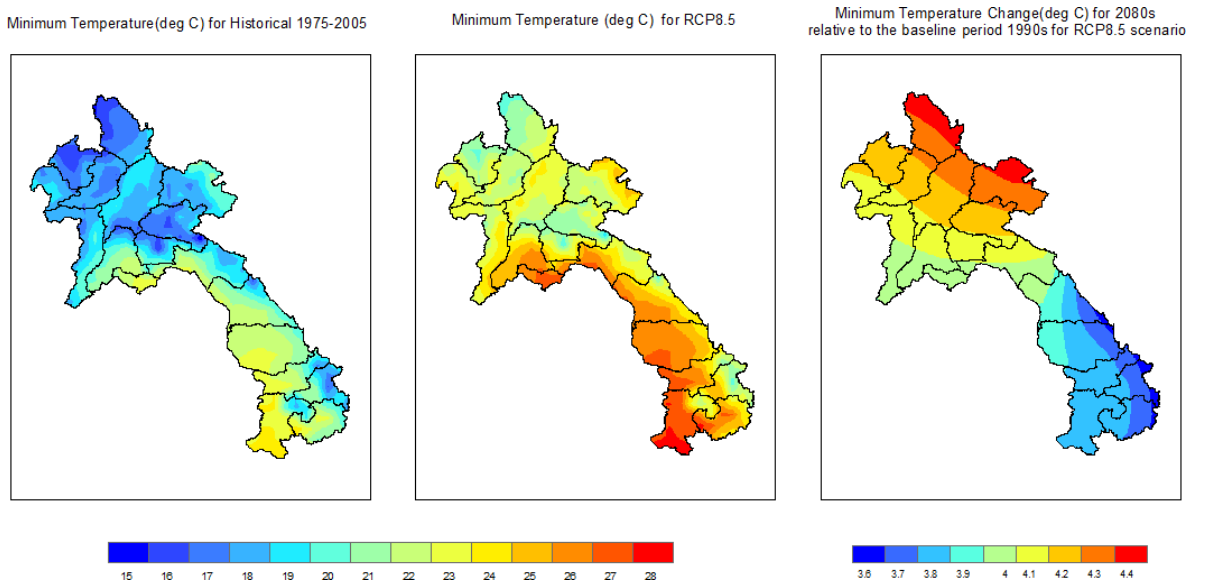


Figure 34 Change in Minimum temperature between Baseline, Observed, and Projected for long-term (2070-2099) RCP 8.5.[52]

[51] Footnote 37
[52] Footnote 37

Looking at the temperature in a month, the minimum temperature increases each month for both short-term (2021-2050 or 2030s) or long-term (2070-2099 or 2080s) under RCP 4.5 and 8.5. For short-term, the projected temperature under RCP 4.5 and 8.5 were 16.01 °C and 25.46 °C and 16.17°C to 25.66°C, respectively. The maximum temperature projected under RCP 4.5 and 8.5 were 27.21 °C and 33.76 °C and 27.41°C to 33.95°C, respectively (Table 16). For long-term, the projected maximum temperature ranged from 28.38 °C to 34.98 °C for under RCP 4.5 and about 29°C to 36°C under RCP 8.5 (Table 17).

Table 16 Monthly maximum and minimum temperature comparison with Baseline, Historical, and Observed for short-term (2021-2050) RCP 4.5 and RCP 8.5.[53]

	Minimum Temperature Short-Term(2021-2050)			Maximum Temperature Short-Term(2021-2050)		
Month	Historical	RCP4.5	RCP8.5	Historical	RCP4.5	RCP8.5
Jan	14.84	16.01	16.17	26.24	27.32	27.67
Feb	16.58	17.49	17.63	28.18	29.00	29.30
Mar	19.26	20.32	20.48	30.67	31.80	31.96
Apr	22.06	23.38	23.57	32.38	33.70	33.86
May	23.63	25.03	25.17	32.38	33.76	33.95
Jun	24.08	25.46	25.66	31.56	32.91	33.19
Jul	23.86	25.18	25.29	30.95	32.29	32.39
Aug	23.62	24.82	25.08	30.68	31.82	32.13
Sep	23.03	24.30	24.56	30.39	31.61	31.88
Oct	21.46	22.70	22.90	29.43	30.58	30.87
Nov	18.58	19.82	19.98	27.74	28.84	29.12
Dec	15.71	16.86	16.96	26.21	27.21	27.41

Table 17 Monthly minimum and maximum temperature comparison with Baseline, Historical, and Observed for long-term (2070-2099) RCP 4.5 and RCP 8.5.[54]

	Minimum Temperature Long-Term(2070-2099)			Maximum Temperature Short-Term(2070-2099)		
Month	Historical	RCP4.5	RCP8.5	Historical	RCP4.5	RCP8.5
Jan	14.84	17.18	18.69	26.24	28.69	29
Feb	16.58	18.76	19.96	28.18	30.32	31
Mar	19.26	21.52	23.26	30.67	32.95	34
Apr	22.06	24.61	26.76	32.38	34.98	36
May	23.63	26.13	28.20	32.38	34.81	36
Jun	24.08	26.42	28.54	31.56	33.94	36
Jul	23.86	26.08	27.95	30.95	33.18	35
Aug	23.62	25.82	27.61	30.68	32.91	34
Sep	23.03	25.32	27.34	30.39	32.62	34
Oct	21.46	23.56	25.62	29.43	31.63	33
Nov	18.58	20.66	22.50	27.74	29.88	31
Dec	15.71	17.87	19.26	26.21	28.38	29

WBG and ADB (2021) reported that temperature in Lao PDR is expected to be rose in line

[53] Footnote 37
[54] Footnote 37

with the global average temperature. The CCKP model showed the mean temperature would be increased 1.2°C to 4.1°C by the 2090s in comparison with the baseline, 1986–2005, under the lowest emissions pathway (RCP2.6) and highest emissions pathway (RCP8.5), respectively. The rises of the minimum and maximum temperatures are expected to be more rapid than the rise in average temperature. The monthly minimum temperature is expected to be rose 10–20% faster, and the greatest rise may be in the hottest months, April and May (Figure 35).

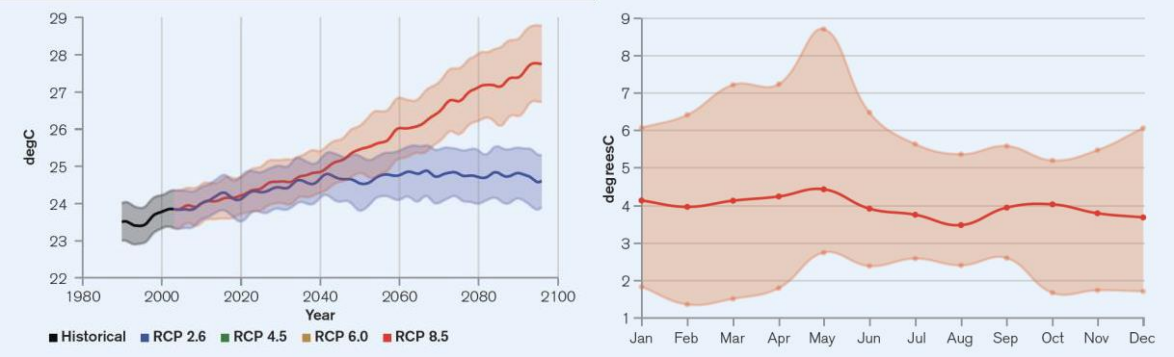


Figure 35 Historic and projected average annual mean temperature in Lao PDR under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble (left) and Projected change (°C) in monthly temperature, shown by month, for Lao PDR for the period 2080–210[55]

Furthermore, as shown in the Figure 36 below, the number of days when ambient temperatures exceed 35°C is projected to increase under all emissions scenarios. Without adequate adaptation measures, annual heat-related deaths in the South- Eastern Asian region, could increase 295% by 2030 and 691% by 2050[56].

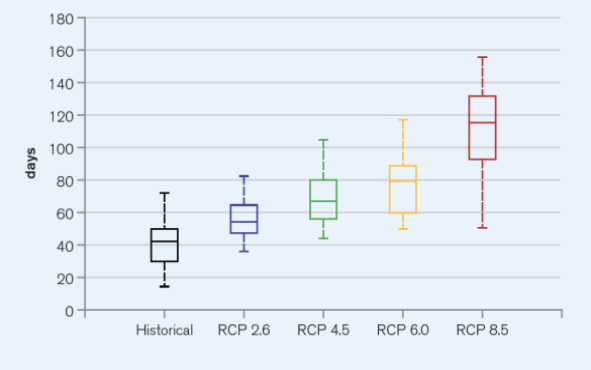


Figure 36 Historical (1986–2005) and projected (2080–2099) number of days per year with temperatures exceeding 35°C under four emissions pathways[57]

[55] The World Bank Group and the Asian Development Bank (2021). Climate Risk Country Profile: Lao PDR
[56] Honda et al. (2014) used the A1B emissions scenario from CMIP3 (most comparable to RCP6.0).
[57] Footnote 55

4.2.2.2 Rainfalls

As described in the SNC, the seasonal and annual rainfalls increased at the rates of 2,046 and 2,741 mm/year for seasonal and annual rainfall, respectively. Based on probability analysis, the frequency of monthly rainfall with intensity of more than 600 mm increased, while those between 300 – 500 mm declined, between 1901 and 2006.

The rainfall slightly increased for the whole three decades. The annual rainfall increased at approximately 1.46 mm/yr. and the seasonal monsoon rainfall increased about 0.5 mm/yr. (Figure 37). However, the number of rainy days, especially those greater than 2.5 cm/day and 5 cm/day tended to decrease. Between 1976 and 1985, number of rainy days with rainfall greater than 2.5 cm/day and 5 cm/day was 139 days and 15 days, respectively and it reduced to 101 days and 16 days between 1985-1995 and 100 days and 3 days between 1995 and 2005.

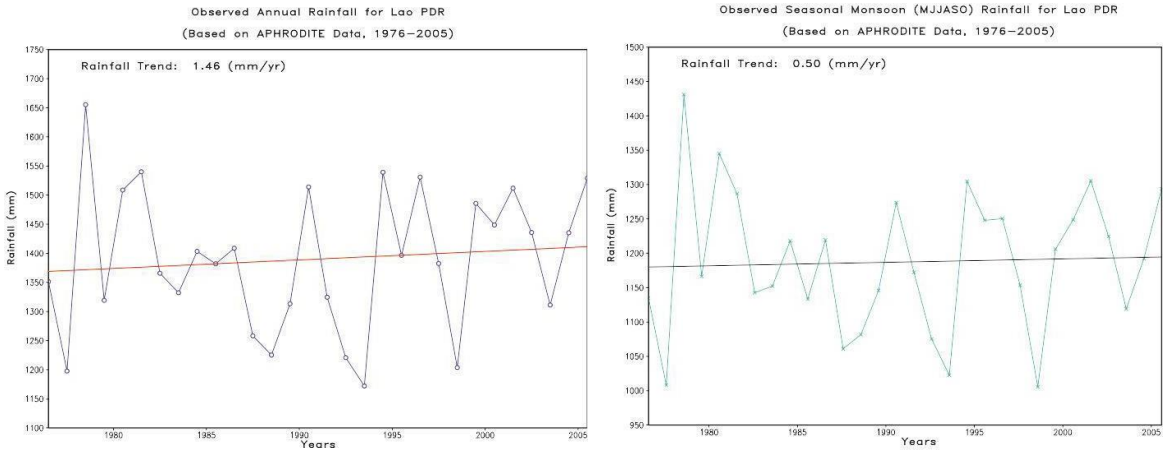


Figure 37 Annual Rainfall Trend for Lao PDR from 1976-2005 (left) and Seasonal Monsoon (MJJASO) Rainfall Trend for Lao PDR from 1976-2005 (right)[58]

Mean annual rainfall over Lao PDR varied from year to year or period to period, and sometimes above or below the normal range. The rainfall was quite high in the central and southern region, where annual and seasonal rainfall reached 2,600 mm and 2,400 mm, respectively (Figure 38), and the annual and seasonal rainfall increased about 31mm and 28mm these central and southern region provinces, especially the earn tern side and along Annamite Range, which border with Vietnam. In contrary, it was drier or deficit of rainfall in other region, especially Luang Prabang and Bokeo, and some parts of Champasack, Aattapue, Sayabouly, Luang Namtha, Oudomxay, Huaphan and Phongsaly province (Figure 39).

The highest rainfall was in 1978, when the rainfall increased nearly 20%. From 1977 to 1993, there was significant decrease of rainfall. In 1977, 1987, 1988, 1992, 1993, and 1999 the rainfall decreased of over 7%. However, it backed to normal from 1994 to 2005 (Figure 40).

[58] Footnote 37

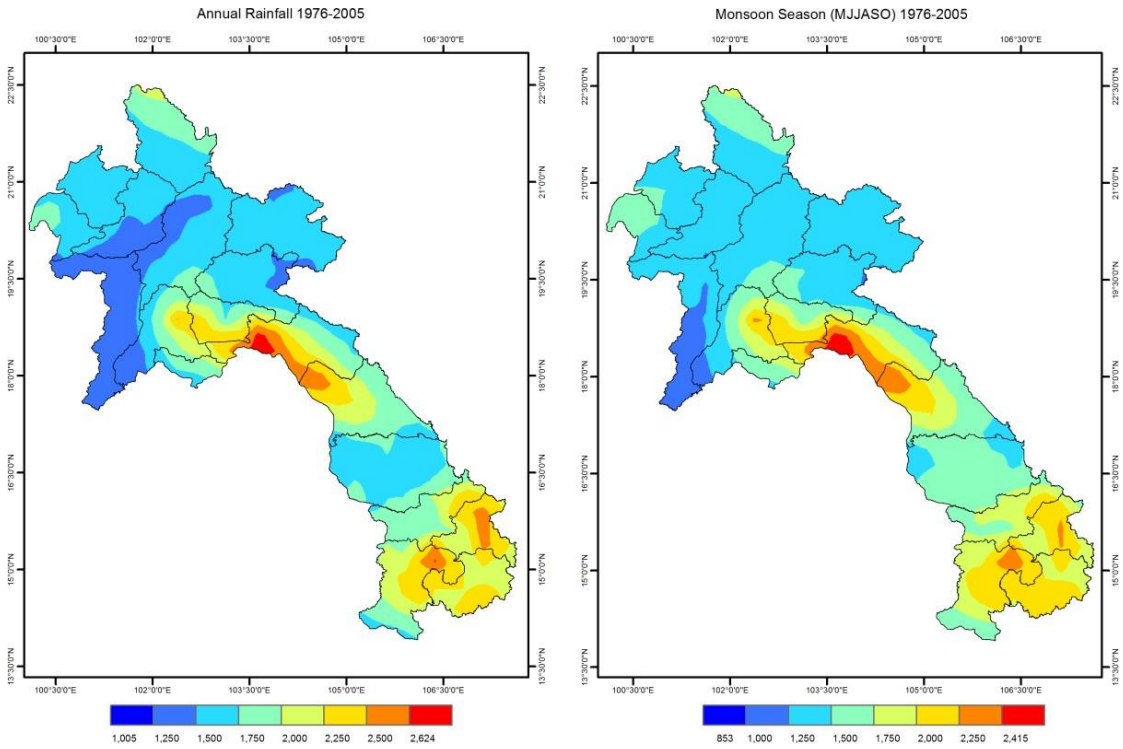


Figure 38 Spatial distribution of Annual Rainfall (mm) and Monsoon Seasonal (May-October) 1976-2005 over Lao PDR.[59]

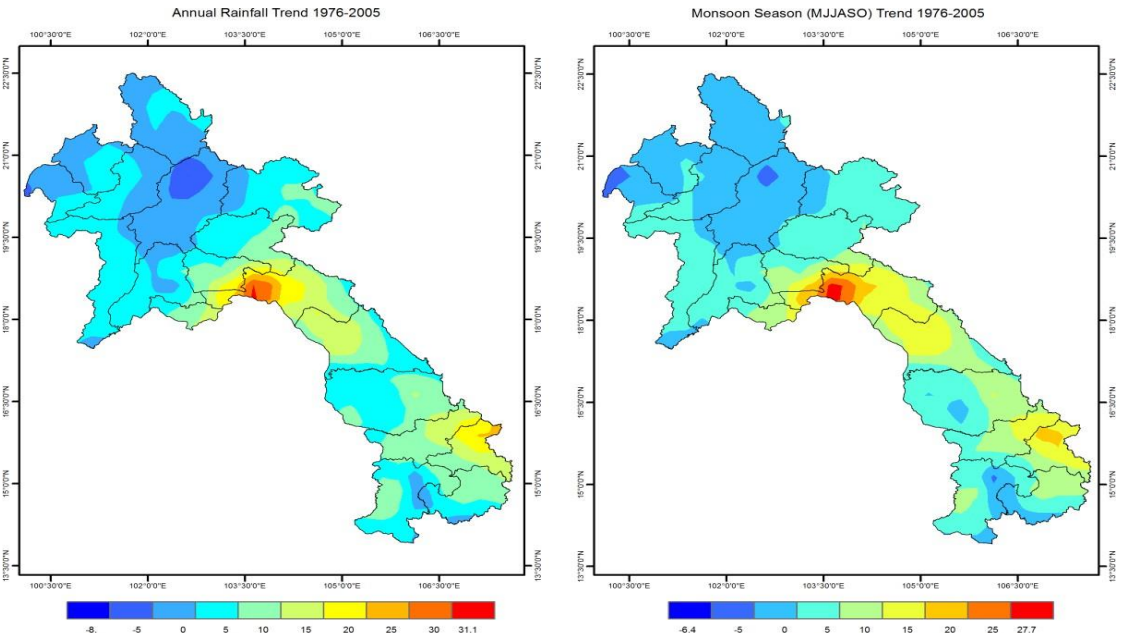


Figure 39 Annual Rainfall and Seasonal Monsoon (MJJASO) Rainfall Trend for Lao PDR from 1976-2005.[60]

[59] Footnote 37
[60] Footnote 37

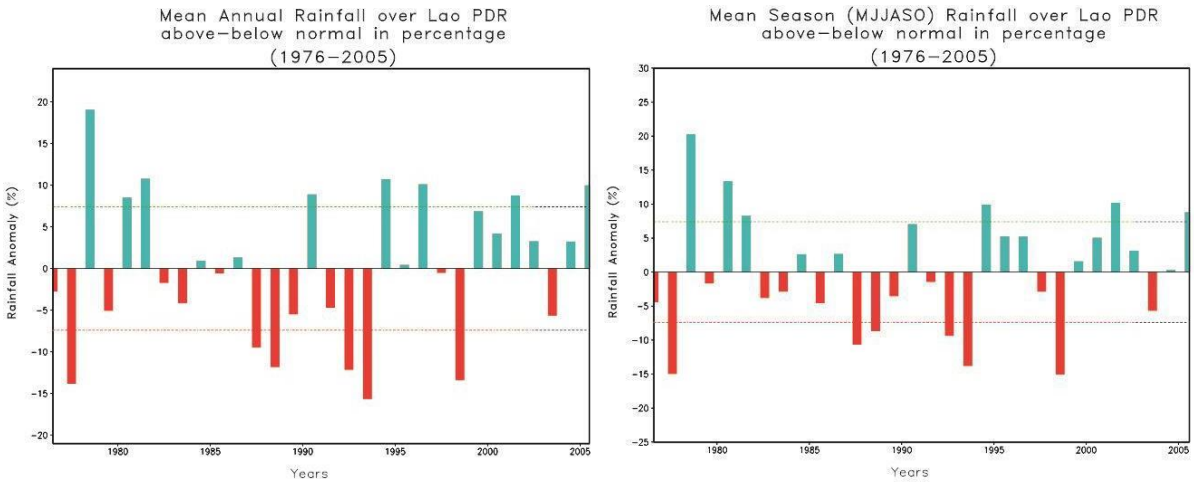


Figure 40 Mean Annual Rainfall over Lao PDR in 1975 -2005 expressed as percentage (left) and Mean Season (MJJASO) Rainfall over Lao PDR above-below normal in percentage (right)[61]

The SNC (2013) projected the future climate scenarios between 2021 to 2060 using rainfall data between 1991 and 2000 from 17 stations and GCMs including scaling factors, and the result showed that there would not be any significant change of rainfall patterns over the next one or two decades in any regions of the Lao PDR. However, by the middle of this century, rainfall patterns could slightly change or decrease, particularly in some areas of the Northern and the Central region, especially during transition period and the delays of the monsoon onsets in the southern part. These suggest a possible shift in rainy season. The previous study of future climate in the Lao PDR using seven GCMs (Lefroy R. and others, 2010) suggested that "the rainfall in the early wet season, in May, would decrease and rainfall at the very start of the wet season in April and the end of the wet season in October, would increase. This is a continuation of the trend seen in the 20th century for a delay in the main wet season, in June to October, and perhaps an increased in the risk of a false start to the wet season, with more rain in April, but less rain in May. Thus, rainfall variability remains the critical issue".

Projection precipitation based on the rainfall historical or baseline data 1975-2005 showed that there will be more precipitation in center parts of Laos or around 190 mm per day in Khammuan province and some area on the east south of the country. In the northwest, change of precipitation ranges from 100 to 150 mm per in Xayabouly, Borkeo, Luang Namtha, and Oudomxay province. Under RCP 8.5 scenario projection, precipitation will be as high as 250 to 260 mm per day in Khammuan province. Meanwhile, the result showed that the precipitation in Xaysomboun proince and on the east part of Phongsaly, Luang Prabang, and Houaphan province, Champasak, Attapue, and Xekong province will decrease around 10% to 25%. A high precipitation changes occurs in Khamuan province-center part region and relative to the northwest region, change of precipitation ranges from 30% to 45% mm per year in Xayabouly, Borkeo, Luang Namtha, and Oudomxay province (Figure 41).

[61] Footnote 37

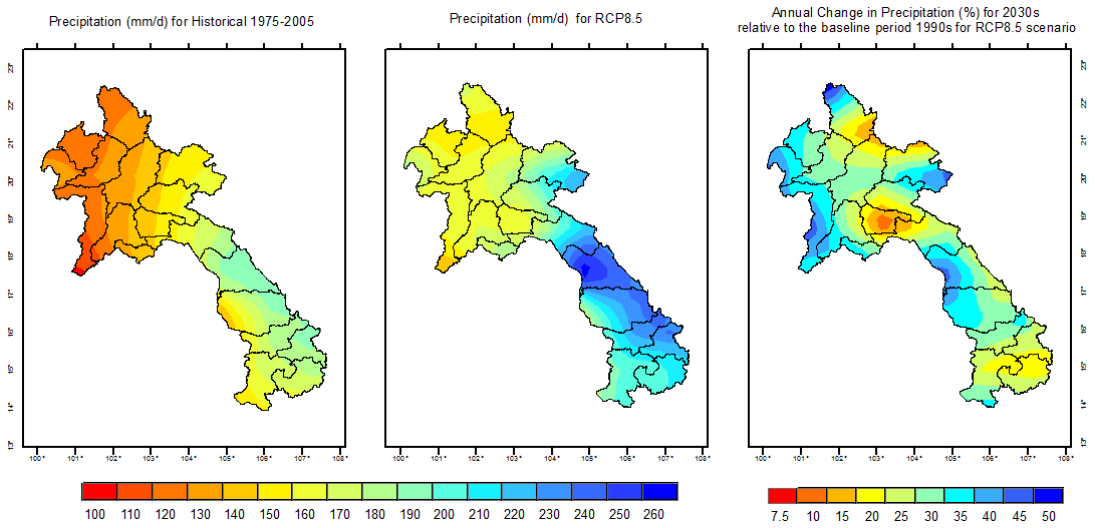


Figure 41 Precipitation Change for Historical 1975-2005 and Projected Annual Change in Precipitation (%) for 2030s Relative to Baseline Period 1990s for RCP 8.5.[62]

Projected seasonal precipitation between May and October using historical data 1975-2005 indicate that there will be higher precipitation, which range from 220 to 280 mm per day in the center to south region of the country, especially Khammuan province, whereas there will be lower precipitation in the northwest part of the country, or 145 to 180 mm per day. For RCP 4.5 scenario, the result shows a similar trend as mentioned above. There will be lessor precipitation in the north region, such as Luang Prabang province (2% decrease) and on the southwest of Xayabouly, Vientiane and Boulikhamxay province (5.5% to 6% decrease) (Figure 42).

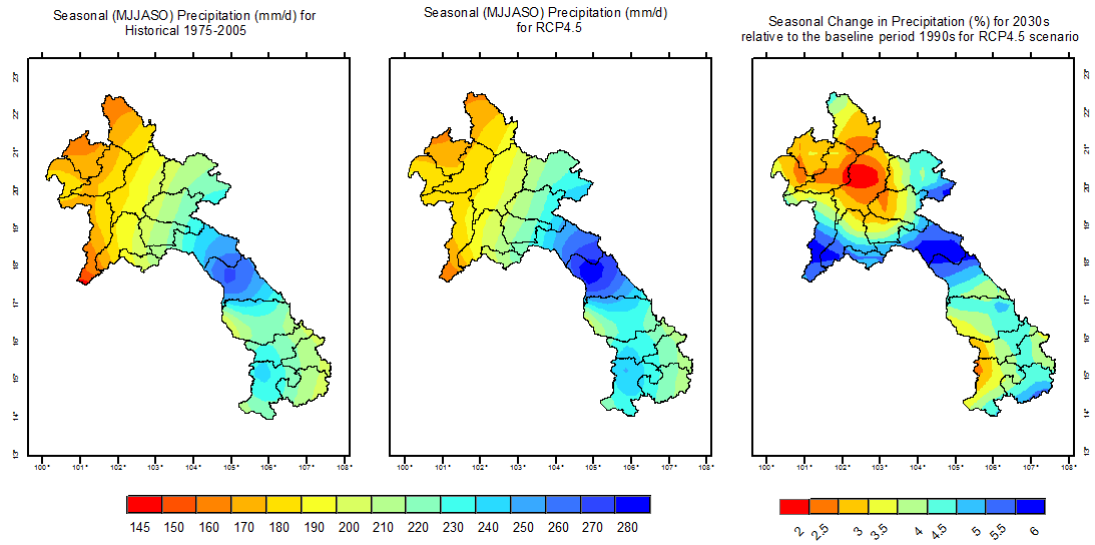


Figure 42 Seasonal (MJJASO) Precipitation Change for Historical 1975-2005 and Projected Annual Change in Precipitation (%) for 2030s Relative to Baseline Period 1990s for RCP 4.5.[63]

[62] Footnote 37
[63] Footnote 37

The projected seasonal precipitation during May to October for short-term (2021-2050 or 2030s) increased from 8 to 56% over historical rainfall 1975-2005. Rainfalls ranged from 145 to 220 mm per day in several part of the country, and the highest rainfall was found in Khamaun province, 260 mm per day, for 1975-2005. Under RCP 8.5 scenario, the projected precipitation in Khamuan province would around 380 mm per day, and between 260 to 310 mm per day for many provinces in south region, while slightly increase of precipitation is expected in the north region. Xaysomboun province is expected to experience minor increase of precipitation of about 8% to 20%, while some provinces in the northeast and south region have a higher precipitation of around 35% to 56% (Figure 43).

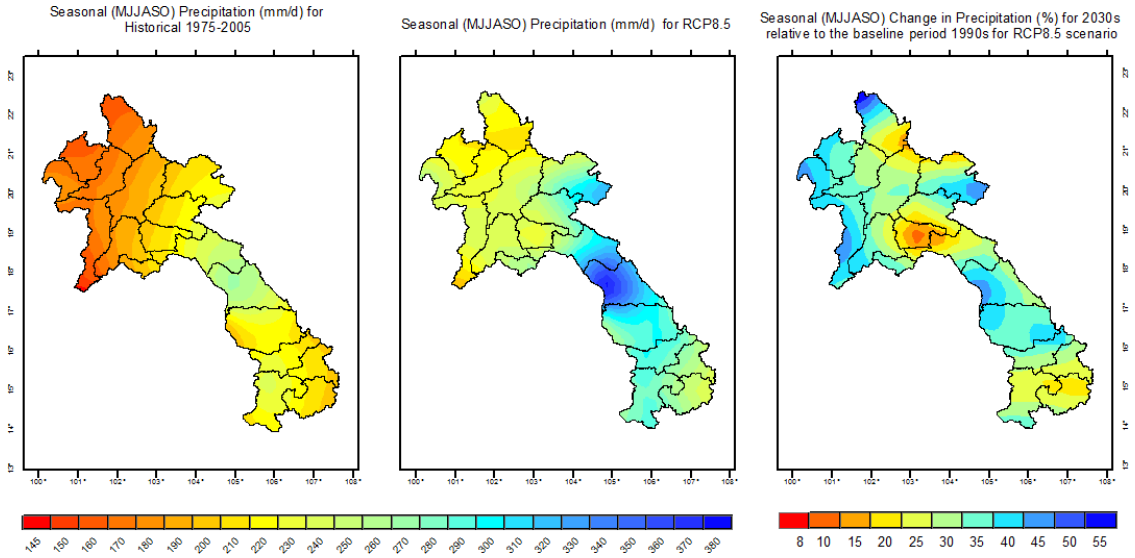


Figure 43 Projection Seasonal (MJJASO) Precipitation Change for Historical 1975-2005, seasonal change in precipitation (%) for 2030s relative to baseline period 1990s for RCP 8.5[64]

The projection the number of rainy days in a year for Lao PDR in three scenarios: historical, RCP 4.5, and RCP 8.5, under each RCP scenarios for the short-term (2021-2050) and long-term (2070-2099) showed that the number of rainy days with rainfall greater than 2.5 cm/day increased in all three scenarios. It was 279 days for the baseline, and 457 days for RCP 4.5 for short-term and 556 days for long-term. Under RCP 8.5, the number of raining day will be 1,524 days and 1,877 days for short-and long-term, respectively. Number of rainy with rainfall greater or equals 5 and 10 cm/days, however, decreased under RCP 4.5 for both shot-and long-term. In comparison the short-term and long-term projection under RCP 8.5, the number of rainy days with rainfall greater or equals 2.5, 5, and 10 cm/days are much different and decrease.

For short-term 2021-2050; many provinces in the north parts of Laos: Xayaboury, Luang Namtha, Phongsaly, Oudomxay, and Bokeo province have lowest annual precipitation, or below 1,500mm per year, whereas other provinces in the center and south parts Laos including Khammuan and Xekong province have the highest annual precipitation over 2,000 mm per year. Several provinces have very small amount of rainfall (less than 500 mm per year) in dry season (January to May) but have higher rainfall (over 1,000 mm per year) in raining season (June to September).

[64] Footnote 37

Rainfall in some province in the south parts such as Savannakhet, saravan, Xekong, and Attapue province are prolonged until November (Figure 44).

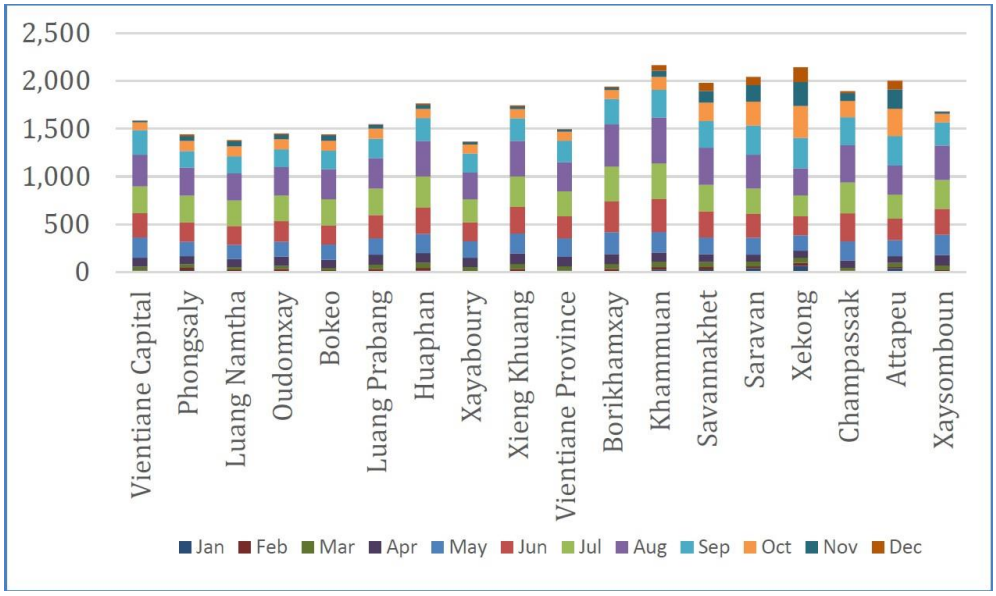


Figure 44 Historical annual precipitation for short term (2021-2050).[65]

Under RCP 4.5 scenario, the annual precipitation trend is similar to the historical annual precipitation 1975 to 2005. However, two provinces in the north parts of Laos: Xayaboury and Luang Namtha have lower participation or approximately 1500mm per year, whereas many provinces in the center and south parts have much higher rainfall (over 2,000 mm per year). Under RCP 4.5, there will be very small amount of rainfall in the dry season, January to May (less than 500 mm per year), but higher rainfall (over 1,000 mm per year) in the raining season (June to September), and some provinces in the south such as Savannakhet, saravan, Xekong, and Attapue province will experience prolonged raining season until November with rainfall up to 2,000 mm per year.

For the short-term 2021-2050 under RCP 8.5 scenario, the annual precipitation in seven provinces in the north of Laos: Phongsaly, Luang Namtha, Oudomxay, Bokeo, Luang Prabang, Xayaboury, Vientiane, and Xaysomboun province will have a lower rainfall (below 1,500 mm per year). In contrast, in Khammuan province might have the highest rainfall up to 2,800 mm per year, followed by in Savannakhet, Saravan, Xekong provice, 2,600 mm per year (Figure 45 and 46).

[65] Footnote 37

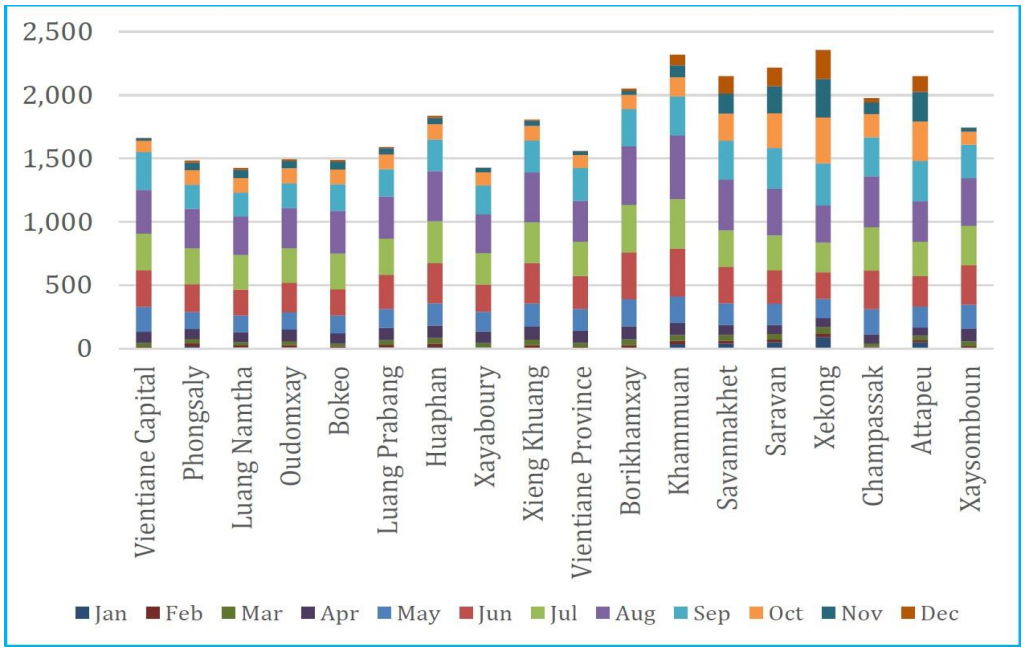


Figure 45 Projection annual precipitation for short term (2021-2050) underRCP4.5 scenarios[66]

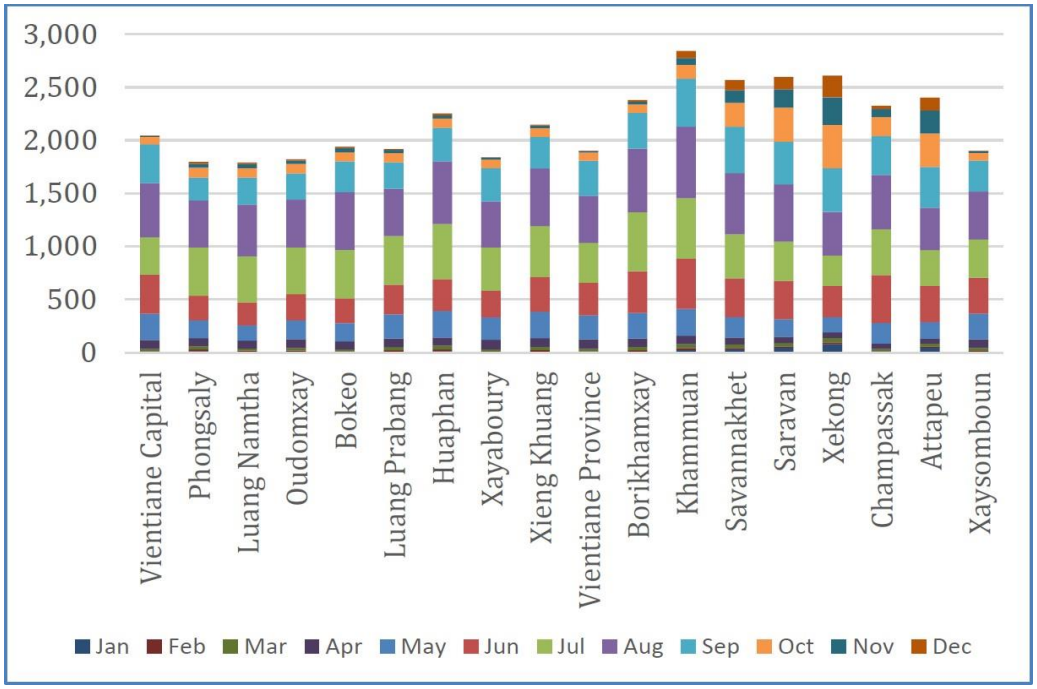


Figure 46 Projection annual precipitation for short term (2021-2050) underRCP8.5[67]

The projection annual precipitation for short-term (2021-2050) under RCP 4.5 and RCP 8.5 scenarios, the rainfall occurs all year round start from January to December, and historical data

[66] Footnote 37
[67] Footnote 37

has the highest precipitation in August (342 mm per year). Under RCP 4.5, the projected result indicated a lower rainfall compare to the historical data during February to May, but increase from June to December. Unlike the RCP 8.5, projected result shows decrease of rainfall during January to April and November. The highest of rainfall is in August, with rainfall of about 342.19, 360.45, and 502.78 mm per year for historical, RCP 4.5, and RCP 8.5, respectively (Table 18; Figure 46 and 47).

Changes annual rainfall for short-term 2021-2050 is expected when compare the future projection over the based year, 1975-2005. The negative change or decrease of annual rainfall in dry season, especially February to April is observed for both RCP 4.5 and RCP 8.5 scenarios. The change ranged from -8% to 19% (or decreased around 2-6 mm/month) under RCP 4.5 for February to April. Under RCP 8.5, The change ranged from -1% to 37% (or decreased around 1-17 mm/month) for January to April (Figure 48 and 49).

Table 18 Projection for Annual and Seasonal Precipitation Short-Term (2021-2050) under Historical, RCP 4.5 and RCP 8.5 Scenario[68]

Month	Annual			Seasonal		
	Historical	RCP4.5	RCP8.5	Historical	RCP4.5	RCP8.5
Jan	17.20	21.52	16.97	-	-	-
Feb	19.14	17.10	11.97	-	-	-
Mar	43.74	37.52	28.25	-	-	-
Apr	90.56	86.18	73.20	-	-	-
May	184.04	168.94	203.64	184.04	168.94	203.64
Jun	248.48	271.97	321.41	248.48	271.97	321.41
Jul	287.45	296.95	428.61	287.45	296.95	428.61
Aug	342.19	360.45	502.78	342.19	360.45	502.78
Sep	244.72	263.64	331.46	244.72	263.64	331.46
Oct	140.40	156.02	142.59	140.40	156.02	142.59
Nov	73.57	90.03	68.77	-	-	-
Dec	32.97	48.13	41.08	-	-	-

[68] Footnote 37

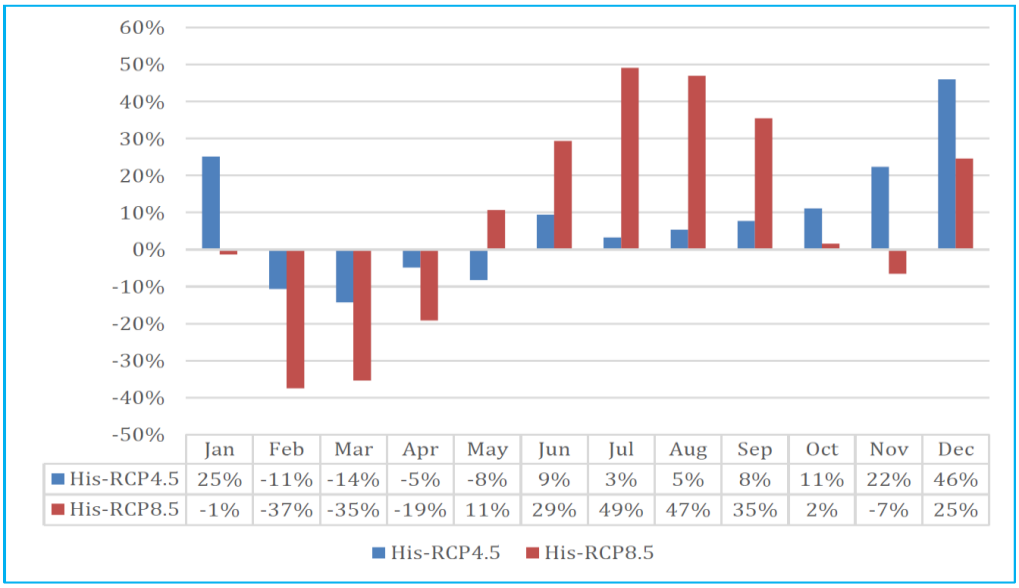


Figure 47 Projection Percentage Changes Annual Rainfall for Short-term (2021-2050) to Based Year (1975-2005) for RCP 4.5 and RCP 8.5.[69]

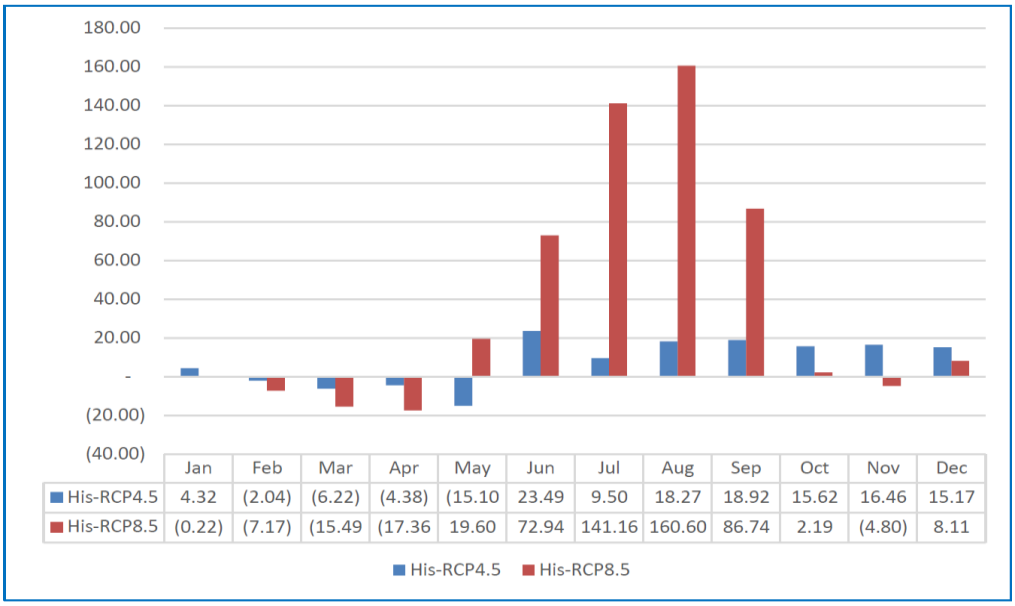


Figure 48 Projection Changes Annual Rainfall for Short-term (2021-2050) to Based Year (1975- 2005) for RCP 4.5 and RCP 8.5.[70]

[69] Footnote 37
[70] Footnote 37

The WBG and ADB (2021) reported that most of the ensemble models showed increases in annual precipitation rates, with larger changes under higher emissions pathways (Figure 50). However, uncertainty in precipitation trends remains high, as reflected in the range of model estimates. This uncertainty is also seen in the small number of studies applying downscaling techniques to assessing precipitation changes[71]. One downscaling study projected annual precipitation changes in the range of −27% to 41% under 3°C of warming[72]. The poor performance of global climate models in consistently projecting precipitation trends has been linked to their poor simulation of the El Niño phenomenon[73, 74].

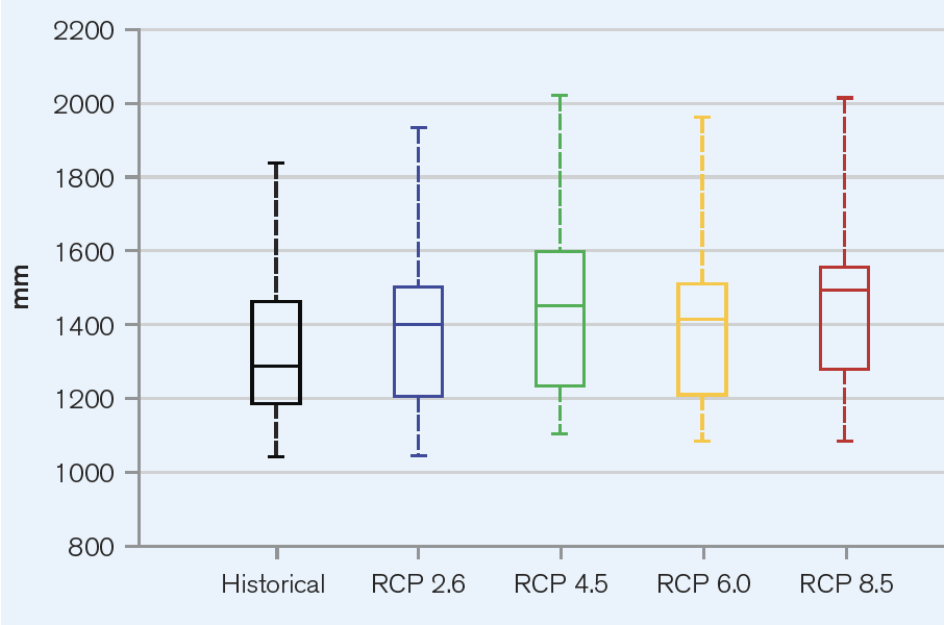


Figure 49 Projected average annual precipitation (mm) for Lao PDR in the period 2080–2099[75]

4.2.3 CLIMATE HAZARDS AND IMPACTS

Climate hazards such as storms, floods and droughts have been occurred Lao PDR with increased frequency, magnitude and impacts. In addition, heatwave is anticipated to be a acritical hazard in the future along with the increase of temperature. Floods including river and flash flood are the most common and disastrous ones, which occur more frequent compared with others.

[71] Lacombe, G., Hoanh, C. T., & Smakhtin, V. (2012). Multi-year variability or unidirectional trends? Mapping long-term precipitation and temperature changes in continental Southeast Asia using PRECIS regional climate model. Climatic Change, 113(2), 285–299. URL: https://link.springer.com/article/10.1007%2Fs10584-011-0359-3

[72] Shrestha, B., Babel, M.S., Maskey, S., Griensven, A.V., Uhlenbrook, S., Green, A. and Akkharath, I. (2013). Impact of climate change on sediment yield in the Mekong River Basin: a case study of the Nam Ou Basin, Lao PDR. Hydrology and Earth System Sciences, 17(1), pp.1–20. URL: https://www.hydrol-earth-syst-sci.net/17/1/2013/hess-17-1-2013.pdf

[73] Yun, K.S., Yeh, S.W. and Ha, K.J. (2016). Inter-El Niño variability in CMIP5 models: Model deficiencies and future changes. Journal of Geophysical Research: Atmospheres, 121, 3894–3906. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016JD024964

[74] Chen, C., Cane, M.A., Wittenberg, A.T. and Chen, D. (2017). ENSO in the CMIP5 simulations: life cycles, diversity, and responses to climate change. Journal of Climate, 30, 775–801. URL: https://journals.ametsoc.org/doi/pdf/10.1175/JCLI-D-15- 0901.1

[75] Footnote 55

From 1966 to 2020, the country has experienced more than 45 floods. 1966 – 2008, flood hazard occurred 33 times and the annual average economic loss was approximately 140 million USD. In the last decade, 2009 -2017, floods were more frequent with accumulated economic loss of about eight billion USD. Cumulative economic loses was about 1.4 billion USD, and about half billion for drought (Table 19).

Table 19 Cumulative frequency and impacts of hazards on economic, 2009 -2017[76]

Year	Cumulative frequency			Cumulative economic loses (million $)		
	Flood	Storm	Drought	Flood	Storm	Drought
2009	917	333	101	589.48	68.36	50.85
2010	1,104	517	145	632.77	76.27	52.84
2011	1,300	704	151	815.97	90.54	53.74
2012	1,333	785	156	819.17	97.47	53.89
2013	1,345	785	156	988.17	216.47	53.89
2014	1,399	785	156	988.78	216.47	53.89
2015	1,426	804	156	997.16	217.64	53.89
2016	1,478	839	157	1,013	218.48	53.89
2017	1,479	839	157	1,013	218.48	53.89
Total	**11,781**	**6,391**	**1,335**	**7,857.5**	**1,420.18**	**480.77**

Notes: Data of the year 2013 based on (GFDRR, 2014)

Lao PDR experienced increase of temperatures and hot days, and expected to face the heatwave issue in the future. The current median probability of a heat wave[77]suggest that climate change made a 29% contribution to the extreme temperatures experienced across Southeast Asia in April 2016, while ENSO contributed 49%. The WBG and ADB (2021) reported that under the CCKP model, there will be a significant increase in the annual probability of a heat wave under the different emissions pathways compared with the baseline, 1986–2005. The number of days with the temperatures over 35°C increase from around 40 days to 50–110 days, depending on emissions pathway and climate model. Simultaneous increase in temperatures suggests a transition to a chronically heat stressed environment. However, Lao PDR has not recorded number of people affected associated with heatwave, and limited an in-depth-study and monitoring.

Lao PDR, in general, is vulnerable to climate change and hazards. The study under the SNC using the aggregate indices for vulnerability and adaptive capacity called Sensitivity and Exposure index

[76] Modified from MoNRE (2018). Lao PDR's Disaster Risk Management Status Report 2015-2017

[77] Heatwave is defined as a period of three or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 3%.34

(SEI) and Adaptive Capacity Index (ACI) to reflect the vulnerability and adaptive capacity levels of the villages in the Lao PDR, the higher the SEI (ACI), the more vulnerable (adaptive capacity) the village showed that Xiengkhuang, Sekong and Attapeu provinces, including the large proportions of villages are high risks to flooding, while provinces in the Central and Southern regions, such as Xayabury, Vientiane, Savanakhet, Khammoune and Champasak are at risk of drought.

Based on climate scenario from NASA-NEXGDDP that used baseline year of 1976-2005 for projection of 2021-2050 under RCP4.5 and RCP8.5, Lao PDR's vulnerability is at medium level, on average. Of which, 10 provinces are highly vulnerable, 4 are medium, 7 are low and 1 very low. Phongsaly, Huaphan, Xiengkhouang and Salavan provinces are very high risk or vulnerable to climate change, especially Yod Ou, Kua, Mai district Phongsaly; Pakbeng district of Oudomxay province; Paktha district of Bokeo province; Xiengkor district of Huaphan province; Kham and Mokmai district of Xiengkhouang province and Toumlan district of Salavan provinces (MONRE, 2020) (Figure 51).

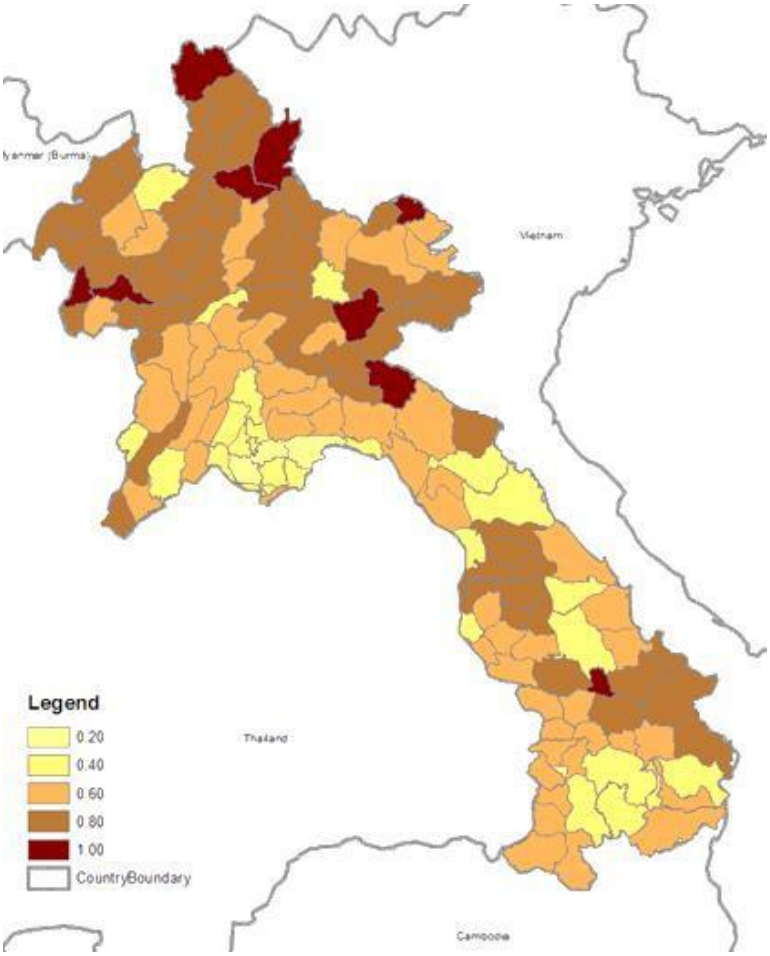


Figure 50 Climate change vulnerability map of Lao PDR[78]

[78] MONRE (2020). Climate change vulnerability assessment report.

Based on the Inform Risk Index, Lao PDR was ranked 69th out of 191 countries in 2019 in term of disaster risk level[79], while considering exposure to flooding, Lao PDR was ranked 6th, tropical cyclones ranked 47th, drought ranked 115th, and quite limited coping capacity (Table 20).

Table 20 Inform Risk Index for Lao PDR[80]

Flood (0–10)	Tropical Cyclone (0–10)	Drought (0–10)	Vulnerability (0–10)	Lack of Coping Capacity (0–10)	Overall Inform Risk Level (0–10)	Rank (1–191)
9.1 [4.5]	3.3 [1.7]	2.4 [3.2]	4.0 [3.6]	5.8 [4.5]	4.5 [3.8]	69

Notes: Global average scores are shown in brackets

These are in line with previous findings, which indicated that Lao PDR has low adaptive capacity and vulnerable to climate hazards in the Southeast Asia region (Figure 52 and 53).

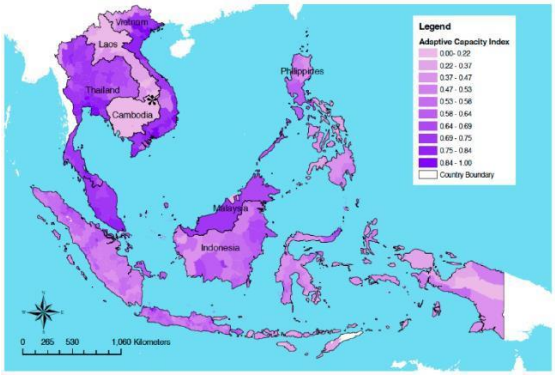


Figure 51 Climate change adaptive capacity of Lao PDR[81]

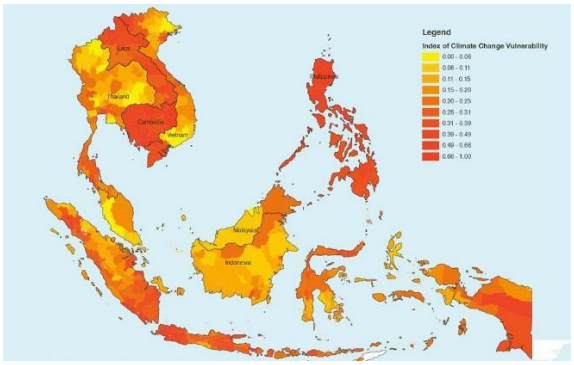


Figure 52 Climate change vulnerability index of Lao PDR[82]

[79] European Commission (2019). INFORM Index for Risk Management. Lao PDR Country Profile. URL: https://drmkc.jrc.ec.europa.eu/inform-index/Countries/Country-Profile-Map

[80] Footnote 55

[81] Yusuf, A.A. and Francisco, H. (2009) Climate Change Vulnerability Mapping for Southeast

[82] Footnote 81

4.2.3.2 WATER RESOURCES SECTOR

An assessment by Paltan et al. (2018) showed that even under lower emissions pathways coherent with the Paris Climate Agreement, almost all Asian countries including Lao PDR will face an increase in the frequency of extreme river flows. What would historically have been a 1 in 100-year flow, could become a 1 in 50-year or 1 in 25-year event in most of South, Southeast, and East Asia. The amount of rainfall accumulated during extreme rainfall events is projected to increase of up to 23% under the highest emissions pathway. This phenomenon may increase the risk of flash and landslide.[83]. Based on the WB and ADB (2021) and the use of the World Resources Institute's AQUEDUCT Global Flood Analyzer.[84], the baseline of population and economic impacted by floods in Lao PDR was about 48,000 people and $159 million per year, respectively, and likely to increase by 40,000 people and $295 million, under the RCP8.5 emissions pathway by the 2030s (AQUEDUCT Scenario B). A study on climate change could impact on Nam Ou watershed, a largest watershed in Lao PDR, under this TNC using the Soil & Water Assessment Tool (SWAT) revealed that there will be an increase of precipitation and flow in raining season, but drier in dry season in the area.

Under PRC8.5 scenario, there would be more extreme flow and flood event which might take longer in comparison with the baseline. In contrast, there would be extreme drought under PRC4.5 scenarios (Figure 54). This is expected to cause significant impact to the hydropower project and water use in up and downstream of the basin. Hydropower electricity of 9 dams in Nam Ou River would be decrease from 28% to 55% under RCP4.5 scenario and about 7% under RCP 8.5 (Table 21). This is in line with an assessment of MRC (2018), who reported that hydropower electricity production could increase in rainy season, while it decreased in dry season.[85].

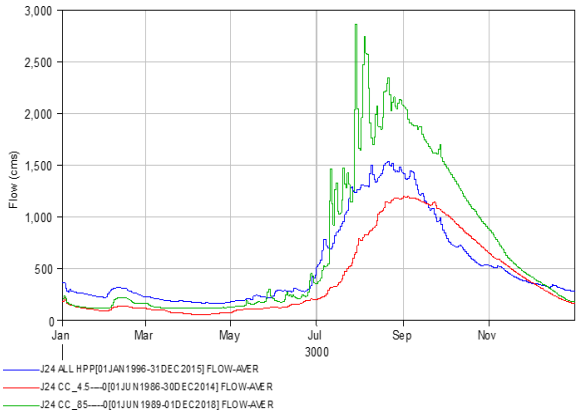


Figure 53 Nam Ou River Flow under RCP 4.5 and 8.5 Scenario.[86]

[83] 19 Paltan, H., Allen, M., Haustein, K., Fuldauer, L., & Dadson, S. (2018). Global implications of 1.5°C and 2°C warmer worlds on extreme river flows Global implications of 1.5°C and 2°C warmer worlds on extreme river flows. Environmental Research Letters, 13. URL: https://doi.org/10.1088/1748-9326/aad985.

[84] 20 WRI (2018). AQUEDUCT Global Flood Analyzer. URL: https://floods.wri.org/# [Accessed: 22/11/2018].

[85] MRC (2018). Basin-Wide Assessment of Climate Change Impacts on Hydropower Production. Final Report. URL: https://www.mrcmekong.org/assets/Publications/Basin-wide-Assessment-of-Climate-Change-Impacts-on-Hydropower-Production_report-13May19.pdf

[86] TNC Team (2021). Technical report on vulnerability assessment

Table 21 Climate change impact on hydropower projects and electricity production[87]

NO	Name of Hydropower Project	Install capacity (MW)	Baseline (MWh)	RPC4.5 (MWh)	Change (%)	RPC8.5 (MWh)	Change (%)
1	NamOu1	180	1,118,418	796,211	28.81%	1,075,473	3.84%
2	NamOu2	120	496,083	356,550	28.13%	465,265	6.21%
3	NamOu3	210	937,985	654,193	30.26%	868,921	7.36%
4	NamOu4	132	536,204	306,743	42.79%	439,357	18.06%
5	NamOu5	240	1,019,633	634,474	37.77%	915,964	10.17%
6	NamOu6	180	759,206	439,852	42.06%	736,349	3.01%
7	NamOu7	210	921,727	410,671	55.45%	924,254	**-0.27%**
8	NamNga2	14.5	54,428	25,350	53.42%	51,266	5.81%
9	NamLeng	60		44,804		137,113	
	Average				**39.84**		**6.77**

Drought that Lao PDR is facing includes meteorological[88] and hydrological[89] drought. An annual median probability of severe meteorological drought is around 4%, as indicated by a standardized precipitation evaporation index (SPEI) of less than −2.25[90]. Naumann et al. (2018) provide a global overview of changes in drought conditions under different warming scenarios, including Southeast Asia Region and suggest that the return periods of 12-month droughts could reduce and no significant change under lower levels of global warming. However, once temperature reaches 2–3°C, the event that presently occurs once in every hundred years may return more frequent or more than once in every fifty years. The projections of the CCKP model showed an increased annual likelihood of drought. Overall, it is likely that future drought patterns will depend on the influence of climate change on monsoon and ENSO patterns[91].

4.2.3.3 AGRICULTURE SECTOR

In general, or at an international or regional level, it is well-perceived that agriculture sector is vulnerable to climate change and hazards, which could directly and indirectly affect production system including crops and livestock production and productivity, resources, facilities and infrastructure. At global level, an estimate showed that the global wheat and maize yields would decline 5% and 6%, respectively, even the Paris Climate Agreement is met and warming is limited to 1.5°C[92].

[87] Footnote 86
[88] Drought associates with a precipitation deficit
[89] Drought associates with a deficit or low in surface and subsurface water flow
[90] Footnote 55
[91] Adamson, P. and Bird, J. (2010). The Mekong: a drought-prone tropical environment? International Journal of Water Resources Development, 26(4), pp.579–594. URL: https://www.tandfonline.com/doi/abs/10.1080/07900627.2010.519632
[92] Tebaldi, C., & Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48/pdf

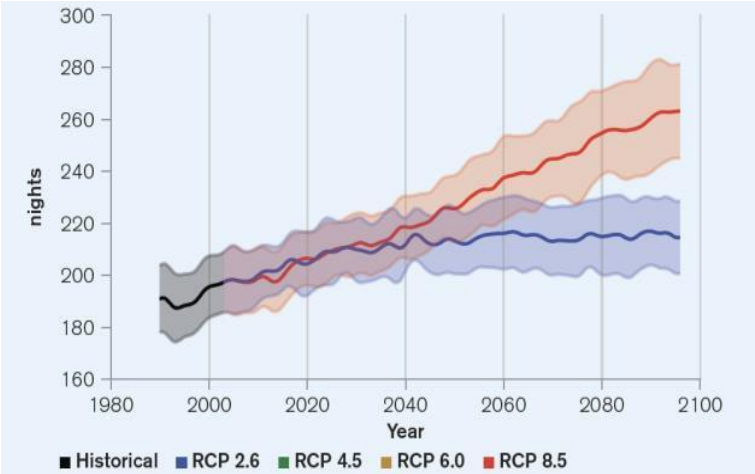


Figure 54 Number of nights nighttime temperatures (T-min > 20°C) in Lao PDR through the end of the century for RCP2.6 (blue) and RCP8.5 (red) emissions pathways.[93]

Rice is especially vulnerable to climate change. A study has suggested that the influence of climate change on temperature and rainfall patterns could depress local rice yields by around 5–20% by the 2040s, with losses typically larger on higher emissions pathways.

A study under this TNC, applying the Aqua Crop model for simulating rice production in Nam Ou watershed under RCP4.5 scenarios for the future time period (2020-2050) relative to baseline period (2005-2016). It can be seen that under the current cultivating practices and cultivars, rice yields in all provinces in the future will be lower than those of the baseline. Rice yields under RCP4.5 scenarios are slightly less than the baseline

a) Rice production under scenario RCP4.5

The simulating results of rice production in Nam Ou basing under RCP4.5 scenarios for the future time period (2020-2050) relative to baseline period (2005-2016) are presented in Table 22 and Figure 56– Figure 58. It can be seen that under the current cultivating practices and cultivars, rice yields in all provinces in the future are less than the baseline. Rice yields under RCP4.5 scenarios are slightly less than the baseline in the first ten years; after which the production will be greater than the baseline.

[93] Footnote 55

Table 22 Comparison of simulated and based year rice production[94]

Phongsaly					
Baseline	T_{Max}	T_{Min}	$T_{Average}$	PCP	Rice production (Ave, ton/ha)
2005-2016	24.5	4.28	14.39	1720.79	4.49
RCP 4.5					
2020-2030	24.76	16.36	20.56	1577.14	4.37
2031-2040	25.32	16.63	20.97	1940.70	4.66
2041-2050	25.22	16.74	20.98	1912.99	4.85
Oudomxay					
Baseline	T_{Max}	T_{Min}	$T_{Average}$	PCP	Rice production (Ave, ton/ha)
2005-2016	29.27	5.00	17.13	1554.06	4.44
RCP 4.5					
2020-2030	29.56	17.69	23.63	1173.92	4.23
2031-2040	30.01	17.99	24	1452.85	4.55
2041-2050	29.92	18.09	24	1455.32	4.81
Luang Prabang					
Baseline	T_{Max}	T_{Min}	$T_{Average}$	PCP	Rice production (Ave, ton/ha)
2005-2016	31.46	8.13	19.79	1529.31	4.33
RCP 4.5					
2020-2030	30.41	20.5	25.46	1081.04	4.32
2031-2040	30.94	20.74	25.84	1329.38	4.65
2041-2050	30.96	20.86	25.91	1334.36	4.88

Notes:

Phongsaly:

The Nash–Sutcliffe model efficiency coefficient (NSE): 0.68 (PBIAS (%): 25-50)
Percent Bias (PBIAS) value: 1.39
Root Mean Square Error (RMSE) (t/ha): 0.2

Oudomxay:

The Nash–Sutcliffe model efficiency coefficient (NSE): 0.67 (PBIAS (%): 25-50)
Percent Bias (PBIAS) value: 0.41
Root Mean Square Error (RMSE) (t/ha): 0.08

Luang Prabang:

The Nash–Sutcliffe model efficiency coefficient (NSE): 0.57 (PBIAS (%): 25-50)
Percent Bias (PBIAS) value: 1.56
Root Mean Square Error (RMSE) (t/ha): 0.19

[94] Footnote 86

The simulation results of rice yield and the temperature in Phongsaly province in 2021-2050 under RCp4.5 show in correlated trend. The simulation rice production under RCP4.5, the correlation between temperature and rice yield in Oudomxay province shows opposite fluctuation from 2042-2050. As shown in Figure 58, the correlation of temperature and rice yield in Luang Prabang also shows opposite fluctuation in during 2044-2050.

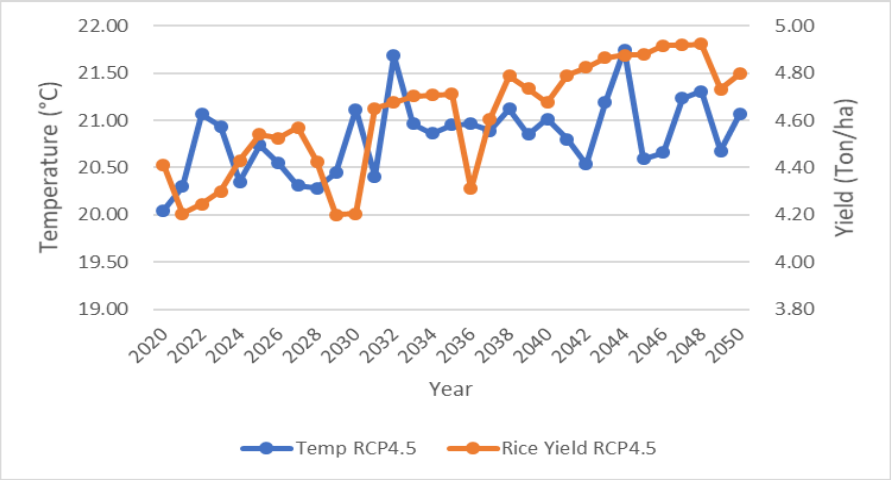


Figure 55 Rice production in Phongsaly 2020-2050 under RCP4.5[95]

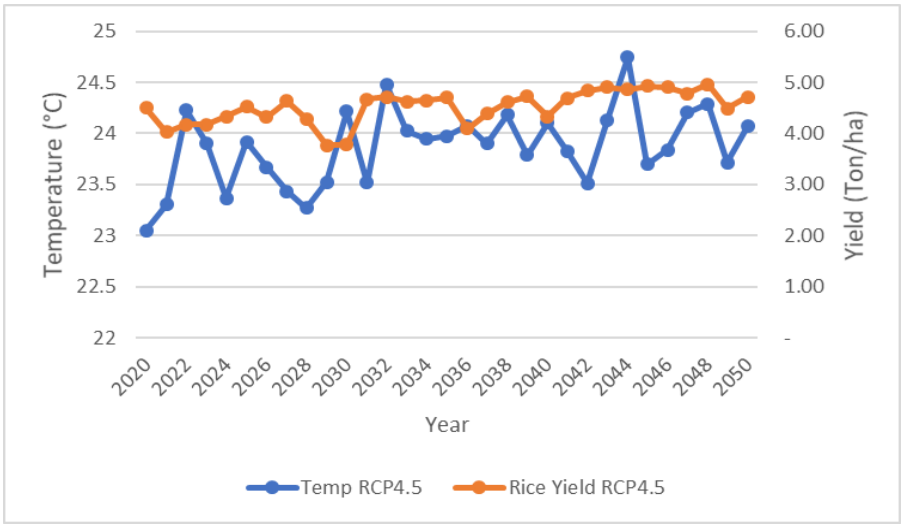


Figure 56 [96]Rice production in Oudomxay 2020-2050 under RCP4.5

[95] Footnote 86
[96] Footnote 86

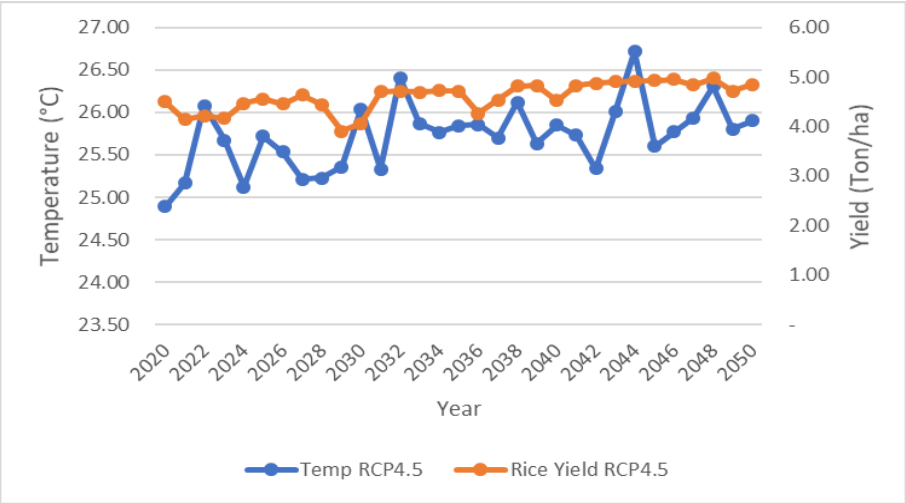


Figure 57 Rice production in Luang Prabang 2020-2050 under with RCP4.5[97]

b) Maize production under scenario RCP4.5

The simulating results of maize production in NamOu basing under RCP4.5 scenarios for the future between 2020-2050, relative to baseline period (2005-2016) are presented in Table 23 and Figure 59 – Figure 61. It can be seen that under the current cultivating practices and cultivars, maize yields in Phongsaly are higher than the baseline. However, for Oudomxay the future yields are less than the baseline, while for Luang Prabang, the yields in the first twenty years are less than the baseline, and increases more than the baseline in the last ten years (during 2041-2050).

Table 23 Comparison of simulated and based year maize production[98]

	T_{Max}	T_{Min}	$T_{Average}$	PCP	Maize production (Average, Ton/ha)
Phongsaly					
Baseline					
2005-2016	24.50	4.28	14.39	1720.79	5.83
RCP 4.5					
2020-2030	24.76	16.36	20.56	1577.14	5.90
2031-2040	25.32	16.63	20.97	1940.70	5.95
2041-2050	25.22	16.74	20.98	1912.99	5.99
Oudomxay					
Baseline					5.28
2005-2016	29.27	5.00	17.13	1554.06	
RCP 4.5					
2020-2030	29.56	17.69	23.63	1173.92	5.03

[97] Footnote 86
[98] Footnote 86

2031-2040	30.01	17.99	24.00	1452.85	4.99
2041-2050	29.92	18.09	24.00	1455.32	5.12
Luang Prabang					
Baseline					
2005-2016	31.46	8.13	19.79	1529.31	5.66
RCP 4.5					
2020-2030	30.41	20.50	25.46	1081.04	5.50
2031-2040	30.94	20.74	25.84	1329.38	5.54
2041-2050	30.96	20.86	25.91	1334.36	5.57

Notes:

Phongsaly:

The Nash–Sutcliffe model efficiency coefficient (NSE): 0.46 (PBIAS (%): 25-50%)

Percent Bias (PBIAS) value: 5.87

Root Mean Square Error (RMSE) (t/ha): 0.79

Oudomxay:

The Nash–Sutcliffe model efficiency coefficient (NSE): 0.96 (PBIAS (%): <25%)

Percent Bias (PBIAS) value: 2.91

Root Mean Square Error (RMSE) (t/ha): 0.26

Luang Prabang:

The Nash–Sutcliffe model efficiency coefficient (NSE): 0.79 (PBIAS (%): <25%)

Percent Bias (PBIAS) value: 6.28

Root Mean Square Error (RMSE) (t/ha): 0.48

The correlation of temperature and maize yield is higher in 2031-2034 and the trend shows the opposite fluctuation in the entire period of simulation except the year 2043- 2044. The result of simulation of temperature and maize production in Oudomxay is different from that of Phongsaly, as it shows the positive fluctuation. In Figure 60, the correlation in Luang Prabang also shows the opposite fluctuation.

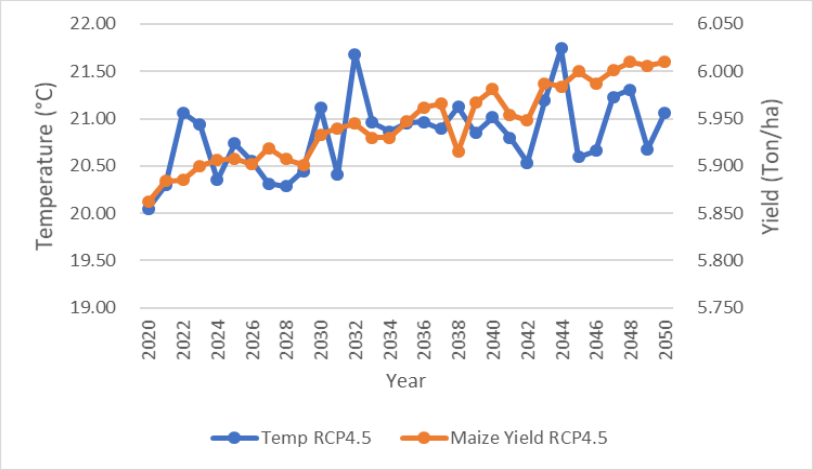


Figure 58 Maize production in Phongsaly 2020-2050 under with RCP4.5[99]

[99] Footnote 86

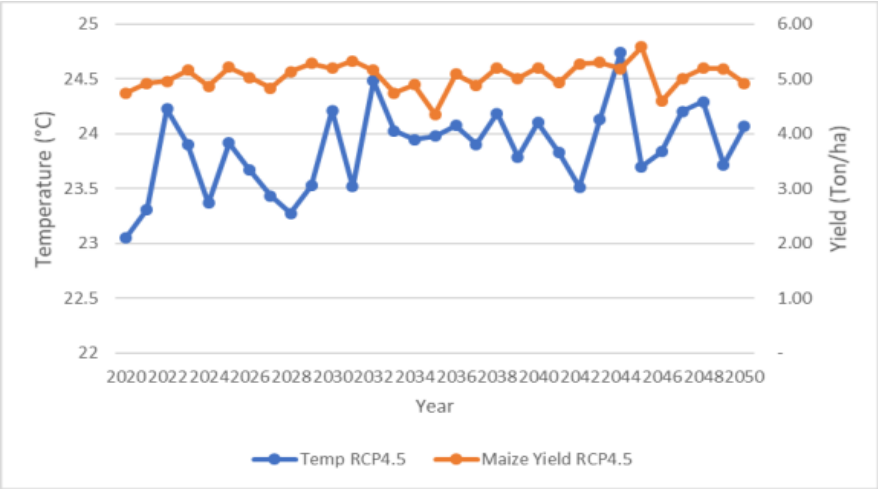


Figure 59 Maize production in Oudomxay 2020-2050 under with RCP4.5[100]

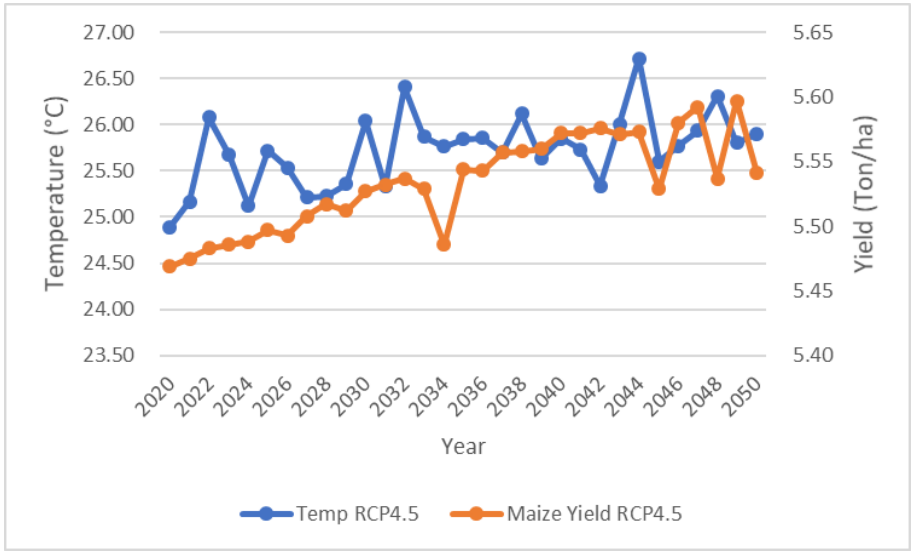


Figure 60 Maize production in Luang Prabang 2020-2050 under RCP4.5[101]

[100] Footnote 86
[101] Footnote 86

c) Rice production under scenario RCP8.5

The simulating results of rice production in Nam Ou basing under RCP8.5 scenarios for the future time period (2020-2050) relative to baseline period (2005-2016) are presented in Table 24 and Figure 62 – Figure 64. It can be seen that under the current cultivating practices and cultivars, rice yields in all provinces in the future are mostly more than the baseline (except for Oudomxay in the first ten years).

Table 24 Comparison of simulated and based year rice production, RCP8.5 and Baseline[102]

Phongsaly					
Baseline	T_{Max}	T_{Min}	$T_{Average}$	PCP	Rice production (Ave, ton/ha)
2005-2016	24.5	4.28	14.39	1720.79	4.49
RCP 8.5					
2020-2030	25.12	16.68	20.9	1994.02	4.54
2031-2040	25.28	16.67	20.98	2150.87	4.83
2041-2050	25.75	17.08	21.41	2152.25	5.08
Oudomxay					
Baseline	T_{Max}	T_{Min}	$T_{Average}$	PCP	Rice production (Ave, ton/ha)
2005-2016	29.27	5.00	17.13	1554.06	4.44
RCP 8.5					
2020-2030	29.85	18.02	23.94	1406.06	4.41
2031-2040	29.96	17.99	23.97	1481.34	4.56
2041-2050	30.47	18.51	24.49	1433.48	4.74
Luang Prabang					
Baseline	T_{Max}	T_{Min}	$T_{Average}$	PCP	Rice production (Ave, ton/ha)
2005-2016	31.46	8.13	19.79	1529.31	4.33
RCP 8.5					
2020-2030	30.77	20.87	25.82	1279.6	4.49
2031-2040	30.86	20.8	25.83	1337.47	4.68
2041-2050	31.48	21.31	26.4	1303.64	4.83

The correlation between temperature and rice yield under RCP8.5 scenario is varied. In 2022-2025, the temperature and rice yield in Phongsaly is quite correlated positively (Figure 62).

[102] Footnote 86

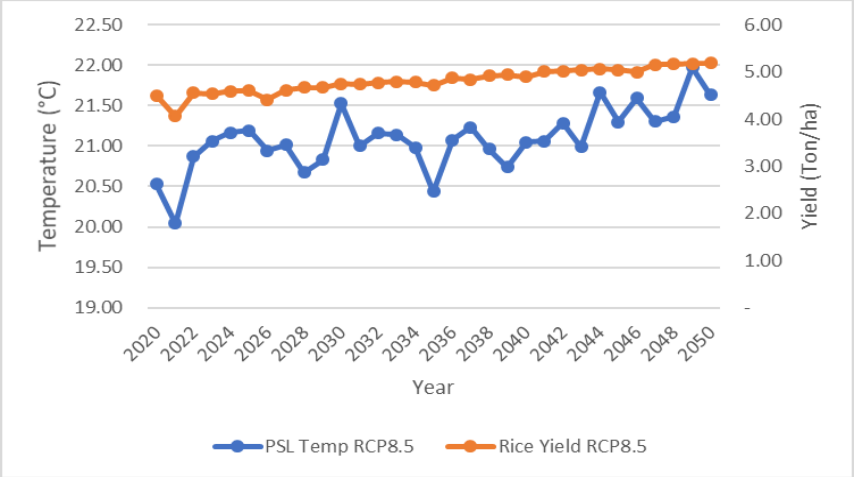


Figure 61 Rice production in Phongsaly 2020-2050 under RCP8.5[103]

In Figure 63, the shape trend is also correlated however some years the correlation of temperature and rice yield production is on the opposite (during 2045 and 2050). The gap between temperature and rice production is larger in 2021 and it is closer in 2045-2047.

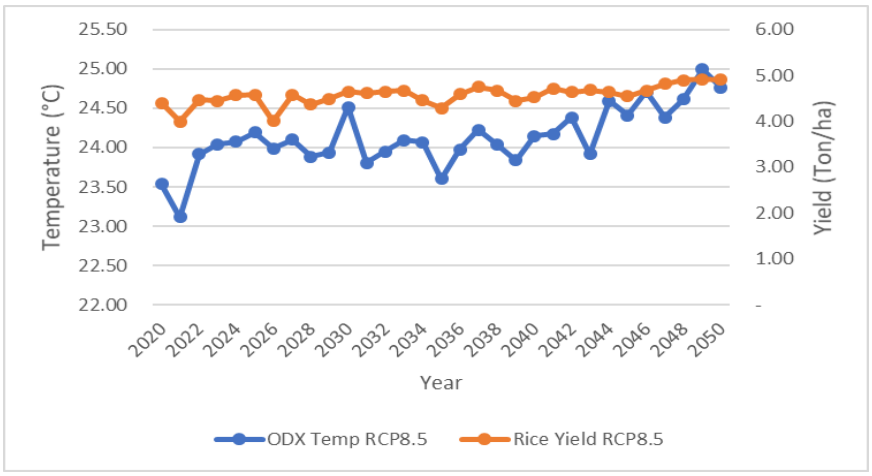


Figure 62 Rice production in Oudomxay 2020-2050 under with RCP8.5[104]

In Figure 64, in Luang Prabang, the correlation of temperature and rice yield production is on the opposite (in 2043 and 2045). The gap between temperature and maize production is larger during 2031 and 2044. The production drops significantly in 2021, 2026, 2028, 2035, 2040, and 2045.

[103] Footnote 86
[104] Footnote 86

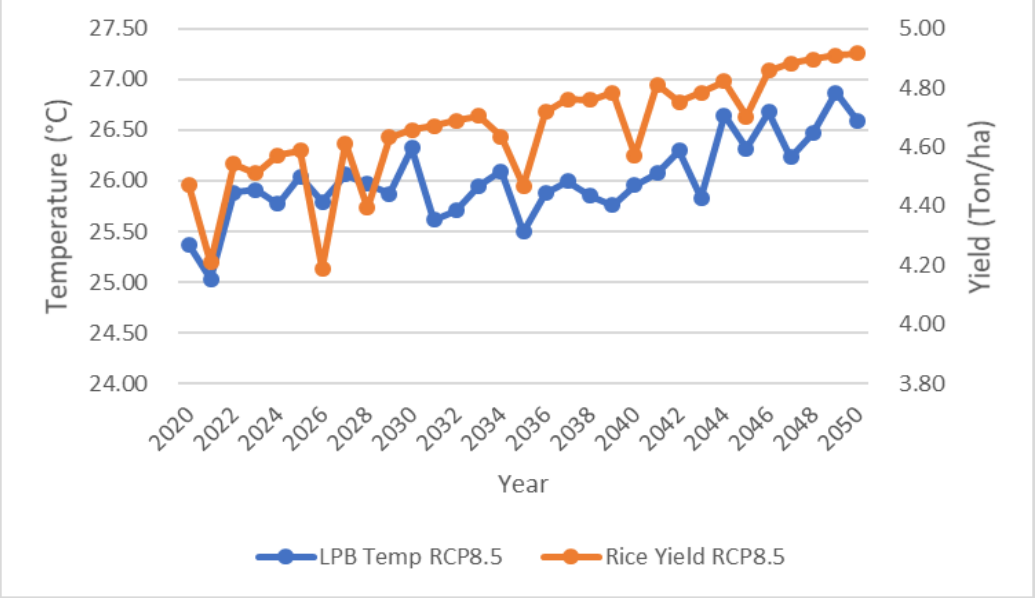


Figure 63 Rice production in Luang Prabang 2020-2050 under with RCP8.5[105]

d) Maize production under scenario RCP8.5

The simulating results of maize production in Nam Ou basing under RCP8.5 scenarios for the future time period (2020-2050) relative to baseline period (2005-2016) are presented in Table 25 and Figure 64 – Figure 66. It can be seen that under the current cultivating practices and cultivars, maize yields in all provinces in the future are less than the baseline. Maize yields under RCP8.5 scenarios are slightly less than those of RCP4.5.

Table 25 Comparison of simulated and based year maize production[106]

	T_{Max}	T_{Min}	$T_{Average}$	PCP	Maize production (Average, Ton/ha)
Phongsaly					
Baseline					
2005-2016	24.50	4.28	14.39	1,720.79	5.83
RCP 8.5					
2020-2030	25.12	16.68	20.90	1,994.02	5.89
2031-2040	25.28	16.67	20.98	2,150.87	5.94
2041-2050	25.75	17.08	21.41	2,152.25	5.98
Oudomxay					
Baseline					5.28
2005-2016	29.27	5.00	17.13	1,554.06	
RCP 8.5					
2020-2030	29.85	18.02	23.94	1,406.06	4.96

[105] Footnote 86
[106] Footnote 86

2031-2040	29.96	17.99	23.97	1,481.34	5.03
2041-2050	30.47	18.51	24.49	1,433.48	5.14

Luang Prabang					
Baseline					
2005-2016	31.46	8.13	19.79	1,529.31	6.09
RCP 8.5					
2020-2030	30.77	20.87	25.82	1,279.60	5.48
2031-2040	30.86	20.80	25.83	1,337.47	5.53
2041-2050	31.48	21.31	26.40	1,303.64	5.56

In Figure 64, the shape trend of maize production and temperature is correlated, however the gap is larger in the beginning (2020-2030) and it is closer after ten and twenty years later.

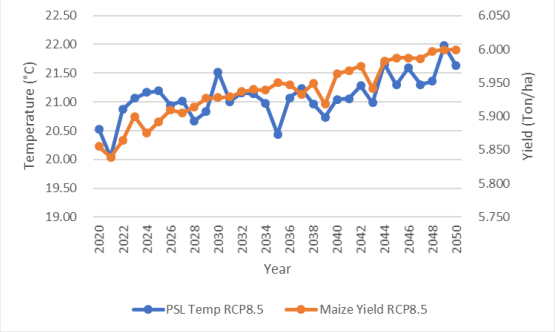


Figure 64 Maize production in Phongsaly 2020-2050 under RCP8.5.[107]

In Figure 65, the shape trend is also correlated and the gap between temperature and maize production is larger in the beginning (2020-2030) and it is closer after ten and twenty years later.

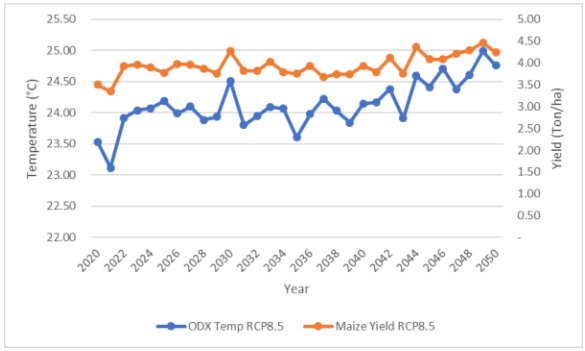


Figure 65 Maize production in Oudomxay 2020-2050 under with RCP8.5.[108]

In Figure 66, the shape trend is also correlated and the gap between temperature and maize production is larger in the beginning (2020-2030) and it is closer after ten and twenty years later.

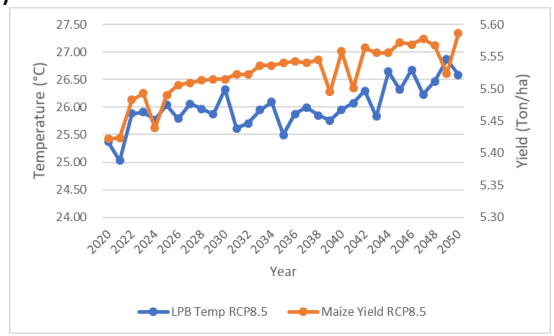


Figure 66 Maize production in Luang Prabang 2020-2050 under with RCP8.5.[109]

[107] Footnote 86
[108] Footnote 86
[109] Footnote 86

This case study was relevant to northern region, where temperatures is relatively low or cold. Increase temperature could possibly increase yield of rice and maize in the future. An assessment using DSSAT CERES-Rice and three General Circulation Models (GCMs) such as CSMK3, HadCM3 and HadGEM with high and low climate sensitivity found that rice yield under all six climate change scenarios will increase between +6.8% and +12.8% for 2035-2065 period compared with baseline 1995 to 2009. However, yields will not increase further in long-term, 2070 to 2100.[110].

4.2.3.4 OTHER SECTORS

Climate change impacts on other sectors have not been comprehensively studied, and do did under the TNC. However, climate change has implications on other sectors such as forest resources, tourism, urban, public health, labour, education, gender, etc. Forests are possibly at risk of climate change since their area, ecosystems and plant diversity as well as its resilience and adaptive capacity decreased or degraded. So, it is an immediate need to implement effectively measures to avoid or reduce deforestation and forest degradation such as law enforcement, sustainable forest management, prevention of forest fire prevention and encroachment or conversion. In addition, it needs to enhance forest restoration, diversification, and management of forest in the context of climate change. In addition, as pointing out in the WB (2022), energy, tourism, urban, public health, labour, education, gender is at risk given the increase of climate hazards including floods, storms, drought, heat wave and its effects on the production and food, water resources, infrastructure, etc., the decrease or degradation of natural resources and lack of climate-oriented planning and development. For example, one degree increase in ambient temperature can result in a 0.5%–8.5% increase in electricity demand for cooling and so on, leading to increase stress on the energy generation system itself and cost. There is a potential to increase of tourist in higher latitudes, and a decline in the attractiveness of heat stressed nations, which maybe Lao PDR.

The people, especially the low income, gender, elders, children, disable, slum and rural people are anticipated to face high risks due to the increase of climate hazards, effects on economy, natural resources and their low adaptive capacity. Many cities and urban in Lao PDR are located along the Mekong and other rivers and are affected by floods or inundation. Increase frequency and intensity of floods are possibly exacerbate the impacts on urban.

ADB has indicated that many households in Lao PDR have a high probability of falling into extreme poverty when exposed to more floods and drought frequently. Even an event occurs once in every five years could possibly cause a household to fall into extreme poverty situation.

WB (2022) suggested that there could be approximately 53.8 deaths per million population in Lao PDR in relation climate hazardous and lack of food by the 2050s under emissions pathway

[110] Boulidam, S. (2012). Simulation of climate change impact on lowland paddy rice production potential in Savannakhet province, Laos. na.

RCP8.5.

Heat-related mortality tends to increase as a result of the increase of emissions and temperatures exceed 35°C. Without adequate adaptation, annual heat-related deaths in the South-Eastern Asian region, could increase 295% and 691% by 2030 and by 2050, respectively [111].

Disease such as Malaria is projected to increase to 400,000 from lower emissions scenario (RCP2.6) to higher emissions scenario (RCP8.5) by the 2040s and 2070s, respectively. Dengue fever, which is projected to increases under both emissions pathways. Leptospirosis is also projected to increase as a result of the increase of floods. The increase of both drought and floods would increase incidence of diarrheal disease and deaths.

4.3 ADAPTATION MEASURES, BARRIERS AND OPTIONS IN KEY SECTORS

4.3.2 ADAPTATION POLICIES AND PLANS

Lao PDR periodically developed and implemented adaptation policies, strategies, plans and measures. Between 2010 and 2020, the developed policies, strategies, plans and implementation progress and achievements, constraints and gaps were summarized as follows.

1. Legal Framework on Climate Change Adaptation

Law on Environmental Protection (2013), Meteorological and Hydrological (2017), Water resources (2018), Disaster Risk Management (2019), and Decree on Climate Change (2019) and Environmental Impact Assessment (EIA) (2019), for example, defined policies and principles on the management and promotion of climate change adaptation, among others.
Environmental Protection Law (EPL) (2013) defines climate change adaptation as an objective of environment protection, and Decree on EIA (2019) includes climate hazards and disaster risks assessment as a component of EIA. Decree on Climate Change endorsed in 2019 specifically provides principles, regulations and measures to prevent, protect and reduce potential impacts of climate change in each sector as well as on lives, properties, environment, biodiversity and infrastructure. Meteorological and Hydrological, Water resources and Disaster Risk Management Law also promote adaptation, especially promotion monitoring, the development and operation of an effective early warning system and response to climate and hydrological hazards such as floods and drought risk and impact.

2. Climate Change Adaptation Strategies and Plans

The key climate change adaption strategies or plans are the National Adaptation Programme of Action to Climate Change (NAPA) and those defined in the SNC, and National Strategy on Climate Change (NSCC), National Determined Contributions (NDC), Climate Change Strategy Action Plan (CCSAP) in 2013-2020 and Technology Action Plan (TAP) for Climate Change Adaptation in

[111] Honda et al. (2014) used the A1B emissions scenario from CMIP3 (most comparable to RCP6.0) to estimate that heat-related deaths in the South-Eastern Asian region

agriculture, forestry and water resources, the 8th National Socio-Economic Development Plan-NSEDP (2016-2020) and the 9th NSEDP (2021-2025), National Green Growth Strategy to 2030, and sectoral strategies such as the 10-Year Natural Resources and Environment Strategy 2016-2025, a draft Urban Development Strategy to 2030, Agriculture Development Strategy to 2025 and Vision to 2030, Strategy on Climate Change and Health Adaptation 2018-2025 and action plan 2018-2020 and the Mekong Climate Change Adaptation Strategy and Action Plan and the Basin Development Strategy 2021-2030.

The NAPA was developed and implemented since 2009[112], and it was being updated as the National Adaptation Program (NAP) in 2022. NAPA 2009 defined 45 priority projects to enhance climate resilience in 4 four sectors: agriculture, forestry, water resources and public health. It was an open-ended plan and did not define a quantitative specific adaptation target, and M&E and reporting system for tracking the progress and impacts, leading to difficulty to measure the impacts. The issues and gaps were expected to address under NAP, which was being updated and expected to be in place by 2024.

The first NSCC was launched in 2010, and envisioned that *''the Lao PDR is capable of mitigating and adapting to changing climatic conditions in a way that promotes sustainable economic development, reduces poverty, protects public health and safety, enhances the quality of Lao PDR's natural environment, and advances the quality of life for all Lao people''.* To realize the visions, the NSCC defined overall goals and identified adaptation measures in 7 sectors namely agriculture and food security, forestry and land use, evaluation of the strategy impact water resources, energy and transport, industry, urban development and public health. The strategy, however, neither defined a quantitative specific adaptation target and timeframe for achieving it. The strategy was being revised and expected to be in place by the end of 2022. The gaps were addressed in the updated NSCC, but evaluation of the strategy impact including support received are difficult due to the lack of an inclusive M&E and reporting system.

CCSAP for 2013-2020 defined adaption actions or measures in 7 sectors in accordance with the NSCC. The Initial NDC (2015) defined priority projects in 5 four sectors: agriculture, forestry, water resources, urban development and public health, which were in line with the NSCC and NAPA. NDC was updated in 2021, and the updated adaptation measures in the key sectors until 2025 are as follows.

Table 26 NDC adaptation measures in the key sectors until 2025[113]

No	Sector	Target 2025
1	Agriculture	Mainstream climate change adaptation in sectoral strategy and action plan, including through results-based management framework
2	Forestry and Land Use Change	Mainstream climate change adaptation in sectoral strategy and action plan including through results-based management framework
3	Water Resources	Mainstream climate change adaptation in sectoral strategy and action plan

[112] Government of Lao PDR (2009). National Adaptation Programme of Action to Climate Change 2009. Vientiane.
[113] Lao PDR (2021). Nationally Determined Contribution (NDC).

		including through results-based management framework
4	Transport and Urban Development	Mainstream climate change adaptation in sectoral strategy and action plan including through results-based management framework
5	Health	Implement the Strategy on Climate Change and Health Adaptation to 2025
		Implementation of the 'Scaling-Up Water Supply, Sanitation and Hygiene' Project
6	Energy	Mainstream climate change adaptation in sectoral strategy and action plan including through results-based management framework

The Mekong Climate Change Adaptation Strategy and Action Plan and the Basin Development Strategy 2021-2030[114] issued in 2021 and defines a strategic priority to strengthen resilience against climate risks, extreme floods and droughts, including cooperation with other countries.

4.3.3 PROGRESS AND ACHIEVEMENTS, CONSTRAINST AND GAPS

1. Climate Change Adaptation Projects, Actions and Gaps in Sectors

By sector and project, since 2013 and in accordance with the climate change action plan 2013-2020, the main progress and gaps towards the adaptation are as follows:

Table 27 Climate Change Adaptation Projects, Actions and Gaps in Sectors

Sector and main progress/achievement	Deviations and gaps
Agriculture	
1) Improving the resilience of the agriculture sector to climate change impact[115] 2) Initiatives of climate smart agriculture such as Laos Climate Services for Agriculture (LaCSA)[116], which is a project that provides agro-meteorological information in a compact format relevant to Lao farmers. In addition, agriculture techniques such as seed selection, use of greenhouse for vegetables production, water management practice, integrated and organic agriculture farming, etc. 3) Promotion of climate resilience in rice and maize[117]	- Lack of assessment of climate change impacts, vulnerability or resilience of entire agriculture sector including resources and value chains - Lack of assessment, development and deployment of adaptation technology and practice in the sector such as resilient crop varieties and systems, crop diversification, water management in drought area, resilient infrastructure and irrigation, etc.

[114] Mekong River Commission (2021). The integrated water resources management–based Basin Development Strategy for the Lower Mekong Basin 2021–2030 and the MRC Strategic Plan 2021–2025. Vientiane: MRC Secretariat. URL: https://www.mrcmekong.org/assets/Publications/BDS-2021-2030-and-MRC-SP-2021- 2025.pdf

[115] UNDP (2010). Improving the resilience of the agriculture sector in Lao PDR to climate change impacts. URL: https://www.adaptation-undp.org/projects/ldcf1-lao-pdr

[116] Laos Climate Services for Agriculture. URL: https://www.lacsa.net/mapView.do

[117] 31 GIZ, ASEAN, NAFRI and SEARCAR (2022). Promotion of Climate Resilience in Rice and Maize Lao PDR National Study. URL: https://snrd-asia.org/download/forest_and_climate_change_for-cc/Lao-Report.pdf

and initiatives of research and development of crop varieties that are tolerant to flood or drought [118, 119, 120]	- Lack of disease and insect outbreak surveillance systems for crops and
4) Vaccination campaigns and monitoring of disease outbreak in the livestock sub-sector 5) Enhancement of agribusiness value chain by improving the resilience of agricultural infrastructure, enhancing crop productivity, promoting crop diversification and commercialization. 6) Mainstreaming climate risk study and management in project implementation, especially EIA system of foreign investment and financed by development partners.	livestock in the context of climate change - Lack of study, monitoring of expansion and impacts and management invasive alien plant species in the context of climate change - Lack of financial, insurance and other mechanism for handling climate risk in agribusiness and production
Forestry and Land Use Change	
1) Maintaining forest cover (the forest cover accounted for 67% in 2020, increased 58% in 2015) 2) Maintaining protection and conservation forest including buffer zones and biodiversity (9.8 million ha). 3) Promotes and maintains sustainable forest management of the production forest and community forest. As of 2020, all sustainable forest management planning was completed for all production forest (4.3 million ha). 4) Restoration of degraded forest (4.5 million ha) and forest plantation on barren land (about 0.5 million ha)	- Lack of assessment of climate change impacts on or vulnerability of forestry sector including forest resources and habitats or ecosystems - Lack of study, planning and implementation of ecosystem-based adaptation to increase resilience of forest and other resources, community and socioeconomic development - Limited or ineffective sustainable or integrated forest and non-timber forest product management that take into account and for climate change adaptation
Water Resources	
1) Water resources assessment and modelling, river basin profiles and basin management plans are also being drafted. 2) Establishment of aquatics, especially fish conservation areas 3) Enhances climate change adaptation in wetland including climate risk and vulnerability assessment of two Ramsar sites: Beung Kiat Ngong and Xe Champhone and increase resilience of vulnerable communities in the area [121],	- Lack of comprehensive assessment of climate change impacts on or vulnerability of water resources sector including aquatics resources and habitat, and site-and resources specific (e.g., important watershed, reservoirs, dams, wetland, aquatics and habitat etc) adaptation plan, implementation and monitoring

[118] 33 Phimata, O (2020). Rice centre sprouts new climate-resilient varieties. Vientiane Times. URL: https://www.vientianetimes.org.la/freeContent/FreeConten_Rice_2.php

[119] 32 Jackson, T. M., Newby, J., Phouyyavong, K., Vorlason, S., Simali, P., Sihathep, V., ... & Wade, L. J. (2022). Performance and adoption of submergence-tolerant TDK1-Sub1 rice in southern Lao PDR. Crop and Environment, 1(2), 108-114. URL: https://www.sciencedirect.com/science/article/pii/S2773126X22000211

[120] 34 Inthapanya, P, et al (2013). Recommended low land rice varieties for Lao PDR. URL: https://nardt.org/images/ACC_13/files/Recommended%20low%20land%20rice%20varieties%20for%20Lao%20PDR.pdf

[121] FAO (n.d). Climate Adaptation in Wetland Areas in Lao PDR (CAWA). URL: https://www.fao.org/in-action/climate-adaptation-

4) Started of the Mekong Adaptation and Resilience to Climate Change, including vulnerability assessment in 2014.[122]	- Limited comprehensive analysis of climate risk and adaptation plan of actions in the watershed management plan
5) Report, and starting project for Water Resource Management and Climate Change Adaptation in Mekong River Basin in 2022.[123]	
Transport and Urban Development	
1) Guidelines for Environmentally Sustainable Cities of Lao PDR were developed to provide guidance and steps to city government on how to analyse urban issues and promote urban environmental management to encourage cities in Lao PDR to become clean, green and beautiful. 2) Ministry of Public Works and Transport adopted a policy on mainstreaming climate resilience into this sector. The draft urban development strategy to 2030 explicitly calls for enhanced resilience in urban development. Ongoing investments include climate resilience road improvement for some critical sections for national and local road network, riverbank protection and drainage canal improvement in major cities to prevent both overflow river flooding and inundation. 3) Improving urban resilience using ecosystem-based adaptation approach is initiated in some Major cities including Pakse, Kaisone Phomvihane, Paksan and Oudomxay. 4) Building resilience in key structures like roads, bridges, buildings both construction and maintenance is also a priority on the agenda. The climate resilience road asset management system, which includes vulnerability data such as landslides and flooding, is being finalized. The system will be used for road maintenance planning, prioritization and budgeting.	- Lack of assessment and monitoring of climate risk or vulnerability on the sector including risks or vulnerability and resilience of urban and rural infrastructure - Lack of climate adaptation and resilience technology needs assessment, development and diffusion - Limited mainstreaming or considerations of climate risks and hazards in the planning and development of infrastructure, construction standards or code of practices.
Public Health	
1) The Strategy on Climate Change and Health Adaptation 2018-2025 and action plan 2018- 2020 was developed and provides strategic directions to build resilience in the public sector. The strategy has 10 components including organizational and staff capacity strengthening, vulnerability	- Lack of assessment and monitoring of climate risk or vulnerability on the sector including risks or vulnerability and resilience of the public health infrastructure and facilities - Lack of climate adaptation and

in-wetland-areas-in-lao-pdr-cawa/publications/en/

[122] IUCN Lao PDR (2014). USAID Mekong Adaptation and Resilience to Climate Change (USAID Mekong ARCC): Vulnerability Assessment Report.

[123] UNDP Lao PDR (2022). Project for Water Resource Management and Climate Change Adaptation in Mekong River Basin for Laos and Cambodia. URL: https://www.undp.org/laopdr/press-releases/project-water-resource-management-and-climate-change-adaptation-mekong-river-basin-laos-and-cambodia-officially-launched

assessment, integration of risk monitoring and early warning systems, health and climate research, sustainability of technology and	resilience technology needs assessment, development and diffusion
Infrastructure, management of health environment determinants, climate informed health programs, emergency preparedness, climate and health financing. So far, master trainers on climate change and health impacts were conducted to provide training on mitigating impact of climate change in the health sectors in 7 provinces. Information Education Communication materials related to climate change and health impacts were also developed and disseminated to public. 2) The 'Scaling Up Water Supply, Sanitation and Hygiene' project that aims to increase access to improved water sources and sanitation services in rural areas will contribute to public health climate adaptation.	- Limited mainstreaming or considerations of climate risks and hazards in the planning and development of infrastructure, construction standards or code of practices, especially those are at risks or in floods and other disaster-prone areas. - Lack of health risk and disease surveillance system in the context of climate change - Inadequate infrastructure, facilities, equipment and public health services as well as capacity for adaptation and response
Energy	
1) In 2018, the Dam Safety Guidelines, Emergency Action Plan was developed to provide recommendations to hydropower companies to put in place and implement emergency action plans. In addition, hydropower reservoirs will be effectively managed and shared for multipurpose uses to enhance resilience of the surrounding communities and other sectors through improved flood and drought measures, improved productivity and water use for recreation and households.	- Few dams or hydropower projects adopt or enforce the measures, but it lacks M&E and reporting. Climate and disaster risk assessment and map, a sound early warning system and emergency response plan requirements have not been clearly defined in polices e.g., EIA decree, regulation on dam safety, and implemented by dams or hydropower projects.
Education and Awareness Raising	
1. Mainstreaming of climate change in formal education system or curriculum, especially bachelor level, the primary school and secondary school. More details are provided in the section 6.3. **2.** The National Strategy on Education and Awareness on the Environment and Climate Change (2018 – 2025) was developed in 2018, and envisages "Lao people become more knowledgeable and aware, understand, care, participate and take ownership in natural resources management, environmental protection and adaptation to climate change, ensuring socio-economic development in line with green and sustainable manner" by 2030.	- Limited climate change curriculum development in all levels both formal and non-formal education - Lack of assessment and monitoring of climate risk or vulnerability on the sector including risks or vulnerability and resilience of the educational infrastructure and facilities - Limited mainstreaming or considerations of climate risks and hazards in the planning and development of infrastructure, construction standards or code of practices, especially those are at risks or in floods and storms-prone areas.

3. Climate Change Adaptation Constraints and Gaps

Those policies and measures have not been fully and effectively implemented as a result of the limited human and financial resources, and the detail or specific action plan for specific hazards, sectors, areas and communities. In addition, it has been difficult for assessment or evaluation of the implementation, achievements or impacts, and its effectiveness, relevance and sustainability due to the lack of an inclusive and effective monitoring and evaluation (M&E) system including the baseline and adaptation targets, reporting and coordination.

4.3.4 ADAPTATION MEASURES IN THE FUTURE

The adaptation actions or measures in the future or until 2030 are mainly defined in the update NSCC. The adaption actions or measures under this TNC, in accordance with NC term, elaborated and included those actions and measures to be implemented in next 2 to 4 years or until 2025. Those overall measures and actions are as follows and by sectors as outlined in the NSCC (2023).

1) Enhance climate change adaption and response capacity of the communities, production and value chains, businesses, services, infrastructure, ecosystems and sectors that are especially at risk of climate change and disasters;
2) Develop and implement the end-to-end early warning systems including centres and strengthening capacity on climate change and hazards monitoring, assessment, reporting, communication, response planning;
3) Enhance capacity of all sectors for response, recovery, and building back from climate change impacts and disasters;
4) Develop, deploy and transfer modern and appropriate technologies and practices for prevention, adaptation, resilience and building back from climate change impacts;
5) Strengthen organizational capacity and human resources including number and capacity of personnel to ensure development and implementation of policies, plans and actions for climate change adaptation and resilience in an effective, efficient and sustainable manner;
6) Promote and enhance climate change education, awareness raising, and access to information to increase knowledge and awareness of safe behaviours, and reduce ignorance and unsafe practices when responding to climate change phenomena and disasters.
7) Create an enabling environment, promote and enhance law enforcement to ensure an effective, efficient and sustainable prevention, adaptation, resilience and building back from climate change impacts;
8) Develop and implement an effective climate finance mechanism for action measures and actions.

CHAPTER 5 PROGRAMMES CONTAINING MEASURES TO MITIGATE CLIMATE CHANGE

5.1 OVERVIEW OF MITIGATION POLICIES, PLANS AND IMPLEMENTATION

Lao PDR, in accordance with the UNFCCC and COP decisions, to the extent its capacity allows, developed and implemented climate change mitigation policies, plans and programmes periodically. Following the submission of the SNC in 2013, for instance, Lao PDR developed and updated policies and plans at national and sectoral level for mitigating climate change. Those important ones include Decree on Climate Change (2019), the updated National Strategy on Climate Change (NSCC) (2021), the First Intended Nationally Determined Contributions to Climate Change (INDC) in 2015 and the updated or the second one in 2021, and Climate Change Technology Action Plan (TAP) under Technology Needs Assessment (TNA) (2017). In addition, Lao PDR adopted the sustainable development goals (SDGs), and national and sectoral policies and plans such as the 8th and the 9th National Socioeconomic Development Plan (NSEDP) 2016-2020 (2016) and 2021-2025 (2021), the National Green Growth Strategy of the Lao PDR till 2030 (NGGS) (2018), MONRE's Vision to 2030 and 10-year Strategy, 2016-2025 (2015), Renewable Energy Development Strategy in Lao PDR (2011), Forestry Strategy to 2035 and the Vision to 2050 of the Lao PDR (2021) mainstreamed mitigation actions. At the programme and project level, nationally appropriate mitigation actions (NAMAs) on renewable energy, transport sector, and reducing emissions from deforestation and forest degradation (REDD+) were implemented on the ground.

The Table 28 below summarised the policies, plans, programmes and other existing plans including its goals or emissions reduction potentials.

Table 28 Key climate mitigation measures and goals

Mitigation Policies and Plans	**Main Targets/Measures or Emissions Reduction Potentials**
The updated National Strategy on Climate Change (NSCCS) (2023)	Reaffirmed the development goals and targets defined in NDC, forestry and green growth strategy
Determined Contributions to Climate Change (NDC) (2021)	- Unconditionally reduces greenhouse gas emissions (GHG) in 2030 by 60% compared to a business-as-usual (BAU) scenario. It includes emissions reduction in land use, land-use change and forestry (LULUCF) by 1.1 MtCO2eq/year by reducing deforestation; increase hydropower capacity from 5.5 GW to 13 GW; introducing 50,000 energy efficient cook stoves and build a new bus rapid transit system in Vientiane and a new railway to China. - Conditionally, increases the forest cover to 70% of total land area, develops 1 GW of renewable energy including wind and solar power, 300 MW of biomass-fired power plant, and reduces final energy consumption by 10% compared to a BAU scenario. National GHG emissions in 2020 have been estimated around 53 MtCO2eq between 2000 and 2020 and Lao PDR expected to achieve to reduce emissions by 34% compared to the BAU scenario.

Mitigation Policies and Plans	Main Targets/Measures or Emissions Reduction Potentials
The 9th Five-Year National Socioeconomic Development Plan (NSEDP) 2021-2025 (2021)	- Reduce greenhouse gas emissions (at least 30 million tCO2eq) from deforestation - Plantation of 200,000 ha and reforestation of 1,800,000 ha annually - Sales value of forest carbon credits (>US$95 million) - Rates of clean energy use in transportation accounted for 14% (annually)
The National Green Growth Strategy of the Lao PDR till 2030 (NGGS) (2018)	Emissions reduce from 0.15 (2015) to less than 0.6 by 2025 and <1.2 t/cap/yr. by 2030[124].
MONRE's Vision to 2030 and 10-year Strategy 2016-2025 (2015)	- Establish a park per community (population>100,000) by 2030 - Slash and burnt agricultural reduced by 15% by 2030
Renewable Energy Development Strategy in Lao PDR (2011)	- Electricity is available to 90% of household in rural area by 2020[41] - Renewable energy shares 30% of energy consumption by 2025. - 10% of the fuel use in transport sector replaced by biofuel by 2025 - 58 MW from biomass - 51 MW from biogas - 48 MW from solar power - 73 MW from wind power - 36 MW from municipal solid waste - 400 MW from small-scale hydropower - Build large (>15 MW) hydropower plants to provide clean electricity to neighbouring countries. - Energy saving by 10% by 2030 - Increased energy use efficiency by 10% by 2025
Forestry Strategy to 2035 and the Vision to 2050 of the Lao PDR (2021)	- Forest cover increased to 70% of land area or 16.58 million hectares by 2035 - 2.5 million ha of degraded forest restored by 2035 - 500,000 ha of plantation established on barren land by 2035 - Reduced 55 million tCO2eq id by 2035 (avoided 40 million tCO2eq from deforestation and forest degradation and removed 15 milliontCO2eq from forest restoration) - 50% of the protection and conservation forest are well-prevented and managed by 2030

5.2 PROGRESS, ACHIEVEMENTS AND CONSTRAINTS ON MITIGATION

Lao PDR had made a remarkable progress and achievements against the planned mitigation measures, especially renewable energy development. However, the actual emissions reduction has not been evaluated. In addition, there is no system to track and MRV of the progresses and achievements. Apart from policies and plans, the main progresses and achievements or variations of the key mitigation action implementation were summarised in Table 29, and constraints on mitigation were summarized in Table 30.

[124] Green Growth Secretariat (2019). National Green Growth Strategy to the year 2030 of Lao PDR.

Table 29 Main progress on the implementation of climate mitigation measures

Sector/Strategy	Main Progress, Achievements or Variations
Agriculture and Forestry Sector (Forestry Strategy, etc)	1. Maintained forest cover. As of 2018, forest cover was 58% of the total land areas (the 2020 target was 70%. This target was extended to 2030 under the forest strategy to 2035 and the Vision to 2050 of the Lao PDR (2021). 2. Illegal forest logging, encroachment and deforestation observably decreased following enforcement of, particularly the Decree No 15/PM (2016) on Strengthening Strictness of Timber Harvest Management and Inspection, Timber Transport and Business. In addition, progress has been made on the Forest Law Enforcement, Governance and Trade (FLEGT), especially Voluntary Partnership Agreements (VPAs) on verified legal timber and Timber Legality Assurance System (TLAS). 3. 7 REDD+ projects and 16 Readiness Initiatives have been implemented through the country since 2010. Forest Reference Emission Level (FREL) established in 2021, and National Forest Monitoring System has been improved since 2018. 4. 446,000 ha of plantation established by 2015. 5. 463,618.06 ha of degraded forest restored. 6. Promotion of organic farm: about 67% of agriculture is organic by default and 0.5% of agricultural farm land was certified as organic farming land 7. Promotion of good agriculture practice: 1% of agricultural farm land was certified as GAP 8. Promotion of biogas (see also energy sector)
Energy Sector (Renewable Energy Development Strategy in Lao PDR, 2011)	1. 9 solar power plants (32 MW) developed between 2015 and 2017 (66.67% compared to the target). 2. 39.7 MW from biomass (68.44% compared to the target). 2 biomass power plants (25 MW) developed from 2013-2017, and 60 MW plant is under construction [49]. 3. 74.77 MW small scale of hydropower plants developed from 2011-2017 (22.5 MW from 2015-2017) 4. 92% of households nationwide have access to electricity in 2017. 5. As of 2020, total 46 large scale hydropower plants attained 6,129 MW (161,170 million kWh). 6. Renewable energy including large hydropower shared 86.14 % of electricity consumption by 2015. 7. 2,500-hectare Jatropha plantation and for biodiesel established, and a biodiesel factory (2,000 litters per/day) operated in Xayabuly Province 8. Pre-feasibility studies of 2 wind power projects conducted. One (64 MW) is in Savannakhet and another one (50 MW) in Champasak Province.
Sector/Strategy	**Main Progress, Achievements or Variations**
	9. Promotion of energy saving cooking stoves: about 1,200 stoves were distributed and used.

Transport sector	1. 42 public buses are being operated under NAMAs, but its effects regarding GHG reduction have not been assessed. The Planned Road network and BRT under NAMAs have not been implemented. 2. Electric Vehicle (EV) Project initiated in Luang Prabang since 2012, and now EV use has increased in other provinces, especially Vientiane capital and Oudomxay province. 3. LAO: Vientiane Sustainable Urban Transport Project was started in 2014[125], and 12.9-kilometer Bus Rapid Transit project was started in Vientiane capital in 2021 and expected to be operated in 2024[126].
Multi-sectors including MONRE's Vision to 2030 and 10-year Strategy 2016-2025, NSCCS, NGGS, the 9th NSEDP 2021-2025, etc)	1. Promoted sustainable solid waste management including feasibility on waste-to-energy 2. Piloted low emissions specific economic zone development

Table 30 Key barriers or constraints on climate change mitigation

Area/Categories	Key barriers or constraints
Economic and financial	1. High cost and inadequate financial resources to invest in mitigation technologies or actions, especially clean, renewable energy, low emission and adaption technologies
	2. Unclear or lack of financial incentives and mechanism for promotion
	3. Limited budget and financial resources
Market	1. No domestic carbon market, while regional markets are variable, low price and difficult to access 2. Failure or non-marketable climate change technologies and measures
Policy, legal and regulatory	Less effective on the development and implementation of a legal and regulatory framework, especially policies and strategies to promote development, deployment, and diffusion or transfer of renewable energy, environmentally friendly, low carbon technologies, carbon credit and trading, including incentives, or translation of COP's decisions into policies and regulations and practice were not effectively and timely implemented.
Network	Inexistent climate change and related expert group/think-tank and network including platform to share information and discussion to find solutions for climate change issues. Access to and networking with the regional networks are difficult and limited.

[125] EIB (2014). VIENTIANE SUSTAINABLE URBAN TRANSPORT. URL: https://www.eib.org/en/projects/pipelines/all/20130587
[126] ADB (2021). Lao PDR: Setting Vientiane on the Road to Sustainable Transport. URL: https://www.adb.org/news/features/lao-

Governance, institutional and organisational capacity and human skills	1. Ineffective organisational arrangement and development within or among the organisations. including organizational planning and reporting system and procedure
	2. Lack of an effective mechanism and coordination amongst stakeholders, especially inadequate or ineffective data sharing, communication, cooperative action or joint implementation, and reporting.
	3. Limited/inadequate human resources, and capacity and skills of the relevant sectors, including education sector. So far, specific or inclusive human resources and capacity development plan and targets, M&E including tracking and reporting system are absent.
	4. Different development priority, values, and conflict of interest among organisations and regions
Information and awareness	1. Inadequate technical, financial and economic, social-culture, physical including environmental and climate information for in-depth or inclusive GHG inventory, climate change mitigation, adaptation including technology assessment, planning and development 2. Information dissemination, sharing and awareness raising are ineffective and conducted through the country, including communities and sectors.
Technologies and tools	Limited/inadequate technologies, tools, models and best practices for climate change mitigation and adaptation including assessment, projection/planning, tracking and M&E of progress
Others	Geographical constraints including land-locked situation results in difficulties for climate change mitigation and adaptation including application of technologies

5.3 EMISSIONS PROJECTION AND THE PLANNED NAMAs

Projection of emissions was initiated under the SNC and other initiatives since 2012-2013. Under the SNC, the projection of emissions in energy (fuel oils), industry (cement), forest cover change, agriculture (rice field and livestock) and solid waste were carried out using an econometric model. Emissions projection for energy sector was also conducted using Long-range Energy Alternatives Planning system (LEAP) in 2012.[127], 2016.[128] and 2021.[129]. Recently, there was a projection under the updated NDC 2021, using the Greenhouse Gas Abatement Cost Model (GACMO). GACMO was also used in this TNC. In addition, LEAP and the Comprehensive Mitigation Assessment Process (COMAP) were also used to examine consistency or difference aspects of mitigation.

Results and uncertainty of the projection of emissions varied due to different models, data and assumptions. However, results of the projection of emissions and mitigation measures for whole country, multi-sectors or under the 2nd NDC and the TNC project are as follows, while sector

[127] Luukkanen, J., Kouphokham, K. and Panula-Ontto, J., 2012. Future energy demand in Laos. Scenario alternatives for development.

[128] Kouphokham, K., 2016. Lao PDR country report. Kimura, S. and P. Han (eds.) in Energy Outlook and Energy Saving Potential in East Asia 2016, pp.2015-5.

[129] Kimura, S. and Phoumin, H., 2021. Energy Outlook and Energy Saving Potential in East Asia 2020.

specific emissions projection and mitigation measures are discussed in section 5.3.1 to 5.3.4.

Under the 2nd NDC, the emissions baseline scenario was projected using the emissions in the year 2000 or SNC as base year, and the result showed that the GHG emissions levels in Lao PDR could increase to 82,000 ktCO2e in 2020; 104,000 ktCO2e in 2030 and more than 120,000 ktCO2e in 2050 (Figure 68). Under unconditional scenario or own resources and the existing levels of support from development partners and organisations, Lao PDR could possibly reduce emissions of at least 3,975 ktCO2e per year between 2020 to 2030. With increased levels of support from developed country Parties, development partners and organisations (conditional scenario); Lao PDR could possibly achieve emissions reduction at least 45,691 ktCO2e per year for the same period, 2020-2030 (Table 31).

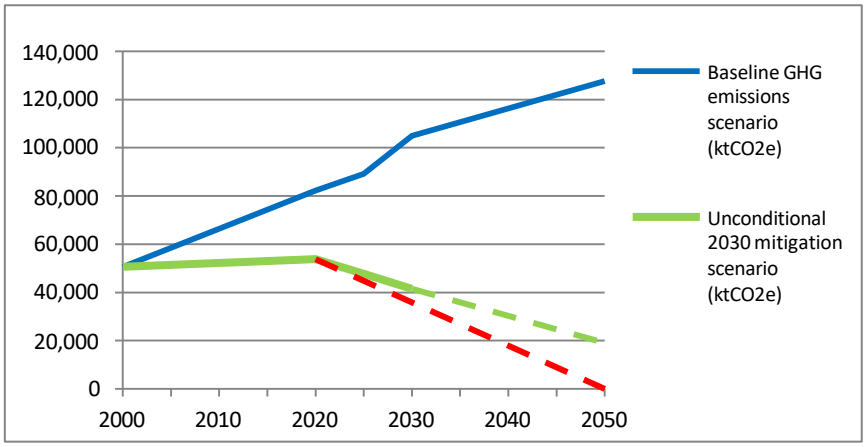


Figure 67 Emissions Projection under NDC 2021.[130]

Table 31 Mitigation Targets and Emission Reduction Potentials under Unconditional and Conditional Scenarios.[131]

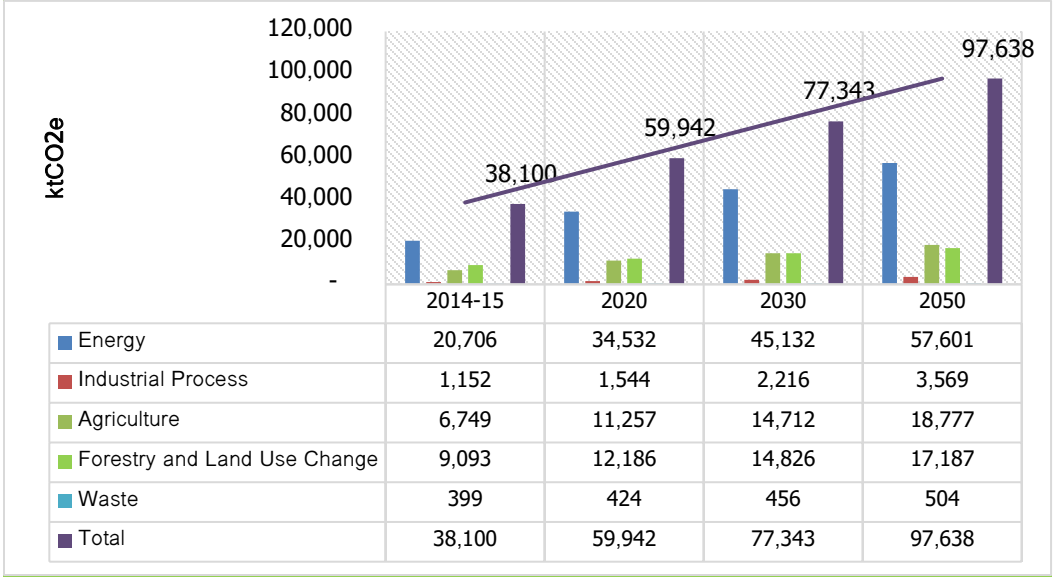
Sector	**Mitigation target (2020-2030)**	**Average abatement between 2020 and 2030 (ktCO2e/y)** (Unconditional)	**Average target between 2020 and 2030 (ktCO2e/y)** (Unconditional)
Land Use Change and Forestry	Reduced emissions from deforestation and forest degradation, foster conservation, sustainable management of forests, buffer zones of national parks and other preserves, and enhancement of forest carbon stocks.	1,100	45,000
Energy			
Hydropower	13GW total hydropower capacity (domestic and export use) in the country	2,500	NA

[130] Footnote 113
[131] Footnote 113

SOLAR and WIND	1 GW total installed capacity in the country	NA	100
BIOMASS	300 MW total installed capacity in the country	NA	84
Energy Efficiency	Introduction of 50,000 energy efficient cook stoves	50	NA
	10% reduction of final energy consumption compared to business-as-usual scenario	NA	280
Transport	• New Bus Rapid Transit system in Vientiane Capital and associated Non-Motorized Transport (NMT) component • Lao-China Railway	25 300	NA NA
	30% Electric Vehicles penetration for 2-wheelers and passengers' cars in national vehicles mix	NA	30
	Biofuels to meet 10% of transport fuels	NA	29
Agriculture	50,000 hectares adjusted water management practices in lowland rice cultivation	NA	128
Waste	Implementation of 500 tons/day sustainable municipal solid waste management project	NA	40
Total		**3,975**	**45,691**

However, under the TNC project, a study used emissions in 2014 or BUR as the base year and updated data or assumptions[132] found that the emissions in the future are on the same trend, but lower than those estimated under the 2nd NDC. Greenhouse gases increased from 2014 (24 million tons of CO2e) to 38.1 million tons of CO2e in 2015, and increased to 59.94 million tons in 2020, 77.34 million tons in 2030 and 94.07 million tons of CO2e in 2050 (Figure 69). Among them, the release of greenhouse gases from now until 2050 would be about 2.7 billion tCO2e or about 74.62 million tons per year.

[132] 55 Population growth (1.55% for 2014-2020, 1.34% for 2020-2030 and 0.79% for 2030-2050); GDP growth (5.90% for 2014-2020,
3.60% for 2020-2030 and 5.00% for 2030-2050); fuel use in sectors (1.55% for 2014-2020, 1.34% for 2020-2030 and 0.79% for 2030-2050); forestry emissions (5% for 2014-2020, 4% for 2020-2030 and 3% for 2030-2050); Waste emission (1% for 2014-2020, 1.5% for 2020-2030 and 2% for 2030-2050); and industry process (5% for 2014-2020, 7.5% for 2020-2030 and 10% for 2030-2050).



	2014-15	2020	2030	2050
Energy	20,706	34,532	45,132	57,601
Industrial Process	1,152	1,544	2,216	3,569
Agriculture	6,749	11,257	14,712	18,777
Forestry and Land Use Change	9,093	12,186	14,826	17,187
Waste	399	424	456	504
Total	38,100	59,942	77,343	97,638

Figure 68 Projected Emissions by Sector until 2050[133]

Overall, according to the initial assessment, Lao PDR will not be able to reduce greenhouse gases to equal or below zero if the investment of the public sector, private sector and various organizations at home and abroad in managing climate change is still at the level and characteristics that exist or there are no conditions or enabling environment. However, if the existing policies and plans are effectively implemented, Lao PDR could possibly reduce greenhouse gas emissions to a relatively good level compared to the baseline greenhouse gas emissions. Greenhouse gas emissions could decrease from approximately 26 million tons, or from 60 million tons to 34 million tons in 2020; 33 million tons (from approximately 77 million tons to 44 million tons) in 2030, and 39 million tons (from about 94 million tons to 55 million tons) in 2050. This means Lao PDR could possibly reduce greenhouse gases by about 1,100 million tons from 2014 to 2050 or within 45 years or about 30.58 million tons per year (Figure 70, Table 32).

[133] TNC Team (2021). Mitigation assessment using the Greenhouse Gas Abatement Cost Model (GACMO)

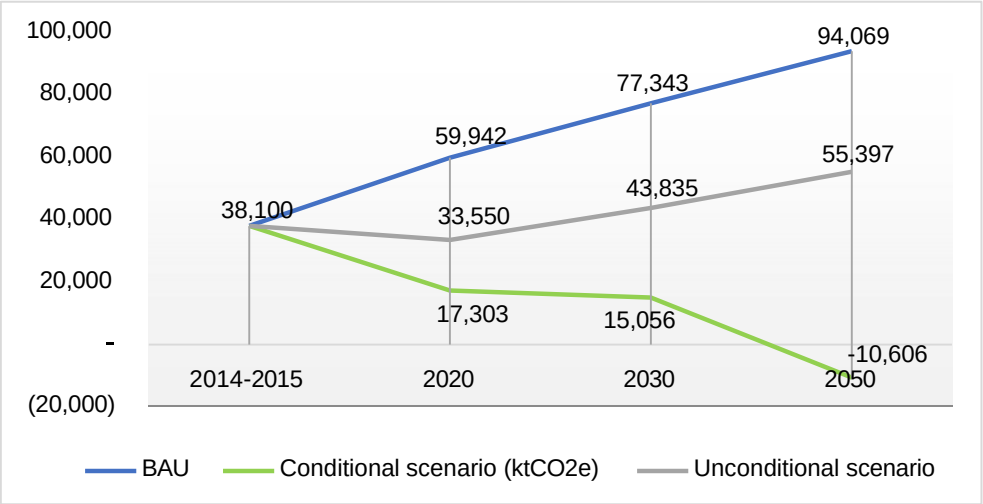


Figure 69 Projected Emissions (ktCO2e) and Unconditional and Conditional Mitigation Scenario until 2050[134]

Table 32 Unconditional reductions in greenhouse gas emissions by 2050[135]

Year	GHGs (th.tCO2e)	%	Year	GHGs (th.tCO2e)	%	Year	GHGs (th.tCO2e)	%	Year	GHGs (th.tCO2e)	%
2014	0	19	2021	23,009	37	2031	33,766	43	2041	36,348	42
2015	7,972	24	2022	24,175	38	2032	34,024	43	2042	36,606	42
2016	10,746	28	2023	25,342	39	2033	34,283	43	2043	36,865	42
2017	13,520	31	2024	26,508	40	2034	34,541	43	2044	37,123	42
2018	16,294	34	2025	27,675	40	2035	34,799	43	2045	37,381	42
2019	19,068	44	2026	28,842	41	2036	35,057	43	2046	37,639	41
2020	26,392	19	2027	30,008	42	2037	35,315	42	2047	37,897	41
			2028	31,175	42	2038	35,574	42	2048	38,156	41
			2029	32,341	43	2039	35,832	42	2049	38,414	41
			2030	33,508	43	2040	36,090	42	2050	38,672	41
Sub-t.	**93,991**			**282,583**			**349,281**			**375,101**	
Ave.	**15,665**	**30**		**28,258**	**41**		**34,928**	**43**		**37,510**	**42**
Total											**1,100,956**
Ave.											**30,582**
Ave%											**40**

Notes: TNC Team, 2021. Adjusted from Figure 68

With the Conditional scenario with the substantial increased investment of the public, private sector and various domestic and foreign organizations (about 8 billion dollars in the period 2014-2020, 9.7 billion dollars in the period 2021-2030 and 20 billion dollars in the period 2031-2050) (Table 32) to implement most of the mitigation measures or potentials, Lao PDR could potentially reduce greenhouse gases by as much as or below zero within 45 years or until the year 2050. The total greenhouse gases by about 2.374 million tons from 2014 to 2050 or 66 million tons annually under the Conditional scenario (Table 33).

[134] Footnote 133
[135] Footnote 133

Table 33 Greenhouse Gas Emissions Reduction Under Conditional Scenario and the Net Zero Emission Pathways until 2050[136]

Year	GHGs (th.tCO2e)	%	Year	GHGs (th.tCO2e)	%	Year	GHGs (th.tCO2e)	%	Year	GHGs (th.tCO2e)	%
2014	0	0	2021	44,604	72	2031	64,406	82	2041	85,600	99
2015	6,863	16	2022	46,569	73	2032	66,526	84	2042	87,720	100
2016	14,018	31	2023	48,533	74	2033	68,645	86	2043	89,839	102
2017	21,173	43	2024	50,498	75	2034	70,765	88	2044	91,959	103
2018	28,329	54	2025	52,463	76	2035	72,884	89	2045	94,078	105
2019	35,484	63	2026	54,428	77	2036	75,003	91	2046	96,197	106
2020	42,639	71	2027	56,393	78	2037	77,123	93	2047	98,317	107
			2028	58,357	79	2038	79,242	94	2048	100,436	109
			2029	60,322	80	2039	81,362	96	2049	102,556	110
			2030	62,287	81	2040	83,481	97	2050	104,675	111
Sub-t.	**148,505**			**534,454**			**739,437**			**951,377**	
Ave.	**24,751**	**46**		**53,445**	**76**		**73,944**	**90**		**95,138**	**105**
Total											**2,373,773**
Ave.											**65,938**
Ave%											**83**

Notes: TNC Team (2021). Adjusted from Figure 68

To achieve those targets, Lao PDR, apart from the measures outlined in the Table 34, will implement additional measures as follows and additional mitigation actions under each relevant sectors as discussed in section 5.3.1 to 5.3.4. If setting the minimum and maximum cost between -200 to 200 US$/tCOe2 reduced the cost abetment or savings would range from -20 US$/tCO2e to 12.5 US$/tCO2e (Figure 71).

Table 34 Investment Cost for Mitigation from 2020 to 2050[137]

Summary by Categories	2020		2030		2050	
	Reductions MtCO2/yr.	Investments Billion US$	Reductions MtCO2/yr.	Investments Billion US$	Reductions MtCO2/yr.	Investments Billion US$
HFCs, PFCs, SF& & N2O reduction	0.000	0.00	0.00	0.00	0.09	0.01
Renewables	12.27	7.73	12.41	7.97	21.87	14.38
CH4 reduction & Cement & Coal mine/bed	0.562	0.01	1.70	0.02	5.81	0.18
Supply-side EE	0.001	0.00	3.23	0.14	15.86	0.72
Fuel switch	0.000	0.00	0.00	0.00	0.00	0.00
Demand-side EE	0.009	0.00	0.25	0.15	0.97	0.70
Afforestation & Reforestation	1.348	0.16	9.17	0.87	14.67	2.15
Transport	0.959	0.08	0.61	0.24	2.95	0.42
Carbon capture and storage (CCS)	0.000	0.00	0.00	0.00	0.30	0.42
Total GHG reduction	**15.150**	**7.971**	**27.380**	**9.390**	**62.513**	**18.964**

[136] Footnote 133

[137] Footnote 133

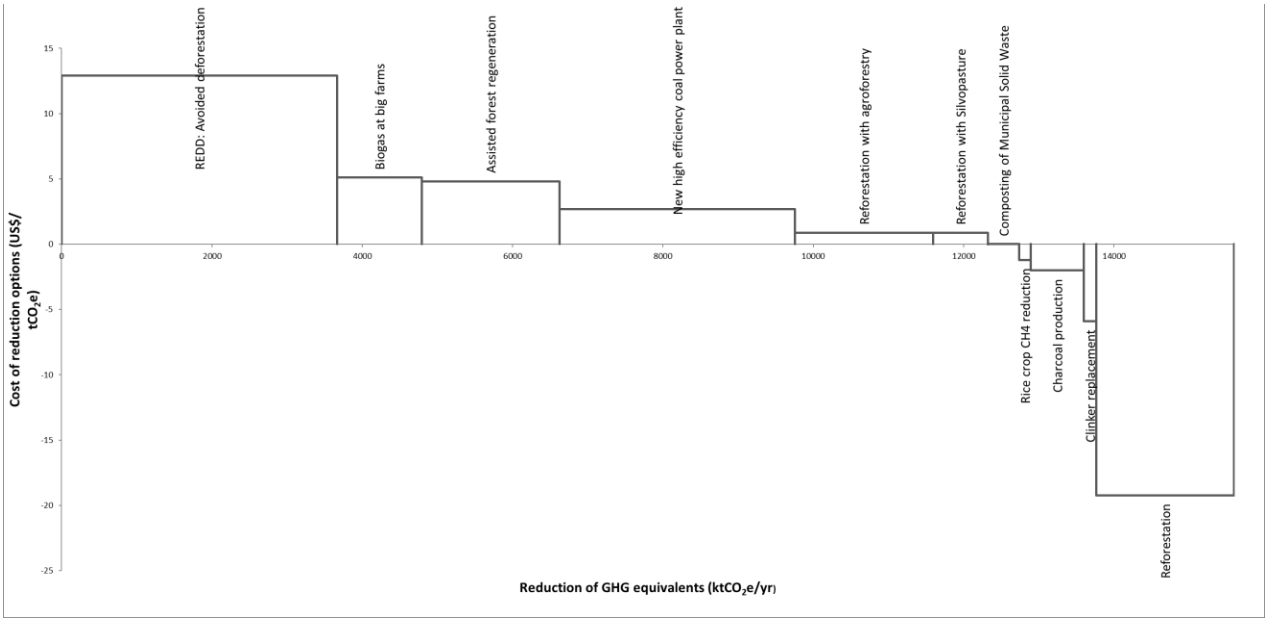
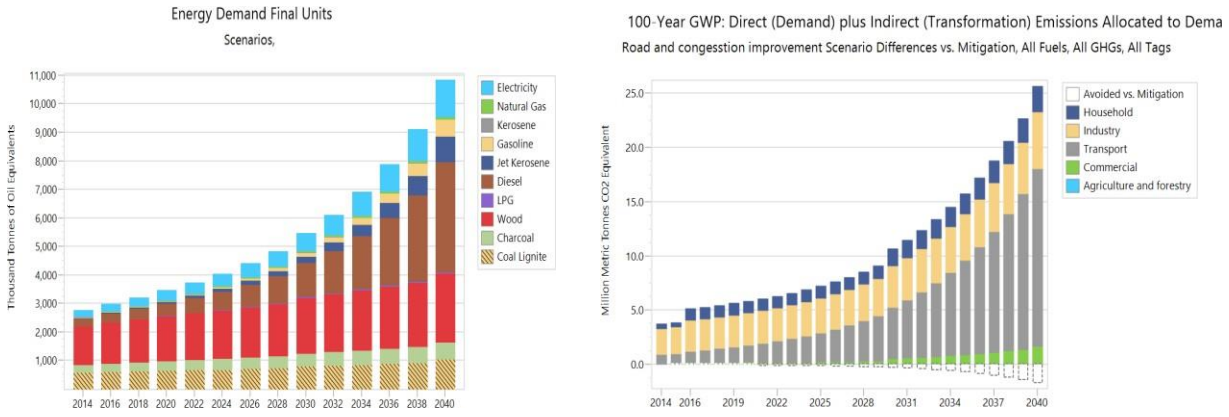


Figure 70 Abatement revenue curve for mitigation measures (threshold -200 to 200 US$/ktCO2e)[138]

5.3.1 ENERGY SECTOR

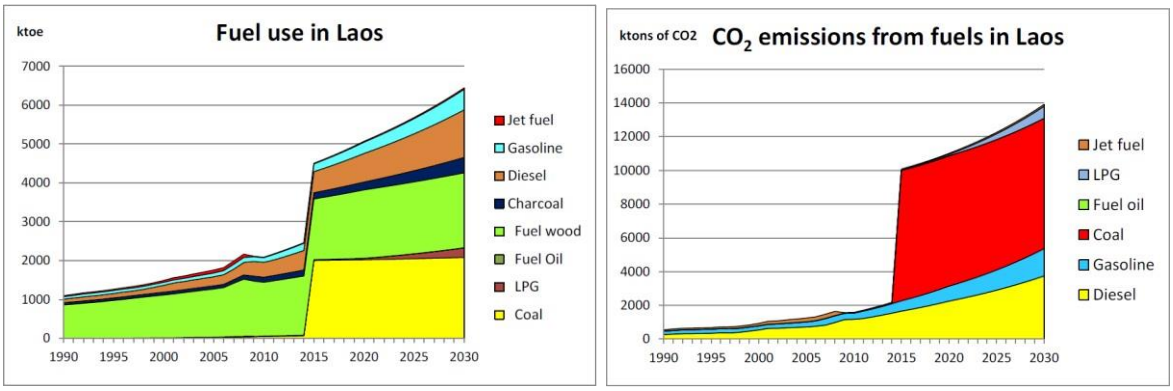
Emissions from energy or power sector was projected to increase up to 35 million tCO2e in 2030 and 44 million tCO2e in 2050 (Figure 68). An estimate of energy demand and emissions using LEAP showed lower emissions in 2040, which was about 26 million tCO2e (Figure 72). This number was about slightly higher than those estimated by Luukkanen et al., (2012), who found that fuels use or demand in Lao PDR was about 6,500 ktoe and emissions 14 million tCO2e in 2030. Khouphokham (2016) projected the energy demand and emissions from fuel oils until 2030 was conducted under SNC. In addition, there was as a study on energy demand and emissions in the future for energy outlook until 2030. All projections showed the increase of energy demand and use as well as emissions (Figure 73), and if mitigation measures such as renewable energy is effectively promoted and implemented, emissions would reduce by 3.6% in comparison with business as usual (BAU) scenarios by 2040 (Figure 74).

[138] Footnote 133



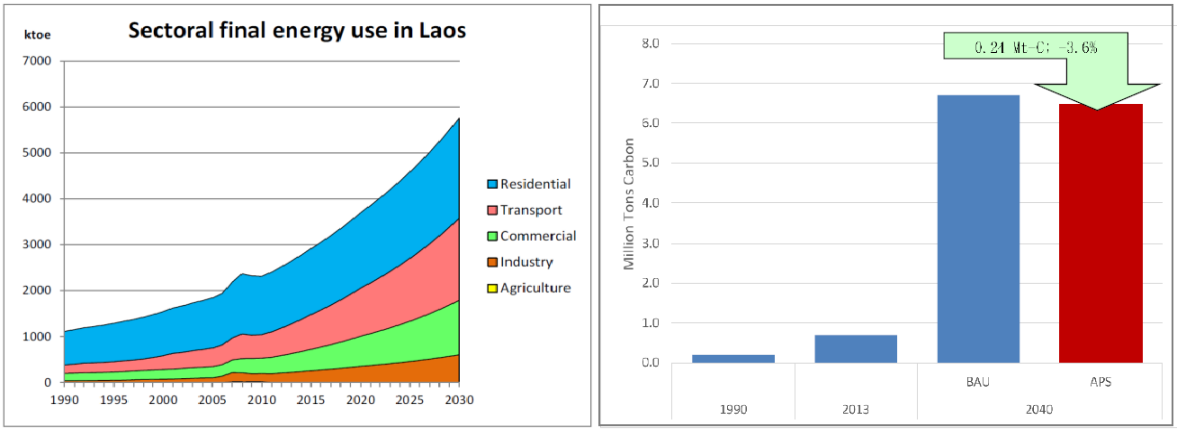
(a) (b)

Figure 71 Projection of fuel demand (a), emissions and mitigation in fuels (b) until 2040[139]



(a) (b)

Figure 72 Projection of fuel demand (a) and emissions from fuels (b) until 2030[140]



(a) (b)

[139] TNC Team (2021). Projection of fuel demand, emissions and mitigation in fuels using the Long-range Energy Alternatives Planning system (LEAP)

[140] Luukkanen, J., Kouphokham, K., & Panula-Ontto, J. (2012). Future energy demand in Laos. Scenario alternatives for development.

Figure 73 Projection of fuel demand (a) and emissions from fuels (b) until 2040.[141]

Mitigating emissions in energy sector requires substantially promotion and investment in renewable energy, low emissions fuel switching and energy efficiency in both supply and demand side. For example, to achieve emissions reduction of about 16 million tCO2e by 2030 and 39 million tCO2e by 2050 requires financial investment of about US$7 to 16 billion by 2030 and 2050, respectively (Figure 69 and Table 35). In addition, emissions could be mitigated by the implementation of the mitigation measures summarized in the Table 35 below. These mitigation measures adopted or adjusted from the NSCC, NDC and energy sectoral plans.

Table 35 Key climate change mitigation measures under Energy Sector until 2030.[142]

	Key Mitigation Measures/Actions
1.	Strengthen energy and resources conservation, efficiency and savings
2.	Promote development and expansion of energy saving cooking stoves
3.	Promote energy saving and efficiency building design and appliances
4.	Improve and develop urban and road network, transport, and logistics system to reduce traffic congestion
5.	Promote development and use of electric vehicles
6.	Improve and develop infrastructure and facilities for cycling and walking
7.	Promote and enhance resource efficiency in wood and non-timber forest product processing and uses
8.	Strengthen capacity for monitoring of Sulphur hexafluoride (SF6) in electrical system
9.	Enhance marketing, promotion, awareness raising and implementation of policies on energy and resources conservation, efficiency and savings
10.	Study and improve energy and resources pricing that promote energy and resources saving

5.3.2 INDUSTRIAL PROCESS AND PRODUCT USE

Emissions projection was made for cement industry under SNC, using econometric model, while the projection of emissions from other of industries were and industrial product use have not been conducted. However, based on previous inventories and emissions, emissions in from sector was gradually increased was anticipated the trend would continue in the future along with gradually growth of the sector. Based on the Figure 68, the projected emissions would increase to 68,000 tCO2e by 2030 and 87,000 tCO2e by 2050, from 31,000 tCO2e in 2014-2015 and 58,000 tCO2e in 2020.

Reducing emissions in industry sector by especially replacement of cement clinker by the lower emissions materials, coal-based methane emissions, industrial products (halocarbons) use and carbon capture and storage would lead to decrease emissions from about 1.7 million tCO2e by 2-30 to 6.2 million tCO2e by 2050. However, investment of about US$ 0.02 to 0.18 billion by 2030 and 2050 are needed for the implementation of the measures (Table 36). In addition, emissions reduction and investment were also expected as a result of the implementation of mitigation

[141] Kouphokham. K (2016). 'Lao PDR Country Report' in Kimura. S and Han. Pan (eds.) in Energy Outlook and Energy Saving Potential in East Asia 2016. ERIA Research Project Report 2015 2015-5, Jakarta: ERIA, pp. 193 -213.
[142] Adjusted from the national strategy on climate change (2022)

measures adopted from especially NSCC and NDC as follows.

Table 36 Key climate change mitigation measures under Industry Sector until 2030[143]

Key Mitigation Measures/Actions
1. Study and develop technology action plan on low-emission and environmentally friendly technologies, resources and energy recovery, efficiency and savings in industrial sector, use of renewable energy, especially solar and heat in industrial zones and for phase out options or substitutes and promote the use of alternative low emissions and intensity products
2. Pilot and create models to promote diffusion of a promising low-emission and environmentally friendly technologies in all sectors
3. Improve industrial solid waste and wastewater treatment and promote waste to energy
4. Pilot and promote circular economy, resources and energy recovery, efficiency and savings in industrial sector
5. Pilot and promote development and use of renewable energy, especially solar and heat in industrial zones
6. Conduct monitoring the use of industrial product such as HFCs, PFCs, SF6, etc. and pilot projects for substitutes and promote the use of alternative low emissions and intensity products
7. Pilot and promote development and deployment of capture and storage technologies in key sectors and the large industry

5.3.3 AGRICULTURE, FORESTRY AND OTHER LAND USE

AFOLU sector's emissions have been on the rising trend. Based on the Figure 68, the projected emissions would be about 15 million tCO2e by 2030 and 19 million tCO2e by 2050, while emission in 2014/2015 and 2020 were only about 7 to 11 million tCO2e, respectively. Mitigating emissions by effective regeneration and protection of forest including avoid deforestation and forest degradation, enhancement of alternative wet and dry rice farming, soil conservation agriculture, etc. would decrease emissions or increase carbon storage in ecosystems by around 9 million tCO2e by 2030 and 15 million tCO2e by 2050. To realize this, an investment of about US$7 to 16 billion are needed by 2030 and 2050, respectively (Table 29).

An assessment using COMAP model, preserving or avoid destruction and degradation of the existing forest (9.55 million ha) from base year 2010 to 2050 could protect carbon storage and avoid emissions of about 6,778 million tCO2e with benefits outlined in Table 34. This result is in line with what was projected using GACMO model (Table 37).

[143] Footnote 142

Table 37 An assessment of mitigation and cost for forestry sector[144]

COST-EFFECTIVENESS INDICATORS	VALUES
Net Present Value of Benefits	
> $/tC	11.69
> $/ha.	8,296
Benefit of Reducing Atmospheric Carbon	
> $/tC-yr.	0.877
Initial Cost of Forest Protection	
> $/tC	0.004
> $/ha.	3
Endowment (Net Present Value of Costs)	
> $/tC	0.31
> $/ha.	218

For further emissions reduction, actions that adjusted from the NSCC, NDC and AFOLU sectoral strategies and plans (Table 38) should be implemented.

Table 38 Key climate change mitigation measures under Agriculture and Forestry Sector until 2030[145]

Key Mitigation Measures/Actions
1. Protect and enhance carbon sequestration of ecosystems
2. Study, identify and promote protection and development of the forests and agricultural land and ecosystems carbon and nitrogen sequestration and storage
3. Promote combatting deforestation and forest degradation
4. Enhance Forest restoration and rehabilitation
5. Strengthen sustainable forest and non-timber forest product management
6. Identify, protect and restore wetland, forest and agricultural soil carbon
7. Protect and expand green areas and landscapes in cities and other settlements
8. Enhance conservation and ecological agricultural practices

5.3.4 WASTE SECTOR

Waste sector's emissions was projected to increase along with socioeconomic development. Based on the Figure 68, the projected emissions would be 405,000 tCO2e by 2030 and 504,000 tCO2e by 2050. These increased from 399,000 tCO2e in 2014/2015 and 424,000 tCO2e in 2020. Mitigation options such as ng emissions by effective regeneration and protection of forest including avoid deforestation and forest degradation, enhancement of alternative wet and dry rice farming, soil conservation agriculture, etc. would decrease emissions or increase carbon storage in ecosystems by around 9 million tCO2e by 2030 and 15 million tCO2e by 2050. To realize this, an investment of about US$7 to 16 billion are needed by 2030 and 2050, respectively (Table 29). For further emissions reduction could be achieved by implementation of the mitigation

[144] TNC Team (2021). Mitigation assessment using Comprehensive mitigation assessment process (COMAP)
[145] Footnote 142

measures in Table 39.

Table 39 Key climate change mitigation measures under Waste Sector until 2030[146].

Key Mitigation Measures/Actions
1. Promote and enhance standardized management of products, processing, and disposal
2. Enhance low emissions waste management through promotion of circular economy, reduction including avoidance, reuse, recycle of solid waste (3Rs), and waste-to-energy
3. Upgrade and develop higher standard landfill systems including sorting and 3Rs, and where possible, deployment of landfill gas or flaring system through the country
4. Upgrade and develop higher standard solid waste and wastewater treatment systems in the main cities and secondary towns

CHAPTER 6 OTHER INFORMATION RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE CONVENTION

6.1 TECHNOLOGY TRANSFER

In accordance with the Article 4.5 of the UNFCCC and the NSCC, Lao PDR took steps to cooperate with the developing country Parties, access to and promote the transfer of environmentally sound and climate change mitigation technologies. However, in general, the development and implementation of the technologies are largely at early stage, where policies and plans as well as the technologies are studied and piloted.

So far, the country completed a Technology Needs Assessment (TNA) including Barrier Analysis and Enabling Framework (BAEF) and Technology Action Plan (TAP) for Mitigation and Adaption in Agriculture, Forestry and Water Resources Sector in 2017-2018, but there have not been a flagship or specific project on technology development and transfer. In addition, climate change related projects have not been clearly classified and assessed whether is a technology transfer or not, to what extent and aspects. However, the followings are some initiatives funded by development partners and investment projects in the area of climate change mitigation, adaptation and others since 2013 or SNC.

6.2 RESEARCH AND SYSTEMATIC OBSERVATION NETWORK

Research and systematic observations are instrumental in successful implementation of the Convention. Article 5 of the Convention called on all Parties to support international efforts to strengthen systematic observation and national scientific and technical research capacities and capabilities. The Global Climate Observing System (GCOS) was established to coordinate the

[146] Footnote 142

international undertaking in observation of Essential Climate Variables (ECVs) in atmospheric, oceanic and terrestrial domains. Several platforms exist to coordinate climate change research such as the World Climate Research Programme (WCRP). Lao PDR continually contributes observations through GCOS and actively collaborates with international communities in climate change research programs. At the same time, Lao PDR also strives to increase its capacity in environmental surveillance and research on climate variability and change, impact and adaptation, and climate change mitigation in response to the country's specific needs. This is consistent with Article 7, paragraph 7(c) of the Paris Agreement, which called on Parties to strengthen scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems. It needs to be in a manner that informs climate services and supports decision-making. The GCOS 2016 Implementation Plan broadens the scope of observations for adaptation and mitigation. This section provides Lao PDR's new development on research and systematic observation since SNC (2013) identified remaining constraints and gaps.

With limited human and financial resources, cooperation and networking; climate change research and systematic observations in Lao PDR have been slow. So far, there are some basic systems as outlined in the Table 40 below, while developing the Climate Risk and Early Warning Systems (CREWS) Initiative to reduce the impacts of disasters caused by hazards by increasing the utilization of early warning and risk information under '*Reinforcing the capacities of meteorological and hydrological services and enhancing the early warning systems in Cambodia and Lao People's Democratic Republic (PDR) project''*[147] and climate informed early warning system for dengue under Strengthening Climate Resilience of the Lao PDR Health System project [148]

Table 40 Systematic Observation Networks

Observation systems	**Description**
General weather observation and forecast	The system is managed by the Department of Meteorology and Hydrology (DMH), MONRE. Its service includes weather forecast using numerical weather prediction (NWP) and early warning system, especially floods, among others. The service relies on surface network including 17 main synoptic stations and 32 secondary synoptic stations, 128 manual rainfall stations and also The Mekong River Commission Hydrological Cycle Observation System (MRC-HYCOS).
Laos Climate Services for Agriculture	Provides agro-meteorological information in a compact format relevant to Lao farmers. The challenge addressed here, is the delivery of the provided information to farmers and other end-users. While the standard output channel are bulletins that are published online and sent to subscribed receivers, these resources may be beyond the reach of many farmers

[147] WMO (n.d.). Reinforcing the capacities of meteorological and hydrological services and enhancing the early warning systems in Cambodia and Lao People's Democratic Republic (PDR). URL: https://public.wmo.int/en/projects/reinforcing-capacities-of-meteorological-and-hydrological-services-and-enhancing-early. Accessed 16 August 2023

[148] https://www.greenclimate.fund/sites/default/files/document/26730-strengthening-climate-resilience-lao-pdr-health-system.pdf

(LaCSA)[149]	
Health surveillance and early warning systems	It is under design and development stage. Details of the System and operational plan should be clear in coming years.
MRC's Mekong Flood and Drought Forecasting, including River Flood Forecast[150], Drought Forecast[151], Flash Flood Guidance System (MRC-FFGS)[152] and Near Real-time Hydro meteorological Monitoring[153]	Monitoring and forecasting: - Combined Drought Index (CDI) - Soil Moisture Deficit Index (SMDI) - Standardized Precipitation Index (SPI1) - Standardized Runoff Index (SRI1)
Disaster Monitoring and Response System (DMRS) powered by powered by Pacific Disaster Centre (PDC)'s hazard monitoring and early warning platform Disaster AWARE, and IDINet[154] at AHA Centre	Lao PDR, in partnering with PDC, is joining other Association of Southeast Asian Nations (ASEAN) Member States makes use of DMRS. DMRS is one of the disaster monitoring tools utilised by the AHA Centre, originally deployed in 2012 for operational use by the ASEAN Centre for Humanitarian Assistance (AHA Centre). ADINET is a repository of information about every disaster incident in the ASEAN region since 2012, operated by the ASEAN Coordinating Centre for AHA Centre.
DE-RISK South East Asia[155]	Applying seasonal climate forecasting and innovative insurance solutions to climate risk management in the agriculture sector in SE Asia

The Meteorological Department, under MONRE is primarily responsible for weather and climate monitoring, assessment, and reporting/dissemination of the information. The Department provides weather data and information to support domestic and international aviation, relevant Ministries and responsible local agencies. It also cooperates with international organizations and regularly exchanges weather data with the World Meteorological Organization as well as provides weather information to the Mekong River Commission Secretariat.

At this stage the Department is emphasizing the establishment of regional and local centres on meteorology and hydrology, particularly weather stations and rainfall gauges. International support for development of monitoring weather events and earthquakes was received from Japan and China in 2007 and 2009 respectively. Early warning systems were introduced, focused

[149] Laos Climate Services for Agriculture (2023). https://www.lacsa.net/agrometIndex.do. Accessed 16 August 2023
[150] MRC (n.d.). Daily Bulletin. URL: http://ffw.mrcmekong.org/bulletin_wet.php. Accessed 16 Augst 2023
[151] MRC (2023). Drought forecasting and early warning for low Mekong basin. Weekly Forecast. URL: http://droughtforecast.mrcmekong.org/maps. Accessed 16 Augst 2023
[152] MRC (n,d). Flash Flood Guidance System (MRC-FFGS). URL: http://ffw.mrcmekong.org/ffg.php. Accessed 16 Augst 2023
[153] MRC (n,d). Near Real-time Hydrometeorological Monitoring. URL: https://monitoring.mrcmekong.org/. Accessed 16 Augst 2023
[154] Asian Disaster Information Network (2023). URL: https://adinet.ahacentre.org/. Accessed 16 Augst 2023
[155] De-Risk SE Asia. URL: https://deriskseasia.org/climate.html. Accessed 16 Augst 2023

on weather and water level forecasts and climate and hydrological information networking. Information is disseminated by radio transceiver, public telephone, facsimile, email and website to the mass media, relevant Ministries and provincial meteorological services.

With regard to human resource development, meteorologists have participated in domestic, regional and international seminars, workshops and trainings, including on issues related to seasonal climate cycles, El Nino and La Nina, long-range weather forecasting and advisories, and utilization of climate predictability tools. Lao PDR also has developed a two-year curriculum in intermediate meteorology for students and technicians. So far, more than 100 persons have completed this course.

At policy level, the Meteorological Department is preparing the meteorological and hydrological strategy of the country focused on floods and droughts. Early warning systems have been strongly enhanced over the last decade, and meteorological information is used to support flood forecasting procedures. The radar station in Vientiane has improved its rainfall forecasting and flash flood warning systems. Experiences after the Typhoon Ketsana disaster in 2009 showed that early warnings systems in the country were not able to cope with increasing and intensified climate variation, with information unable to be disseminated effectively to communities at risk. Development of weather stations and networks, along with significant upgrading of hydro-meteorological stations, will contribute to regional climate information in support of a systematic observation network under the UNFCCC.

Meanwhile, research on climate scenarios in Lao PDR remains at an early stage and benefits primarily from the regional climate model, PRECIS, or from statistically downscaling from global models. As noted above, development of appropriate climate scenarios for Lao PDR to support vulnerability and adaptation studies also will enhance the national integration of climate change and disaster management.

During the period of NSEDP-7, emphasis will be given to research and development on early warning systems and to the development of models to monitor climatic situations and integrate with related indicators.

6.3 CAPACITY BUILDING, EDUCATION AND AWARENESS

6.3.1 Capacity building

Human resource development (HRD) and capacity building is one of the national development priorities of the Lao PDR. Capacity building on climate change affairs is increasingly needed, especially following adoption of policies such as the Paris Agreement, SGDs, decree on climate change, the NSCC, NDC, green growth, REDD strategy, and other sectors' strategies and plans that mainstreamed climate change mitigation and adaptation. However, MONRE and other the relevant ministries do not have a specific or single HRD and capacity building plan on climate change mitigation and or adaptation. As mentioned in section 4.3 and 5.1, apart from MONRE, some miniseries or agencies integrated capacity building development plans or activities on climate change in its strategies and plans.

Despite of the capacity building plan, the actual HRD and capacity building is one of the most challenges and needed for continual development. The government planned to increase the budget for HRD and capacity building, but the actual disbursement was far below the target, and budget for management of environment and climate change was much limited. Training and capacity needs assessment were conducted by MONRE and relevant ministries periodically but it lacked an analysis, effective action planning and implementation. Capacity building has been mainly depended on the international support, especially development partners and implemented under technical cooperation or assistance programmes and projects (Table 41 and 42) and environmental project fund (EPF), which financed by development partners and the government via environmental tax. Critically, there is no monitoring and evaluation (M&E) or tracking and reporting system, leading to difficult to identify and assess the outcomes, effectiveness and impact of capacity development. Over the past decade, there were number of domestic and international trainings and workshops on climate change, including GHG inventory, vulnerability assessment and adaptation planning, mitigation assessment and planning, CDM, JCM, and REDD+ attended by MONRE and other line ministries, but it lacked the M&E and reporting the results and responsive plans.

Table 41 Key Climate Change Related Capacity Building Programmes and Projects Financed by Development Partners between 2013-2022

No	Capacity building related projects and programmes	Description
1	**Mitigation**	
	Strengthening Lao PDR's institutional capacity to comply with the Enhanced Transparency Framework under the Paris Agreement (CBIT)	GEF and executed by UNEP and MONRE.
2	**Adaptation**	
	Building the Capacity of the Lao PDR Government to Advance the National Adaptation Planning Process	LCDF and executed by UNEP and MONRE.
	Building Resilience of Health Systems in Asian LDCs to Climate Change	GCF and executed by UNDP and MONRE.
	Building Climate Resilience of Urban Systems through Ecosystem-based Adaptation (EbA) in the Asia-Pacific Region	A regional programme financed by LCDF and executed by UNEP
	Strengthening Agro-climatic Monitoring and Information Systems to Improve Adaptation to Climate Change and Food Security in Lao PDR	LCDF and executed by FAOP and MAF.

Table 42 Other Climate Change Programmes and Projects Financed and Implemented between 2013-2022

No	Project name	Donor/ Funding Sources	Implementing Agencies/ Government	Implementing Agencies/Non-Government	Location

1	Integrated Water Resource Management and Ecosystem-based Adaptation (EbA) in the Xe Bang Hieng River Basin and Luang Prabang City	LDCF	MONRE/DWR	UNDP	Laos
2	Climate Smart Agriculture alternatives for upland production systems in Lao PDR	LDCF	MAF	FAO	Laos
3	GEF SGP Sixth Operational Phase- Strategic Implementation using STAR Resources, Tranche 2 (Part IV)	GEF	MONRE	UNDP	Region including Laos
4	Lao PDR Intended National Contributions (Lao INDC)	GEF	MONRE	UNDP	Laos
5	Sustainable Management of Peatland Ecosystems in Mekong Countries	GEF	MONRE	IUCN	Region including Laos
6	Vientiane Sustainable Urban Transport Project		MPWT	ADB	Laos
7	Reducing of Green House Gas Emissions in the Industrial Sector through Palletisation Technology	GEF	MOIC	UNIDO	Laos
8	Climate Adaptation in Wetlands Areas (CAWA)	LDCF	MONRE/DOE	FAO	Laos

The capacity projects under EPF included:

1. Capacity Building on Mainstreaming Green Growth Agenda into National, Sub-national and Sectorial Strategies and Action Plan
2. Improvement and development of curriculum on sustainable development including green growth, green economy of the University in Savannakhet, Champassak and Luang Prabang (Souphannouvong).
3. Improvement of environment Curriculum for pre-school, primary, secondary, and vocational school.

In conclusion, there limited capacity building, education and training on climate change as well as capacity gaps. In addition, Laos particularly MONRE and relevant agencies have not had a comprehensive HRD or capacity development plan, financing mechanism and a system including database to track, monitoring and reporting capacity development. To address the gaps and ensure effective implementation of climate change polices and plan; Lao PDR, particularly MONRE and relevant ministries need to:

1) Update and ensure continuity of the training and capacity needs assessment, including analysis and development of the HRD and capacity development plan;
2) Define a financial mechanism for financing the implementation; and
3) Develop an inclusive and/or centralized monitoring and evaluation (M&E), and reporting

system including a database to record, track and assess the effectiveness, outcomes and impact of the support received or investment on the HRD capacity development on climate change nationwide.

6.3.2 Education

The Lao government considers education is a top priority and intends to allocate 17% of the national budget to this sector. So far, there are 3 universities, 26 colleges and 10 technical and vocational schools in the country. Four faculties of the national university namely faculty of forestry, economics and business, education and literature are now able to open the Doctor of Philosophy (Ph.D.) course. Faculty of environment provides a specific climate change course at bachelor and master level. Some faculties such as the faculty of forestry, environmental engineering, water resources and engineering include climate change subjects in their bachelor curriculum. In addition, environment and climate change related studies are mainstreamed in the primary school (year 1 to 5) and secondary school's curriculum (year 6 to 9)[156].

Mainstreaming of climate change, especially Disaster Risk Reduction (DRR) in the education sector was started since 2007- 2008, when Lao PDR received support to Implementation of Hyogo Framework for Action (HFA) through *''Mainstreaming of Disaster Risk Reduction into Development Planning, Policy and Implementation in Asia: Advocacy and Pilot Implementation Project in Education Sector in 3 South East Asian RCC member countries (Cambodia, Lao PDR and the Philippines)"*, MDRD-Education). The project included *(i) Mainstreaming of Disaster Risk Reduction into the Secondary School Curriculum, (ii) Study on Impacts of Disasters on the Education Sector, (iii) Advocacy Workshop on Mainstreaming Disaster Risk Reduction into the Education Sector, and iv) Stakeholder consultation as follow up to the Advocacy Workshop,* and as a result, the curriculum, especially DRR module has been integrated into Natural Science and Social Studies of Grade 7[157].

In 2018, the National Strategy on Environment Education and Awareness (EEA) (2008) was updated with the Vision to 2030 and the National Strategy (2018-2025) on Environment and Climate Change Education and Awareness (ECEA). The ECEA strategy vision that *"Lao citizens are knowledgeable, understanding, conscientious and willing to participate in managing natural resources, protecting the environment and being able to adapt to climate change, ensuring socio-economic development is in a green and sustainable direction".* To achieve these, the strategy, in line with the MONRE's vision and strategy, focuses on education and awareness about *(1) Planning and managing sustainable use of natural resources and the environment (2) Planning and managing environmentally sustainable urban and rural development (3) Build capacity of the Lao PDR on adaptation and mitigation of climate change (4) Maintaining and promoting regional and international cooperation and (5) Strengthening institutional capacity of the MONRE and relevant agencies* . The ECEA includes targets and strategies on climate change related curriculum development and awareness raising for formal education and non-formal education.

[156] MONRE (2018). The Vision to 2030 and the National Strategy (2018-2025) on Environment and Climate Change Education and Awareness.

[157] ADPC (2008). Mainstreaming of disaster risk reduction in the education sector in the Lao PDR.

The NSCC (2010) defined some actions on climate change education, and the updated NSCC to 2030 and vision to 2050 aims to implement the following priority projects or actions, among others.

1. Conduct climate change vulnerability and capacity needs assessments for education sector
2. Develop and implement climate change adaption and response plans and programs for education sector
3. Improve organization and centres for climate change education and research
4. Improve and operate climate change curriculum for both formal and non-formal education at all levels
5. Develop and implement capacity building programs for teachers to teach climate change curriculum
6. Enhance capacity of media, development and implementation of climate change awareness and campaign
7. Develop materials (guidelines, manuals, handbooks, etc.) and methods for effective communication, campaign and awareness raising
8. Enhance development, implementation, M&E and reporting of climate change awareness and campaign plans and programs

In 2020, ministry of education and sport (MOES) launched education sector development plan 2021 to 2025, and included a policy action to finalize and implement Education Emergency Contingency Plan, which takes into account climate change.

Under Sustainable Development Goal (SDG) 4 (Quality Education) ''Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'', Lao PDR and its development partners implemented projects to improve climate change and DRR education in education sector[158, 159].

In addition, the following climate change education programmes and projects or campaign were implemented, among others.

1) In 2011, Lao PDR and the German development agency GiZ launched their technical cooperation on Communicating Environment and Climate Change in Lao PDR (ComC1im), aiming at improving communication and education related to environmental and climate change awareness.
2) An essay competition on the role of Youth in Climate Action[160]
3) Launching of Zero waste Laos (non-profit organisation) and campaign to promote better solid waste management and awareness to reduce environment and climate change problems[161]

[158] The United Nations in Lao PDR (2020). 2019 Progress Report. Lao PDR-United Nations Partnership Framework 2017-2021. A Partnership for Sustainable Development.
[159] The United Nations in Lao PDR (2022). 2021 Progress Report. Lao PDR-United Nations Partnership Framework 2017-2021. A Partnership for Sustainable Development.
[160] UNPFA (2021). Youth for climate action: Key lessons learned from a nationwide essay competition. https://lao.unfpa.org/en/news/youth-climate-action-key-lessons-learned-nationwide-essay-competition
[161] Zerowastelaos (2023). URL: https://www.zerowastelaos.org/. Accessed 16 August 2023.

However, in general, climate change education is limited. 40 projects were planned under the EEA strategy (2008), only few projects were funded and implemented. Those included (1) development of environment education handbooks for the primary school (year 1 to 5) and secondary school's curriculum (year 6 to 9)[162] and awareness raising activities in few provinces; (2) few study-visits abroad; (3) campaign on national important days such as the World Environmental Day, World Water Day, the Earth Day, National Abor Day, Wildlife Day, etc.; and (4) some information dissemination and campaign via media, especially national TV and radio.

6.3.3 Public awareness

Public awareness on environment and climate change were mainly planned and implemented under EEA and NSCC strategy by MONRE and its line agencies at local levels. In addition, there are projects and activities that were planned and implemented by relevant ministries and International organisations. However, in general, like education, climate change awareness raising activities are limited both quantity and quality, and have not covered all sectors and communities through the country.

In past 10 years, there were only few projects that were funded and implemented. Those included (1) development of environment education handbooks for the primary school (year 1 to 5) and secondary school's curriculum (year 6 to 9)[72] and awareness raising activities in few provinces; (2) few study-visits abroad; (3) campaign on national important days such as the World Environmental Day, World Water Day, the Earth Day, National Abor Day, Wildlife Day, etc.; (4) some information dissemination and campaign via media, especially national TV and radio, and (5) a campaign for "green communities and schools'' in Vientiane capital, and Champasack, Savannakhet and Luang Prabang province, and as part of the campaign against global warming, 1 million trees were planted by 2020 in the main cities across the country.

In addition, the following climate change education programmes and projects or campaign were implemented, among others.

1) In 2011, Lao PDR and the German development agency GiZ launched their technical cooperation on Communicating Environment and Climate Change in Lao PDR (ComClim), aiming at improving communication and education related to environmental and climate change awareness.
2) An essay competition on the role of Youth in Climate Action[163]
3) Launching of Zero waste Laos (non-profit organisation) and campaign to promote better solid waste management and awareness to reduce environment and climate change problems[164]

Despite of the achievement and progress, there are gaps and climate change awareness and awareness raising in Lao PDR, in general, are limited. It has not been implemented to cover all

[162] MONRE (2018). The Vision to 2030 and the National Strategy (2018-2025) on Environment and Climate Change Education and Awareness.
[163] Footnote 160
[164] Footnote 161

sectors and communities through the country.

6.4 INFORMATION SHARING AND NETWORKING

At global and regional levels, information on climate change is shared via the UNFCCC and UNs and development partners' cooperation, and communication and information sharing platforms including meetings, media and websites on and in the forms of National Communications, CDM, JCM, REDD+, NAPA, TNA, SDGs report, etc. Within the country, information is shared between and among the national and local levels or horizontally and vertically through the existing organisational arrangement and in the form of or via meetings, information dissemination and communication through media and websites. Policies (e.g., law, regulations and national development strategies), plans and reports, especially foreign funded project reports, for example, are normally posted on the national assembly, relevant ministries, development partners, donors, non-government, non-profit organisations and projects' websites and database. However, each organisation usually shares or post information they have on their communication channels, especially website or database, and there is no specific or inclusive information sharing platform and requirements on information sharing. What kind of information to be disclosed is unclear or unplanned, except: (i) policies, especially laws and regulations, which are required to be disclosed and disseminated to relevant bodies and public; (ii) the projects and supports related to SDGs; and (iii) national statistics which are required to record and share via SDGs and statistical information system, which hosted by the Ministry of Planning and Investment (MONRE).

In general, in the Lao PDR, particularly relevant ministries including MONRE have not had a communication and information sharing plan or strategy and procedures. Information sharing requirements are unclear. Laos also lacks information including information and information kit development and localization. Several strategies and plans, including NSCC, etc. calls for information sharing, but unclear how to. Laos has promoted one-door service, but there is no inclusive information sharing platform including forum. Almost all relevant ministries own a data and information centre, but information for sharing is limited and somehow are inconvenient or inaccessible by stakeholders. At local levels, including provincial, district and village level, an information is usually shared via meetings due to limited access to internet, website, communication materials and resources for development and dissemination.

Likewise, networking remains limited and ineffective. Apart from those of UNFCCC and development partners, there are several network, alliance and association at regional level, such as Climate Action Network (CAN), Global Adaptation Network (GAN), Health and Climate Network, Youth UNESCO Climate Action Network YoU-CAN, Women's Earth and Climate Action Network, Asia Pacific Adaptation Network (APAN), etc., among others, that Lao PDR has not been member or actively participated in. In fact, Lao PDR has not identified, had a database and a plan about networking. In addition, apart from the government, climate network, groups or organisations are limited in number and readiness to expand networking.

These means there are needs for improvement on information sharing and networking at all levels and aspects including policies, requirements, plans, and the development of information,

communication facilities and technologies, organization and capacity.

CHAPTER 7 CONSTRAINTS AND GAPS, FINANCIAL AND CAPACITY NEEDS

7.1 INTRODUCTION

Some constraints and gaps on mitigation and adaption including technology development and diffusion have been identified under SNC, TNA, NSCC and NDC, among others. This section provides the updated or additional constraints and gaps regarding to the commitment under the convention, and for continual improvement of national communications, by desk review, additional analysis using the guidelines on barrier analyses under TNA[165] and stakeholder consultations. As a result, the general or common constraints were summarized section 7.2. Specific constraints and gaps on GHG inventory, mitigation, adaptation and technology development and transfer by sectors were described in section 7.3.

7.2 GENERAL CONSTRAINTS AND GAPS

In general, Lao PDR is facing number of constraints to fulfil the commitments under UNFCCC, including complying with NC reporting requirements as well as the implementation of GHG inventory, climate change mitigation, adaptation, technology development and transfer. Those general or common constraints were summarized in the Table 43 below. Specific constraints and gaps on GHG inventory, mitigation, adaptation and technology development and transfer were summarized in section 7.3.1 to 7.3.7.

Table 43 General Constraints and Gaps

Area/Categories	Key constraints and gaps
Economic and financial	High cost, inadequate financial resources and or financially and economically unfeasible to invest in mitigation and adaptation technologies or actions, especially clean and renewable energy, low emission technologies, sustainable forest restoration and management, carbon capture and storage, and structural measures for climate change adaption and resilience
	Unclear or lack of a sustainable financial incentives and mechanism
Market	1) Market failure or uncertainty e.g., carbon credits market to promote climate change mitigation and adaptation technology development and utilization. No domestic carbon market, while regional markets are variable, difficult to access and low price. 2) Failure of non-marketable or financially and economically unfeasible climate change mitigation and adaptation technologies and measures

[165] Nygaard, I. and Hansen, U. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition. UNEP DTU Partnership, Copenhagen. URL: https://tech-action.unepccc.org/tna-methodology/.

Policy, legal and regulatory	Lack of clear, complete, timely and inconsistent legal and regulatory framework, especially policies on incentives and cooperation to promote development, deployment, and diffusion or transfer of renewable energy, environmentally friendly, low carbon, carbon trading, and adaptation technologies and market-based strategies.
	Ineffective law enforcement
Network	Inexistent climate change and related expert group/think-tank and network including platform to share information and discussion to find solutions for climate change issues in the country.
	Access to and networking with the regional networks are difficult and limited
	Ineffective, inefficient and unsustainable domestic and international networks
Governance, institutional and organisational capacity and human skills	Ineffective organisational arrangement and development within or among the organisations. including organizational planning and reporting system and procedure
	Lack of an effective mechanism and coordination amongst stakeholders, especially inadequate or ineffective data sharing, communication, cooperative action or joint implementation, and reporting.
	Limited/inadequate human resources, and capacity and skills development in relevant sectors, including education sector. So far, specific or inclusive human resources and capacity development plan and targets, M&E including tracking and reporting system are absent.
	Different development priority, values, and conflict of interest among organisations and regions
Information and awareness	3) Inadequate technical, financial and economic, social-culture, physical including environmental and climate information for in-depth or inclusive GHG inventory, climate change mitigation, adaptation including technology assessment, planning and development 4) Information dissemination, sharing and awareness raising are ineffective and conducted through the country, including communities and sectors.
Technologies and tools	Limited/inadequate technologies, tools, models and best practices for GHG inventory, climate change mitigation, adaptation including technology assessment, planning and development, M&E, information dissemination and awareness raising.
Others	Physical including geographical and biological constraints for GHG inventory, climate change mitigation, adaptation including technology assessment, planning and development

7.3 SPECIFIC CONSTRAINTS AND GAPS

7.3.1 GHG inventories

Lao PDR is facing several constraints and gaps on GHG inventory, and needs both technical and financial support to address the following constraints and gaps:

1) Inadequate and or inaccurate information and activity data for GHG inventory, especially

(1) energy or fuels consumption by sector including in different type of transport (road, water and air and type of vehicles); (2) specific industry information including process, type and amount of materials use, solid waste and wastewater discharge; (3) annual or the inventory year land use change matrix, biomass stock, soil carbon, forest fire area and biomass burning including pre-and post-biomass burning, and agriculture residue burning; (4) (time series) data about type (e.g., industrial, household, hazardous and clinical waste), amount and composition of solid waste and management, including proportion of solid waste that are disposed to landfills, open- burned, incinerated and disposed elsewhere; (5) data about type (e.g., industrial, household, hazardous and clinical waste), amount and composition of solid waste and management, including proportion of solid waste that are disposed to landfills, open- burned, incinerated and disposed elsewhere; for the inventory year information about uncertainty of the data. These data and information are not collected and reported in the national or sector statistics systems, due the lack of budget for data development, and awareness. Moreover, they are not disaggregated as categorized by the IPCC Guidelines;

2) Lack of country specific emissions factors in all sectors and almost all activities. These are mainly caused by the lack of R&D including financial human resources. It means Lao PDR need to formulate cost-effective national or regional programmes aiming at the development or improvement of country-specific or regional emissions factors and activity data;
3) Inadequate human resources and capacities of relevant agencies, especially staff including knowledge and skill to develop or handle with data gaps, use of tools, estimation of GHGs in different sectors, key categories and uncertainty analysis, reporting and QA/QC;
4) Lack of a sustainable or effective organisational arrangement and coordination. These result from internal and or external factors and causes, including lack of organisational strengthening and capacity building;
5) Limited GHG networking, exchange platform and forum. Lao PDR regularly joins Workshop on Greenhouse Gas Inventories in Asia (WGIA) including mutual learning, among others, but the exchange is limited or not expended beyond the workshop. The UNFCCC's GHG Help Desk exists, but access, communication and sharing are limited and inconvenient.

7.3.2 Climate change adaptation

The SNC and NCSS outlined constraints and gaps. An assessment under TNC found that several identified constraints and gaps have not completely addressed, and there are additional constraints. All the key constraints and gaps were summarized as.

1) Lack of data, information and development. Those include long-term historical, time series and updated (i) meteorological and hydrological data including water flow and other data for more appropriate national climate scenarios and downscaling; (ii) climate hazards; (iii) a standard or consistent socioeconomic and environmental data for hazard exposure, sensitivity and adaptive capacity analysis; and (iv) adaptation technologies and practices;

2) Lack of database system for archiving, analysis and providing more accurate and timely data. Lao PDR needs as a foundation for impact analysis.
3) Lack of comprehensive or in-depth and continual studies and monitoring climate change, hazards and sectoral impacts. Hazard profile was developed in 2010, but have not updated. There are some climate change assessments, but lack of downscaling and consolidation or harmonization. 7 sectors are identified for adaptation but thus far there are only some initiative studies on climate change impacts on some areas and aspects of water resources, agriculture and health;
4) Lack of comprehensive strategies and plans on adaptation, including lack of timely and update adaptation technology action plan for relevant sectors, NAPA and sectoral, region or local, city, and community adaptation plans including hazard mapping. In addition, it lacks resources mobilization for the implementation and MRV of adaptation;
5) High adaptation cost and limited access to technologies and information;
6) Shortage of financial and human resources, and organisational and staff capacity and awareness on resources mobilisation, implementation and MRV of adaptation;
7) Overlapping or unclear responsibilities and ineffective coordination among stakeholders and lack of a centralized, harmonized or integrated planning and implementation system.

7.3.3 Climate change mitigation

Similar to GHG inventory and adaptation, the key constraints and gaps on climate change as well as greenhouse gas mitigation are:

1) Lack of data, information and development such as (i) data for projection of emissions or development of emissions scenarios; and (ii) mitigation technologies and practices, including financial and economic, and emissions reduction information;
2) Inadequate and timely mitigation policies due to limited financial and human resources to translate COP's decision and regional agreement into country specifies policies;
3) High mitigation cost including high cost on environmentally friendly, low carbon and renewable technology development, access, deployment and diffusion;
4) Inadequate financial and economic incentives, and market-based solutions, including carbon credits and tax;
5) Shortage of financial and human resources, and organisational and staff capacity and awareness on resources mobilisation, implementation and MRV of mitigation;
6) Overlapping or unclear responsibilities and ineffective coordination among stakeholders and lack of a centralized, harmonized or integrated planning and implementation system.

7.3.4 Transfer of technology

Technologies are embedded in all areas of climate change, ranging from basic and advanced or applied research and development to the implementation of actions or measures to address issues. Adoption of appropriate technologies remains highly important to Lao PDR. Constraints and gaps in technological aspects include:

1) High capital costs in technological development
2) Insufficient research and development to advance technical knowledge

3) Limited integration of climate change technological needs into the national science and technology development and innovation process
4) Significant upfront investment for most available or appropriate technologies. Which are protected by patents or licenses. This represents a huge burden for low-income countries like Lao PDR.
5) Continuing need for national capacity enhancement along with technology transfer. This requires financial assistance as well as relaxation of protection of property rights, but is vital in enabling Lao PDR to achieve its "green economy objective.

7.3.5 Climate change research and systematic observation

The Lao PDR has participated in the network of the World Meteorological Organization. Development of the national grid system is extremely limited and urgently need to be strengthened. Constraints and gaps are:

1) Poor, inadequate and lack of uniformity of meteorological observation system
2) Limited technical capacity to handle observation network
3) Lack of human resources to support the development in the areas

7.3.6 Capacity building, including education and public awareness

Public awareness on climate change has only been implemented in recent years. Climate change impacts are difficult to perceive, yet influence all sectors; thus, innovative ideas or approaches to enhance public awareness are urgently needed, but financial support in this area is inadequate.

Constraints and gaps include:

1) Very limited training and public awareness programmes, campaigns or activities at national level.
2) Limited inclusion of climate change subjects into the curriculum at secondary and higher education levels.
3) Need to reach the grassroots level with dissemination of knowledge and experiences in climate change.
4) Extremely limited development of national capacity especially on the global climate change negotiation process. To promote active participation at international level, negotiation and diplomatic skills, including language proficiency, are vital.
5) Limited research network/forum among national academics, scientists and researchers to exchange resources/ experiences and cooperation in climate change research. A regular technical forum should be developed to promote cooperation.

7.3.7 Information sharing and networking

Information sharing and networking on climate change can contribute to many aspects of national progress on the issue, with an efficient information system updating technical and operational aspects as well as providing public understanding and supporting policies and key decisions. Development of an information system and networking in Lao PDR has not been

effective thus far, especially with regard to coping with the rapid evolution of the UNFCCC process. Without an adequate national infrastructure and transport network, effective design of information sharing and strong technical and financial support are even more crucial. Primary constraints and gaps on information and networking include:

Limited information flows among researchers and Government agencies. as well as limited dissemination to the public, especially local communities. Horizontal and vertical systems of information flows need to be developed. Specifically, information exchange within the scientific community and between the scientific community and policymakers, as well as information dissemination to the public, particularly at regional level, must be systematically developed.

1) Lack of updated information. Technical and policy developments on climate change are highly dynamic, particularly in recent years. The lack of trained technical and human resources in Lao PDR constrains the national ability to manage the information flow.
2) Lack of an appropriate information mechanism for local conditions. Many countries use the Internet as a tool to communicate on climate change. However, this may not be practical in Lao PDR, and a mechanism more appropriate to local circumstances should be designed.
3) Limited role of the national focal point. The role of the national focal point requires strengthening to make it the climate change "gateway," nationally and internationally, so that is can perform an important role in information sharing and networking.
4) Insufficient networking with key stakeholders, particularly the private sector and civil society. As the ASEAN Economic Community is operationalized in the coming years, the private sector and civil society will play increasing roles in national development processes. Thus far, however, networking with these groups has been limited in Lao PDR. Because climate change affects many sectors, more efforts will urgently be needed to enhance the information network with numerous stakeholders.

7.4 FINANCIAL AND TECHNICAL SUPPORT RECEIVED AND NEEDS

7.4.1 Financial support received and needs

In general, Lao PDR received continual and increased support from development partners, countries and organisations in the past decade. However, there are financial and technical support gaps in comparison with the needs to address climate change commitment and problems. The estimate of financial needs for mitigation and adaptation under the first NDC was US$ 1.4 billion and US$ 0.97 billion, respectively[166]. Support received under SGD13, the Climate Action or Outcome 1.3 - Climate Change, Disaster Management and Environment from 2017 to 2021 were approximately USD 45 million[167]. The support, in general, is increasing, except the year 2020, when the world including Lao PDR was affected by COVID-19 outbreak (Figure 75). In 2020, the financial need for the climate action was US$ 14.5 million, while available budget was US$ 16.3 million[168]. In future, Lao PDR still need more financial and technical support to implement

[166] Lao PDR (2015). Intended Nationally Determined Contribution.
[167] The United Nations in Lao PDR (2022). 2021 PROGRESS REPORT. Lao PDR - United Nations Partnership Framework 2017-2021. A Partnership for Sustainable Development.
[168] The UN COUNTRY (2023). PROGRESS REPORT 2022. Lao People's Democratic Republic. Vientiane, Lao PDR, February 2023

priority climate change policies and programmes outlined in Table 44. However, the supports were not classifiable whether they were adaptation, mitigation, cross-cutting and capacity building.

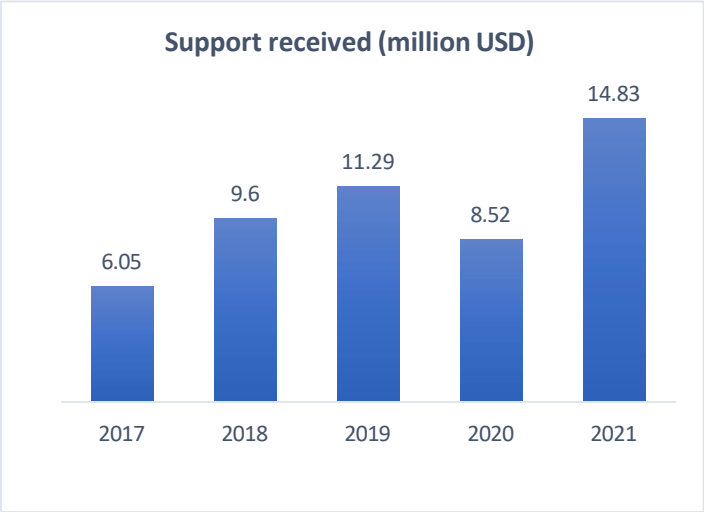


Figure 74 Financial Support Received for Climate Action under SDG 2017-2022[169]

Table 44 Financial and Technical Support Needs for Climate Change Mitigation and Adaptation

No	Mitigation actions or programmes	Budget (million USD)	Remark
1	Implementation of the (2nd) NDC	4,762	
2	Implementation of net zero emissions pathway measures including NDC (estimated under TNC)	9,390-18,960	By 2030 and 2050
3	Implementation of measures for climate change adaptation and resilience including coping with climate hazards	278-371[170]	Annually

Lao PDR has not had a robust system for estimate financial needs and MRV including a database of financial support received, there could be uncertainty in estimate and report of financial support received and needs. Recently, with the support from the development partners, there are some initiatives to improvement MRV of climate finance, for example those under The Capacity-building Initiative for Transparency (CBIT) and SDG, among others. In addition, capacity building needs and MRV on climate finance have included as a priority action in the future under the current NCCS to the year 2030.

7.4.2 7.4.2 Capacity support received and needs

Capacity support received were as described in the section 6.3. In the future, in general, there are immediate needs to strengthen institutional capacity and skills of relevant organisations to address

[169] Footnote 168

[170] The budget was estimated and justified based on 1) The most disastrous disasters in 2018 from two tropical storms and the Xe Pien-Xe Nam Noy Dam break which caused economic loss of about US$371 million or 2.1% of the Lao PDR GDP and 2) The estimated socio-economic damages due to weather and climate-related disasters in Lao PDR (US$ 277.93 million per year) in the Country Assessment Report for Lao PDR: Strengthening of Hydrometeorological Services in Southeast Asia.

the constraints and gaps identified in section 7.2 and 7.3, and key areas as follows.

1. Greenhouse gas inventory
    1. Strengthen institutional capacity, and improve knowledge and skills of MoNRE and relevant organisations to conduct research and development of the country specific emissions factors and activity data or statistics, especially those are relevant to key sources of emissions, database and information sharing system or mechanism
    2. Trainings on the use of IPCC and others' tools and guidelines for GHG inventories from the national to facility level, including review and reporting

2. Climate change vulnerability and risk assessment, resilience and adaptation planning

- Strengthen institutional capacity, and improve knowledge and skills of MoNRE and relevant organisations to conduct research and development of (1) the country climate data including temperatures, rainfalls, extreme events, and hazards and vulnerability as well as exposure, sensitivity and adaptive capacity of the country, regions, sectors and specific targets; (2) technologies for assessments of climate change, hazards, vulnerability, early warning and adaptation
- Trainings on the use of IPCC, UNEP, UNDP and others' tools and framework for Vulnerability and Adaptation, cost-effective adaptation planning and implementation, and reporting.

3. Climate change mitigation

- Strengthen institutional capacity, and improve knowledge and skills of MoNRE and relevant organisations to conduct research and transfer technologies for mitigation such as renewable and alternative, energy efficiency, low carbon, carbon capture and storage (CCS), and ecosystem-based technologies and practices.
- Trainings on the use of IPCC, UNEP, UNDP and others' tools and framework for Vulnerability and Adaptation and Reporting.

4. Others:

- Strengthen institutional capacity, and improve knowledge and skills of MoNRE and relevant organisations to conduct research and development of (1) education including curriculum; (2) observation networks; (3) tools including media and best practices for climate change awareness raising and campaign; (4) sustainable institutional arrangement, constraints, gaps or barrier and enabling environment analysis; and (5) sustainable financing including and financial needs assessment.