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European Roundtable on Climate Change and Sustainable Transition Submission on the call for inputs to the Global Stocktake

Dear Members of the Secretariat,

Thank you for this opportunity to submit our contribution to the first call for inputs to the Global Stocktake.

Decision -/CMA.1 to the Matters relating to Article 14 of the Paris Agreement and paragraphs 99–101 of decision 1/CP.21, Decision 6 (c) indicates that one of the overarching elements of the Global Stocktake entails the establishment of a technical dialogue that will address the social and economic consequences and impacts of Response Measures.

In light of this, the European Roundtable on Climate Change and Sustainable Transition (ERCST) would like to contribute to the efforts related to addressing the social and economic impacts of Response Measures within the context of the Global Stocktake, with the work and research carried out in the past years.

ERCST's work on Response Measures has been pioneering in developing a [Methodology for countries to report on the socio-economic impacts of Response Measures](#) in line with different UNFCCC processes, including BURs, BTRs (after 2024) and NDCs.

ERCST practically applied, tested, and refined its methodology by conducting several country case studies for different jurisdictions around the world, including Chile¹, Ghana, the Maldives and Poland.

Alongside ERCST organized multiple workshops, capacity building sessions, roundtable discussions, COP side events, while actively collaborating with local stakeholders for each one of the case studies.

The last case study developed, that we would like to share for this submission, was carried out in 2021 - '[Reporting on the Impacts of Response Measures: Ghana Case Study](#)' and is available as an attachment to this submission in the following section.

¹ 'Reporting on the impacts of response measures: Chile Country Case Study'
<https://secureservercdn.net/160.153.137.163/z7r.689.myftpupload.com/wp-content/uploads/2019/12/ERCST-Reporting-on-the-impacts-of-Response-Measures-Chile-country-case-study.pdf>

The main findings from the research and the case study identified 12 sectors of the Ghanaian economy as most vulnerable to the impacts of response measures with 80 international response measures that could impact them.

For the identified vulnerable sectors three international response measures were chosen for quantitative assessment: IMO carbon tax for international shipping, CORSIA under ICAO carbon tax for international aviation and the EU Border Carbon Adjustment Mechanism.

The results indicate that the overall effects of the IMO carbon tax on the economy of Ghana are small. On the other hand, the results portray that CORSIA/ICAO will have a stronger impact on the Ghanaian economy, compared to an IMO carbon tax. For the EU CBAM, macroeconomic effects are too small to be meaningful, but they could reshuffle export destination patterns

Based on the results of the socio-economic impacts, the final section of the report explores and recommends domestic and international tools to address these impacts for the different sectors of the economy and societal groups.

Finally, each country should report on the impacts of cross-border mitigation policies, however, most countries don't have the capacity, time, or data requirements to undergo this process.

The methodology that ERCST has developed is replicable to different countries and we aim to make the methodology and data available to every nation, thus allowing countries to better mitigate the effects of response measures and have better long-term planning towards a sustainable transition.

We hope that the methodology developed by ERCST and the case studies undertaken will prove useful for the Global Stocktake and the effort of Parties in identifying and preparing for the impacts of response measures in a more systematic way.

ERCST

European Roundtable on
Climate Change and
Sustainable Transition

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Reporting on the Impacts of Response Measures Ghana Case Study



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Acknowledgments and Disclaimer

This country case study is part of a series prepared for the ERCST Project entitled 'Reporting on Response Measures under Biennial Update Reporting'.

The study was done in collaboration with Angelina Tutuah Mensah, from the Ghana Environmental Protection Agency in Ghana and Ama Essel, an independent consultant in Ghana.

The modelling exercise and quantitative analysis was prepared in collaboration with Dorothee Flaig and Scott McDonald, from Hohenheim University.

The authors of this case study would like to gratefully acknowledge the cooperation of the Ghana Statistical Service for the support in the data collection process.

The views expressed in this paper are attributable only to the authors in a personal capacity, and not to any institution, which they are associated with.

This paper has been the subject of stakeholder consultations, including a workshop convened by the authors with stakeholders including local communities, NGOs, think tanks, academia, policy makers and representatives of industry.

Collaboration:



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Executive Summary

This report presents the results from the ERCST country case study on Ghana that assesses the trans-border impacts from the implementation of climate change mitigation policies (also known as response measures) on Ghana. International response measures could have socio-economic impacts in Ghana in the next years.

The report is part of a series of country case studies under the ‘Reporting on Response Measures under Biennial Update Reporting’ project. In 2019, ERCST developed a methodology for ‘Reporting on the impacts of Response Measures: methodology for country case studies¹’ and a case study for Chile ‘Reporting on the impacts of Response Measures - Chile Country Case Study²’. The case study also builds on the 2015 paper ‘Climate for sustainable growth: country case study for Ghana³’ which was presented at COP 21 in Paris.

The project aims to contribute to Activity 4 of the Katowice Committee of Experts on the Impacts of the Implementation of Response Measures (KCI) work programme⁴ by developing a case study for the country of Ghana, to enhance identify, measure, analyze, and understand the impacts of the implementation of response measures in the jurisdiction, as well as identify measures to address their impacts. The case study is also meant to test and refine the methodology, and to showcase how it could be used in practice. The information from the study and the informal dialogue will be shared and will feed into the discussion of the KCI and the Forum on response measures

The project also aims to support non-Annex I Parties to the UNFCCC in their efforts to fulfil their mandate to report on the impacts of the implementation of response measures under Biennial Update Reporting (BUR) by offering a concrete example of the type of assessment that might be conducted to underpin that reporting. It will also help those countries in future as they transition to requirements to submit Biennial Transparency Reports (BTR).

The work was undertaken in close collaboration with stakeholders in Ghana, leveraging their local knowledge, to ensure maximum relevance of the impacts of response measures that were considered in the case study. The project implemented as a “live” iterative activity, with work done, followed by workshops with local stakeholders, response measures negotiators and relevant institutions to the study. The Ghana Environmental Protection Agency was a catalyst to make sure this was accomplished.

¹<https://secureservercdn.net/160.153.137.163/z7r.689.myftpupload.com/wp-content/uploads/2019/12/Methodology-Description-Chile-country-case-study.pdf>

²<https://secureservercdn.net/160.153.137.163/z7r.689.myftpupload.com/wp-content/uploads/2019/12/ERCST-Reporting-on-the-impacts-of-Response-Measures-Chile-country-case-study.pdf>

³http://www.ceps-ech.eu/sites/default/files/20160115%20Ghana%20case%20study%20CfSG_0.pdf

⁴ https://unfccc.int/sites/default/files/resource/cp2019_13a01_adv.pdf#page=22

The main findings from the research and the case study identify 12 sectors of the Ghanaian economy as most vulnerable to the impacts of response measures with 80 international response measures that could impact them. The identified vulnerable sectors that are at risk of impacts are: cocoa, manufacture of beverages and food products (jojoba oil); palm oil; fishing; oil & gas; mining and quarrying without oil and gas and gold (aluminum and manganese).

Nevertheless, the results also indicate that not all the 12 identified vulnerable sectors are at risk of impacts from country-led response measures, mainly due to strong asymmetry of climate targets and mitigation actions taken between countries and regions.

For the identified vulnerable sectors three international response measure were chosen for quantitative assessment: IMO carbon tax for international shipping, CORSIA under ICAO carbon tax for international aviation and the EU Border Carbon Adjustment Mechanism.

The results indicate that the overall effects of the IMO carbon tax on economy of Ghana are small. On the other hand, the results portray that CORSIA/ICAO will have a stronger impact on the Ghanaian economy, compared to an IMO carbon tax. For the EU CBAM, macroeconomic effects are too small to be meaningful, but they could reshuffle export destination patterns

Even though currently there are a multiplicity of international funding programmes and initiatives in Ghana, this is not enough to meet the projected climate finance needs towards a sustainable transition and mitigate the impacts of response measures. De facto, in its Transmittal Letter for the Updated NDC Ghana announced that it will require \$1,24 Billion per year to achieve its climate targets in the next 10 years, which is way above the climate investments from the past 5 years which amounted to only \$3,08 Million per year.

The identification of key sectors and relevant response measures, and assessing their impacts is a laborious process. However, it can be simplified to be more useful for countries with less capacity to perform such a more exhaustive and comprehensive exercise. There are three main ways to simplify this methodology: (1) limit the number of sectors that are deemed vulnerable, for example by focusing on the top 3 or 5 sectors; (2) limit the number of response measures analyzed, for example focusing on the top 5 or top 10 response measures per sector; (3) limit the data collection and analysis step, and rely on stakeholder input to complement the analysis and ensure relevant sectors and policies are included in the country case study.

This approach is very much a bottom-up approach on how to do a country case study, and essentially tries to connect impacts with individual response measures. The vulnerable sectors are identified and are then linked to relevant international measures.

The case study, and the methodology it follows which shall be outlined below, are not intended to analyze the merit of the policies and measures that are being implemented, or their effectiveness and efficiency, but will focus on their socio-economic impacts, and measures to alleviate any negative impacts in the period of transition.

The basic premise of this research project is that we need to move faster and deeper. For the transition to a low-carbon or climate neutral society to take place, impacts of response measures need to be understood and addressed. Otherwise, the lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action and risk reducing buy-in from important stakeholders. This case study and the overall project's focus should be seen in that light: increasing understanding to strengthen the case for climate mitigation action.

This case study has been developed by the European Roundtable of Climate change and Sustainable Transition (ERCST), an independent think tank based in Brussels, Belgium.

1. Introduction

Climate change is an urgent challenge facing all of humanity, and it is currently being tackled through a broad set of approaches, including the implementation of policies and measures aimed at mitigating greenhouse gas (GHG) emissions. These climate change mitigation policies (also known as ‘Response Measures’) are necessary to force a global transition to low carbon and carbon neutral societies and economies. In the UNFCCC definition, response measures refer to transfer impacts. This paper will refer to measures that international or out of jurisdiction.

To ensure continued momentum and progression towards climate pathways in line with the well below 2°C and preferably to 1.5°C goals outlined in the Paris Agreement, it is extremely important to pay close attention to the way in which the transition to a low-GHG economy is managed.

This transition is critical and is a very ambitious undertaking. The way in which it is managed will have significant impacts on everyday life and societies in general. It should be undertaken in a sustainable way, by moving at the commensurate speed on the environmental, social, and economic axes – this includes understanding and addressing the negative and unintended impacts of climate mitigation policies.

Response measures have significant impacts, both within the jurisdiction implementing them and cross-border in other jurisdictions. These impacts will increase as climate mitigation efforts intensify the coming years and decades. These impacts can undermine the case for and the speed of the transition, therefore they need to be acknowledged and addressed. Otherwise, the lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action and risk reducing buy-in from important stakeholders.

This is not to be interpreted or construed as encouraging a lack of mitigation action. On the contrary, it must be seen as providing a way forward that will ensure that action can be undertaken with the full support of all stakeholders. Otherwise, the lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action and risk reducing buy-in from important stakeholders.

Note that it is the unintended negative impacts of policies that are the most critical to understand, quantify and address. Taking fossil fuel subsidy reform as an example, an *intended negative* impact is to make consuming fossil fuels more expensive in order to disincentivize the burning them. An *intended positive* impact could be savings for the government budget as costly fossil fuel subsidies are decreased. Both these impacts are intended goals of the policy. However, an *unintended negative* impact could be increased energy poverty or increased costs of

transportation for low-income families with significant repercussions on their quality of life. These unintended negative impacts should be the focus of any assessment of response measures and their impacts.

One of the components that have been introduced under the UNFCCC process is the reporting of mitigation policies and their impacts. This document outlines the methodology developed and tested by ERCST in line with the Biennial Update Reports (BUR) process under the UNFCCC, which allows for the reporting of economic and social consequences of response measures by non-Annex I Parties (UNFCCC, 2011a). It also incorporates the available guidance for the transition from BUR to Biennial Transparency Reports (BTR), allowing for the methodology to be adapted to the upcoming BTR reporting process that should be followed by all parties starting in 2024.

Note that there is no obligation for Parties to report on the impacts of response measures in their BURs, but there is an opportunity to do so.

ERCST's work has been pioneering in developing a methodology for identifying adverse impacts of domestic and international response measures. Highlighting this gap of scarcity of methodologies and seeking to provide a template for filling it in, is an important outcome of this project, as addressing impacts in an efficient and optimal manner is heavily dependent on identifying and quantifying them.

The methodology to report on socio-economic impacts of response measures follows nine steps as detailed in the methodology description. To see the step-by-step guide, please refer to 'Reporting on the impacts of Response Measures: methodology for country case studies.'⁵

The methodology that ERCST developed seeks to aid in the identification and assessment of the impacts of three types of response measures:

- (1) Domestic measures in the jurisdiction under review (e.g., Ghanaian climate mitigation measures),
- (2) Domestic measures in other jurisdictions (e.g., climate mitigation measures in countries other than Ghana), and
- (3) International mitigation measures (e.g., policies implemented under the International Civil Aviation Organization (ICAO) or International Maritime Organization (IMO)).

The first type of policies will be referred to as 'domestic policies. The second and third types of policies will be referred to collectively as 'international' or 'out-of-jurisdiction' policies. For the

⁵<https://secureservercdn.net/160.153.137.163/z7r.689.myftpupload.com/wp-content/uploads/2019/12/Methodology-Description-Chile-country-case-study.pdf>

scope of this case study, only international or out-of-jurisdiction response measures were considered.

Since we are considering only international response measures for this case study the methodology will follow seven steps instead of nine. These are outlined in section 3.2 of the report and will guide the reader throughout the case study.

The methodology is also a valuable tool for drafting ex-ante reports to address and manage the unintended risk of possible adverse impacts coming from future response measures, allowing for the implementation of tools to manage the risk at an earlier stage, and even the prevention of such impacts. It can form the basis for ex-ante impact identification, with an emphasis being placed on stakeholder consultations throughout the process from the main sectors of the economy

The work done for this project builds on the 'Country Case Study for Ghana'⁶ part of the Climate for Sustainable Growth project in 2015 and presented at COP 21 in Paris. The study looks at the economic, social, and environmental impacts of domestic and international mitigation policies in Ghana for three broad sectors: a) energy (including transport), b) agriculture, forestry, and other land use (AFOLU) and c) waste. To find out more about the impacts of domestic climate change policies in Ghana, the above-mentioned case study can be consulted.

The 2015 case study was used as a starting point regarding climate mitigation policies and regulations, as well as key sectors of the economy which could be particularly vulnerable to the impacts of response measures. Even though the new case study looks only into international cross border impacts of response measures, it provides a much more in depth qualitative and quantitative analysis - economic modelling - of the 12 different sectors identified as most vulnerable in the Ghanaian economy and that could be adversely affected.

As second leg, the case study also builds on the lessons learnt from the 'Country Case study for Chile'⁷ to report on the impacts of response measures that ERCST conducted in 2019.

Ghana was chosen for this country case study for a variety of reasons. The country has seen significant economic development in the last decades. In addition, it has some history implementing climate change policies in the country, while also being open to strengthening its own climate agenda and prepare for a sustainable transition. ERCST already had background and conducted research in the country which facilitated the assessment. Last but not least, government actors and business stakeholders were interested in cooperating with the research team to build this case study.

⁶http://www.ceps-ech.eu/sites/default/files/20160115%20Ghana%20case%20study%20CfSG_0.pdf

⁷<https://ercst.org/reporting-on-the-impacts-of-response-measures/>

The work was undertaken in close collaboration with stakeholders in Ghana, leveraging their local knowledge, to ensure maximum relevance of the impacts of response measures that were considered in the case study. The project implemented as a 'live' iterative activity, with work done, followed by workshops with local stakeholders, response measures negotiators and relevant institutions to the study. The Ghana Environmental Protection Agency was a catalyst to make sure this was accomplished.

This case study on reporting on socio-economic impacts of response measures follows the seven steps detailed in the methodology report and the key issues addressed for Ghana are:

- Identify sectors vulnerable to the impacts of international response measures,
- List relevant international response measures,
- Quantify the impacts of those response measures, and
- Highlight approaches to mitigate negative and unintended impacts.

2. Background on Response Measures

Mitigation policies and actions are being taken by Parties under the Paris Agreement (PA) to limit climate change and its impacts. These policies, known as 'response measures' under the UNFCCC, can have impacts beyond reducing greenhouse gas (GHG) emissions, both in the jurisdiction implementing them and across borders. These impacts can be positive, or negative and intended or unintended, and be social, economic, or environmental in nature.

To achieve the 2 °C goal of the Paris Agreement, and even more to limit global heating to 1.5 °C, the effective and sustainable mitigation of GHG emissions needs to be enhanced and efforts increased. The increased stringency of response measures in the future could exacerbate their impacts. The aim of policy makers should be to minimize the unintended negative impacts and maximize the positive impacts.

Response measures give rise to a large variety of concerns, including competitiveness concerns, budgetary impacts, job losses, transitioning of sectors etc. Understanding these concerns is fundamental when assessing the sustainability of the transition to a low GHG global economy, as stakeholders with concerns that are not taken into account can potentially slow down a sustainable transition. Buy-in from stakeholders is necessary for a rapid and deep transition, and for this reason, environmental, social, and economic impacts need to be assessed, analyzed, reported, and addressed.

Yet, while there has been considerable debate on how to achieve this, as yet no agreed guidelines or methods for identifying and quantifying these impacts have been outlined. This case study and the related 'Methodology for country case studies' document aim to partially fill this current gap.

Non-Annex I Parties (mostly developing countries) have the possibility (UNFCCC, 2011b) to report on any socio-economic impacts of response measures in other jurisdictions in their Biennial Update Reports (BUR). This methodology is meant to help those countries report on impacts of response measures under the BURs. Therefore, the methodology is geared towards country-level assessments of response measures.

The mandate and guidelines for the BURs reports are to be found in decision 2/CP.17 (UNFCCC, 2011a), with Annex III stipulating that the objectives of the BUR guidelines include "... [facilitating] reporting by non-Annex I Parties, to the extent possible, on any economic and social consequences of response measures" (UNFCCC, 2011a – Para 11-13). The BURs can also be used to highlight needs Parties may have and support they have received.

From 2024 onwards, BUR reporting will be replaced by Biennial Transparency Reporting (BTR), based on guidance elaborated in the Transparency Framework. How reporting requirements will change in detail is as yet not entirely clear. However, two sections of the guidance in the Transparency Framework are relevant with regard to response measures – paragraphs 78 and 90. The first BTR report submission deadline is set to take place on December 31, 2024, with subsequent review of the submitted BTR occurring within the two years prior to the next submission. Parties should submit a new BTR every four years from 2024 onwards (UNFCCC, 2019a).

Under paragraph 78 Parties are allowed to report on how socio-economic impacts of adaptation and/or economic diversification actions with mitigation co-benefits are addressed (UNFCCC, 2018a – Para 78). It should be noted that reporting on measures to address the impacts is different from reporting solely on the impacts of response measures, which is the current focus of this methodology.

Paragraph 90 states that "Each Party is encouraged to provide detailed information, to the extent possible, on the assessment of economic and social impacts of response measures." (UNFCCC, 2018a – Para 90). It is, however, unclear how broad the scope of this assessment should be: does it include the domestic impacts of domestic mitigation measures, the impacts of domestic measures in other jurisdictions or does it only cover the domestic impacts of mitigation measures in other jurisdictions and at the international level.

3. Project Overview

3.1. Project Objectives

The main aim of the study is to test the ERCST methodology which assesses and analyses the adverse, and unintended impacts of existing, and emerging, climate change mitigation measures 'international' or 'out-of-jurisdiction' policies. The project objectives therefore include the following:

1. To describe a methodology on response measures (RM) under BUR reporting, which can then be used under BTR reporting after 2024,
2. To test, refine and improve this methodology by developing country case studies. A major aspect of the test is to see whether all the necessary data to implement the methodology is available and is feasible to access,
3. Highlight relevant challenges, and potential solutions, in both 1 and 2. These challenges are discussed in the methodology document,
4. Engage in discussions on the main findings of the project, both within the country where the methodology is tested - Ghana -and in meetings with relevant high-level policy makers and negotiators on response measures.

3.2. Case Study Methodology

The methodology seeks to identify and quantify the adverse impacts from out-of-jurisdiction and international response measures on sectors of the economy that are deemed vulnerable to their impacts. In addition, potential tools, and lack thereof, to address these impacts at the domestic and international level are discussed.

The ERCST methodology to assess the impacts of domestic and international response measures that was developed in 2019 follows nine steps, however since for this case study we are considering only international response measures, the methodology will follow seven steps instead of nine.

Additionally, the original 2019 methodology had to be adapted for this case study to consider for the different elements of the Ghanaian economy and information availability issues.

Each step in the methodology will be described and discussed in detail, highlighting challenges the project team encountered when testing the methodology throughout the Ghana country case study. The seven steps are:

- Step 1:** Describe the country and its key characteristics
- Step 2:** Identify the top vulnerable sectors in terms of GDP value added
- Step 2.1:** Collect and sort GDP data
- Step 2.2:** Correspondence of GDP activities to international classification standard
- Step 2.3:** Limit the list of sectors by excluding service and domestic activities
- Step 2.4:** Filter the list of sectors for those with significant GDP value added
- Step 3:** Identify sectors potentially vulnerable to international response measures
- Step 3.1:** Collect trade and GHG intensity data for each sector
- Step 3.2:** Perform a correspondence of economic activities to international classification standard for goods
- Step 3.3:** Calculate trade and GHG intensity for each sector
- Step 3.4:** Filter the list of sectors according to their trade intensity
- Step 3.5:** Rank the sectors by using the vulnerability indicator formula
- Step 4:** Employ stakeholder input to identify vulnerable sectors that might have been missed in step 3
- Step 4.1:** (In the case of Ghana) Collect and calculate employment data for each sector
- Step 4.2:** (In the case of Ghana) Add the national planning data
- Step 5:** Identify relevant response measures for the vulnerable sectors identified in the previous step
- Step 5.1:** Identify main export partners of the vulnerable sectors
- Step 5.2:** Search for response measures in international databases
- Step 5.3:** Match response measures to the vulnerable sectors and countries
- Step 5.4:** Filter the results
- Step 6:** Quantitative assessment of the impacts of the identified international response measures
- Step 6.1:** Set up of model

Step 6.2: Add specific response measures to model

Step 6.3: Define simulations

Step 6.4: Collect data for simulations

Step 6.5: Conduct simulations and sensitivity analyses

Step 6.6: Analyze results considering assumptions, model strength and limitations

Step 7: Identify, assess possible tools, and support which may be needed to address the impacts

Step 7.1: Identify domestic mitigation tools

Step 7.2: Identify international mitigation tools

Since it is not feasible to assess the potential impacts of all global climate change measures on all sectors of the Ghanaian economy, a large part of the methodology is focused on sorting through economic sectors and response measures as to enable the analysis to focus on the sectors and policies that are most significant. Steps 2 to 4 focus on identifying the sectors that should be considered vulnerable to the impacts of response measures. Step 5 focuses on identifying the relevant response measures for those sectors.

This approach is very much a bottom-up approach on how to do a country case study, and essentially tries to connect impacts with individual response measures. The vulnerable sectors are identified and are then linked to relevant domestic and international measures.

3.3. Report of the country case study

The aim of this report is to describe our successes and challenges in applying the above outlined methodology in Ghana, and not to go through the detailed description of the methodology⁸. Therefore, for simplification reasons this paper combines the seven steps of the methodology into five chapters:

Step 1. Ghana Country profile

This chapter presents an overview of Ghana, including its general geography, historical context, political system, main sectors of the economy, economic performance recent economic developments.

Steps 2 - 4. Identification of vulnerable sectors

In this chapter the sectors deemed most vulnerable to the impacts of response measures are presented, with a brief discussion on how these sectors were identified.

Step 5. Identification of relevant response measures

Here an overview is presented of the relevant response measures that have the potential to impact the identified sectors.

Step 6. Assessment of impacts of response measures

This chapter contains the results of the limited quantitative analysis of the potential impacts of response measures performed by the research team.

Step 7. Tools to address impacts

In the final chapter, an overview is presented of the domestic and international tools that can be used to help Ghana address and mitigate the impacts of response measures.

⁸ To learn more about on the detailed step by step description the methodology, please refer to ‘Reporting on the impacts of Response Measures: methodology for country case studies.’

4. Step 1. Ghana Country Profile

Step 1 of the methodology consists of an overview of Ghana’s country characteristics, including general geography, historical context, political system, main sectors of the economy and economic performance. This step was carried out mainly through desk research.

4.1. General Profile and Geography

The Republic of Ghana is located in West Africa. It spans the Gulf of Guinea and the Atlantic Ocean to the south and shares borders with the Ivory Coast, Burkina Faso, and Togo. The country is subdivided in 16 regions (see map). With an estimated population of 31 million people (GSS, 2020) it is 2nd largest economy in West Africa and 8th largest in Africa.

Historically, Ghana was known as the Gold Coast. After 113 years of colony, Ghana gained its independence from Britain, in 1957, becoming the first sub-Saharan nation to break free from colonial rule.

After a 17-year period of political instability from 1966 to 1983, marked by multiple coups and low-to-negative growth rates, the economy started to grow continuously for 36 years from 1984 to 2019 based on annual increases in the gross domestic product (GDP).

Ghana is considered one of the more stable countries in West Africa since its transition to multi-party democracy in 1992. Nana Addo Dankwa Akufo-Addo is the current president, serving his second term since 2020 and part of the New Patriotic Party (NPP).

The country’s long-standing democratic tradition and favorable economic stability makes Ghana one of the most attractive country for business on the continent.

Ghana is a lower middle-income country, and the economy relies strongly on the extractive industry and an agricultural production base. Despite the consistent economic gains, the country is still facing challenges associated with rising population and environmental change that include poverty, access to education and healthcare, pollution, and energy access.

Figure 1. Map of Ghana



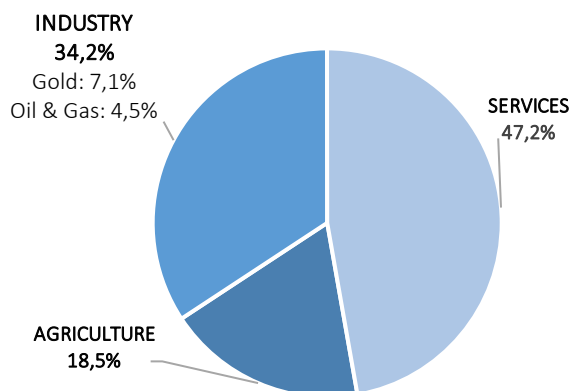
Source: World Atlas

Currently, Ghana is a multinational state, home to a variety of ethnic, linguistic, and religious groups; while the Akan are the largest ethnic group, they constitute only a plurality. The vast majority of Ghanaians are Christian (71.2%).

4.2. Overview of the Ghanaian economy and main sectors

Ghana's relies on its natural environment and climate change poses an important threat to its national development. With a land area of approximately 238 540 square km, Ghana's economy is to a large extent based on natural resource extraction, forestry, and agriculture. Agriculture alone accounts for 18.5% of Ghana's GDP where in particular cocoa and forestry are relevant sectors. De facto, after the Ivory Coast, Ghana is the second largest exporter of cocoa in the world. The industry sector accounts for 34,2% of Ghana's GDP where gold accounts for 7,1% and oil & gas for 4,5% (GSS, 2019). The oil and gas sector became important after the 2007 discovery of the Jubilee oilfield, explaining the 2011 peak in annual GDP growth.

Figure 2. GDP Composition (2019)



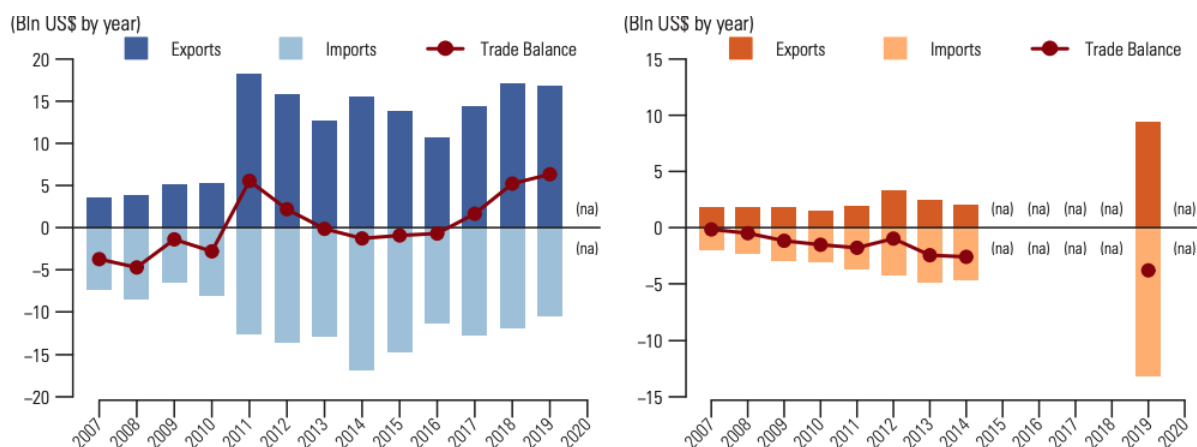
Source: Own elaboration based on GSS data (2019)

The primary sector has been the key driver of growth in last years, with mining (bauxite, gold, aluminum, and manganese) and agriculture (coconut, cocoa, jojoba, and coffee) being the main activities. The country's growth is strongly linked to the increase in hydrocarbon production. The secondary sector is mainly hydrocarbon refining and metallurgy and the service sector mainly consist in telecommunications, tourism, and transport.

As reported in the graphs 2 and 3 below the trade balance of merchandise in Ghana has been positive and growing in the last few years, while for services it appears as negative. Ghana is therefore an important exporter especially of raw materials and primary products.

Figure 3. Total merchandise trade, by value

Figure 4. Total services trade, by value



Source both figures: UN, International Trade Statistics Yearbook (2020)

The table below gives an overview of the main export commodities from Ghana to the world from 2017 to 2019.

Table 1. Top 10 export commodities 2017 to 2019

HS code	4-digit heading of Harmonized System 2012	Value (million US\$)		
		2017	2018	2019
	All Commodities.....	14 358.5	17 099.6	16 768.3
7108	Gold (including gold plated with platinum).....	5 858.3	6 092.6	6 198.9
2709	Petroleum oils and oils obtained from bituminous minerals, crude.....	3 619.7	5 195.0	5 251.7
1801	Cocoa beans, whole or broken, raw or roasted.....	1 642.1	2 437.2	1 852.0
1803	Cocoa paste, whether or not defatted.....	407.4	396.4	409.6
0801	Coconuts, Brazil nuts and cashew nuts, fresh or dried.....	298.1	460.2	246.1
1804	Cocoa butter, fat and oil.....	276.5	287.2	337.3
2602	Manganese ores and concentrates.....	155.4	288.1	349.5
1604	Prepared or preserved fish; caviar.....	140.8	155.3	146.3
3924	Tableware, kitchenware, other household articles and toilet articles.....	213.3	115.8	44.6
4407	Wood sawn or chipped lengthwise, sliced or peeled.....	99.3	119.0	78.4

Source: UN, International Trade Statistics Yearbook (2020)

And the main export destinations of commodities from Ghana in 2019 were:

- China with a share of 16.7% (2.8 billion US\$)
- Switzerland with a share of 14.7% (2.46 billion US\$)
- India with a share of 14.1% (2.38 billion US\$)
- South Africa with a share of 11.7% (1.97 billion US\$)
- Netherlands with a share of 5.76% (966 million US\$)
- United Arab Emirates with a share of 5.36% (899 million US\$)
- USA with a share of 4.2% (704 million US\$)
- United Kingdom with a share of 2.47% (415 million US\$)
- France with a share of 2.24% (377 million US\$)

- Italy with a share of 1.84% (308 million US\$)

Source: UN Comtrade (2020)

The table below gives an overview of the main import commodities of Ghana from 2017 to 2019.

Table 2. Top 10 import commodities 2017 to 2019

HS code	4-digit heading of Harmonized System 2012	Value (million US\$)		
		2017	2018	2019
	All Commodities.....	12718.1	11880.5	10439.8
8703	Motor cars and other motor vehicles principally designed for the transport.....	998.6	956.1	881.8
2523	Portland cement, aluminous cement, slag cement.....	915.4	323.4	319.7
8704	Motor vehicles for the transport of goods.....	544.0	476.8	441.9
1006	Rice.....	401.9	451.9	374.9
0303	Fish, frozen, excluding fish fillets and other fish meat of heading 03.04.....	235.7	235.6	202.1
1511	Palm oil and its fractions.....	286.3	225.4	136.6
3004	Medicaments (excluding goods of heading 30.02, 30.05 or 30.06).....	180.8	251.3	203.2
2710	Petroleum oils, other than crude.....	210.5	188.0	236.1
1001	Wheat and meslin.....	303.8	178.7	139.7
3808	Insecticides, rodenticides, fungicides, herbicides.....	194.9	203.9	154.2

Source: UN, International Trade Statistics Yearbook (2020)

And the main Ghana’s import partners by country in 2019 were:

- China with a share of 18.1% (1.89 billion US\$)
- USA with a share of 9.35% (976 million US\$)
- United Kingdom with a share of 6.56% (685 million US\$)
- India with a share of 5.57% (582 million US\$)
- Belgium with a share of 5.1% (532 million US\$)
- Turkey with a share of 4.47% (466 million US\$)
- South Africa with a share of 3.42% (357 million US\$)
- Vietnam with a share of 3.03% (316 million US\$)
- United Arab Emirates with a share of 2.64% (275 million US\$)
- Canada with a share of 2.55% (266 million US\$)

Source: UN Comtrade (2020)

Both in imports and exports, the Ghanaian economy is heavily reliant on China, with a share of 18.11% for the imports and 16.7% for the exports. Other important trading countries (regions) for Ghana are India, USA, United Kingdom, South Africa, and Europe (including Switzerland, Netherlands, Belgium, France, and Italy). It is crucial to understand the main trading commodities and partners of Ghana since the response measures that these countries implement will impact

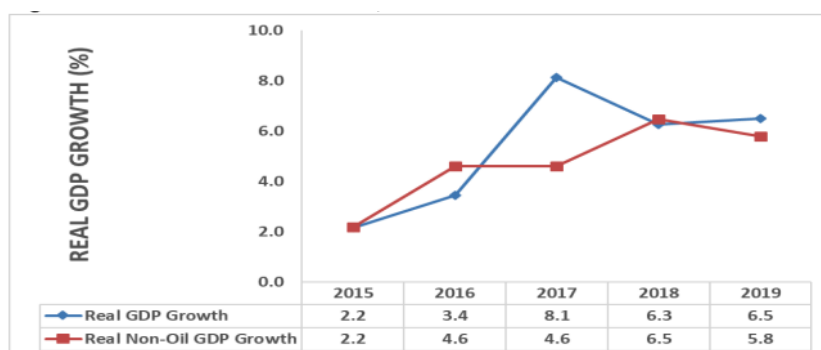
the trade flows with Ghana. The potential response measures and ensuing impacts that they might have on Ghana will be assessed and analyzed in the following sections of the report.

4.3. Recent economic developments and performance

Ghana’s rapid growth was halted by the COVID-19 pandemic, the March 2020 lockdown, and a sharp decline in commodity exports. The economy had grown at an average of 7% in 2017-19, before experiencing a sharp contraction in the second and third quarters of 2020 (World Bank, 2021). In response to the COVID-19, in 2020, the government spent about 2.1% of GDP for its stimulus package. Additionally, the European Union mobilized €86.5 million in emergency budget support to help Ghana in tackling the consequences of the coronavirus pandemic. In 2020, the GDP per capita in Ghana was US\$ 2,328.5 (World Bank, 2021).

It is to be noted that the economic growth in Ghana has also been linked to widening income inequality (GSS, 2018). The income Gini coefficient of Ghana increased from 41.9 in 2006 to 42.3 in 2013, and then to 43.0 in 2017 (GLSS, 2018), above the international severe income inequality benchmark of 40.0. As a matter of fact, 23.4% of the population is below the poverty line. Further, the continuous growth was associated with large-scale environmentally destructive activities which contributed to increased greenhouse gas (GHG) emissions (Anaman and Agyei-Sasu, 2014).

Figure 5. Annual Real GDP Growth, 2015-2019



Source: Ghana Ministry of Finance and Ghana Statistical Service (2020)

The above-presented graph reinforces that GDP growth in Ghana in the past years has been due by a few percentage points to the growth of the oil sector. Furthermore, it is forecasted that real GDP growth will strengthen in 2022, before slowing in 2023-24 and then pick up again in 2025-26. Investment in new oilfields will be slow, delaying a resurgence of real GDP growth to pre-pandemic levels, despite efforts by the government to facilitate industrialization under the Covid-19 Alleviation and Revitalization of Enterprises Support programme.

Ghana has managed to significantly lower inflation from 17% in 2016 to 7.2% in 2019 thanks to a steady decline in non-food inflation and a tight monetary policy.

The overall fiscal deficit doubled to 15.2 percent in 2020. Public debt increased to 81.1 percent of GDP in 2020, placing Ghana at a significant risk of debt distress.

The Ghana Cedi (GH¢) ended the year 2020 with a depreciation rate of 3.9% to the US dollar and 12.1% against the Euro, making it one of the best performing currencies in Sub Saharan Africa.

Lastly, it has to be noted that informal employment in Ghana is overwhelming. The International Labor Organization (ILO) estimated that 86.2% of workers in the country are informal in nature⁹.

5. Steps 2 – 4. Identification of vulnerable sectors

This chapter covers the identification and selection of sectors which could be considered most vulnerable to international response measures. In order to identify the vulnerable sectors in Ghana step 2, 3 and 4 of the methodology have to be undertaken:

- Step 2:** Identify the top vulnerable sectors in terms of GDP value added
- Step 3:** Identify sectors potentially vulnerable to international response measures
- Step 4:** Employ stakeholder input to identify vulnerable sectors that might have been missed in step 3

A detailed overview of the sub-steps that need to be followed for each of these steps will be described in the following sections.

6. Step 2. Identification of top vulnerable sectors in terms of GDP value added

To identify the main sectors of the economy, GDP value added is taken as an indicator. These sectors of the economy are then ranked based on their value-added contribution to national GDP. The top sectors are then taken as the basis to identify international response measures.

The four main sub steps under step 2 for identifying the top vulnerable sectors in terms of GDP value added are:

⁹ https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_626831.pdf

- Step 2.1:** Collect and sort GDP data
- Step 2.2:** Correspondence of GDP activities to international classification standard
- Step 2.3:** Limit the list of sectors by excluding service and domestic activities
- Step 2.4:** Filter the list of sectors for those with significant GDP value added

6.1. Step 2.1. Collect and sort GDP data

The first sub step (2.1) involves collecting and sorting the Gross Domestic Product (GDP) value added data in the country for the different economic sectors. For the case study, the GDP sectoral data was gathered from the Ghana Statistical Service database for the 2019 year.

The publicly available GDP data is disaggregated into 23 economic activities; with the collaboration of the Ghana Statistical Service a more disaggregated dataset was provided, with a total of 73 economic activities. This dataset has a wide range of sectors, from manufacturing to financial and insurance services. The full list of sectors can be found in Annex 1.

For the tourism sector the WTO Tourism Statistics Database 2018 (UNWTO, 2021) was used as the main source. The tourism sector figures include travel and expenditure by main purpose of trip.

6.2. Step 2.2. Correspondence of GDP activities to international classification standard

The second sub step (2.2) implies correspondence from Ghanaian GDP economic activities data to the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4 codes.

Table 3 shows an overview of the ISIC Rev. 4 structure and throughout the case study, sectors will be defined using this classification system at a 2 and 4-digit level of disaggregation. The example of the table below shows an example of the disaggregation for gold related activities, which is a relevant sector for the Ghanaian economy.

Table 3. Overview of ISIC Structure

Sector	Agriculture	Disaggregation Level
Section	B, Mining and Quarrying	1-digit/letter level

Division	07, Mining of metal ores	2-digit level
Group	071, Mining of iron ores	3-digit level
Class	0729, Mining of other non-ferrous metal ores (this class includes gold)	4-digit level

Source: Own elaboration based on United Nations (2008), International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4, ST/ESA/STAT/SER.M/4/Rev.4

Why is it necessary to conduct the extra step of correspondence to ISIC Rev. 4 classification system?

First of all, ISIC Rev 4 is one of the most recognized and widely used standards for classification of economic activities at the international level. Secondly, this classification will facilitate the double concordance that will have to be done in the next step to match the economic activities with exports data. The exports data is classified with the Harmonized System (HS) 2007 used for the international classification of products.

6.3.Step 2.3. Limit the list of sectors by excluding service and domestic activities

The following sub step (2.3) is to limit the list of sectors by excluding service and domestic activities. Service activities (e.g., financial and insurance activities) were left out since they mostly don't have significant emissions compared to the other activities. Domestic activities (e.g., construction) with no exports were left out too since the study is focusing only on international response measures and not domestic. This first filtering resulted from 71 to 56 activities in Ghana that could potentially be vulnerable to international response measures.

6.4.Step 2.4. Further limit the list of sectors in terms of GDP value added

The last sub step (2.4) is to further limit the list of sectors based on their GDP value added ranking. Top 20 activities by GDP value were then selected as a basis to identify the top vulnerable sectors to international response measures

Table 4. Top 20 vulnerable sectors in terms of GDP value added

Table 4. Top 20 vulnerable sectors in terms of GDP value added

Sector Description		Gross Domestic Product (GDP) at Current Market Prices	
ISIC Rev 4 Code	Description	GDP 2019 (M Ghc)	% of GDP
2420, 0729	Gold	23.282	7,1%
0610, 0620, 1920	Oil and gas	14.848	4,5%
0113	Yam	10.870	3,3%
05, 07 (- 0729), 08,09	Mining and quarrying without oil and gas and gold	10.402	3,2%
WTO 1.33 & 1.36	Tourism	8.491	2,6%
0127, 1073	Cocoa	8.050	2,5%
14	Livestock	7.945	2,4%
20	Manufacture of chemicals and chemical products	5.964	1,8%
0122	Plantain	4.857	1,5%
11,10 (-1073, -1020)	Manufacture of beverages and food products	4.575	1,4%
0113	Cassava	4.333	1,3%
02	Forestry and Logging	4.329	1,3%
0129, 0116, 0127	Other tree crops (coffee, rubber, cotton)	3.772	1,2%
22	Manufacture of rubber and plastics products	3.626	1,1%
0111	Groundnuts	3.283	1,0%
023	Manufacture of other non-metallic mineral products	3.110	1,0%
03, 1020	Fishing	3.035	0,9%
25	Manufacture of fabricated metal products, except mach. & equip.	2.782	0,9%
0126	Palm oil	1.926	0,6%
0119	Maize	1.810	0,6%

Source: Own elaboration based on GSS and UNWTO data (2021)

As a result of this step, only sectors with major contributions to Ghana’s GDP were deemed relevant. Note that smaller sectors can be equally or even more vulnerable to the impacts of domestic and international response measures than larger sectors of the economy. However, the impacts for smaller sectors will be less urgent for the overall economy and country, and it might be possible to deal with them at a lower level of governance. Different tools from those used to address the impacts for major exporting and/or employing sectors of the economy might be necessary to address the impacts of response measures on smaller sectors.

7. Step 3. Identification of sectors potentially vulnerable to international response measures

To identify the sectors potentially at risk of international response measure, two indicators are taken into account: sectors that intensively traded and GHG intensive sectors. First, trade intensity will help understand which sectors are most trade exposed. Second, understanding the GHG intensity of each sector allows for the exclusion of those sectors with low or no GHG emissions, as they will be less - or not at all - exposed to climate mitigation policies.

The five sub steps under step 3 for identifying the top vulnerable sectors potentially vulnerable to international response measures are:

- Step 3.1:** Collect trade and GHG intensity data for each sector
- Step 3.2:** Perform a correspondence of economic activities to international classification standard for goods
- Step 3.3:** Calculate trade and GHG intensity for each sector
- Step 3.4:** Filter the list of sectors according to their trade intensity
- Step 3.5:** Rank the sectors by using the vulnerability indicator formula

7.1.Step 3.1. Collect trade and GHG intensity data for each sector

The first sub-step (3.1) for this section of the methodology involves the collection of trade and GHG data for each of the sectors identified in Step 2 in order to be able to afterwards calculate trade and GHG intensity for each sector.

The exports and imports data collected for this step was gathered from the United Nations Comtrade Database - International Trade Statistics for 2019. The full list of exports and imports data for 34 sectors (20 sectors identified before plus 14 relevant products inside those sectors), as well as the concordance table be found in Annex 2.

The GHG sectoral emissions data was primarily collected from the Fourth National GHG Inventory Report (NIR) from Ghana (2016). The full list of sectors from the NIR can be found in Annex 3. The emissions data for the sectors where GHG emissions data was not available at 4-digit disaggregation level was sourced from different sustainability reports from the largest companies in the sector in the country and from reports from international organizations. The sectors to which this method was applied were:

- Gold: GHG emissions from the operations of largest company of selected sector sourced from their Sustainability Reports, in this case Anglo Ashanti Gold (2019), multiplied by the production volume in tones of the gold sector in Ghana source World Gold Council (2019).
- Crops: total production volumes of the sector in Ghana taken from FAO (2019) for each crop, multiplied by the global average GHG intensity of product taken from WWF paper (2019). In the case of palm oil, the emissions from the operations of largest company of the selected sector were taken sourced from their Sustainability Reports, in this case Siat Group (2019).

7.2.Step 3.2. Perform a correspondence of economic activities to trade international classification standard

The second intermediate step (3.2) looked into doing a double correspondence from the identified economic activities to the trade data which is classified into products. The double correspondence is done because:

- GDP sectoral data refers to activities - ISIC Rev.4
- Trade data refers to products - Harmonized System HS2007

The double concordance is done as follows:

- ISIC Rev. 4 → ISIC Rev 3.1 → HS2007 Code

The ISIC Rev 3.1 intermediary concordance is needed since direct ISIC Rev. 4 to HS2007 Code is not available. This is a labor intensive and lengthy process since some ISIC Rev. 4 activities had more than 500 corresponding HS2007 import or export products. The table below portrays an example of double concordance for chemicals and chemical products.

Table 5. Double concordance example for chemicals and chemical products

ISIC Rev 4 Code		ISIC Rev 3.1 Code		HS 2007 Code	
ISIC Rev 4	Description	ISIC Rev 3.1	Description	HS 2007 Code	Description
20	Manufacture of chemicals and chemical products	24	Manufacture of chemicals and chemical products: manufacture of basic chemicals, plastics in primary forms, synthetic rubbers, man-made fibers, fertilizers, paints & varnishes, other chemical products, soap, and detergents (excluded manufacture of pharmaceuticals, medicinal chemicals, and botanical products)	1518,1520, 2707,28 (-284330), 2901-2934, 2942, 300670, 31-38, 3901-3914, 4002, 4402, 5402-5405, 5501-5504, 710410, 710420, 8523	All products under the described categories (e.g., polymers, silicones, soaps, washing preparations) of ISIC Rev 3 (subtracted 24330 Gold comps.)

Source: own elaboration based on above mentioned different classification systems (2021)

7.3.Step 3.3: Calculate trade and GHG intensity for each sector

The following sub-step (3.3) is to calculate trade and GHG intensity for each identified sector. The two main questions being answered for the analysis of this step then are:

1. Is the sector internationally traded?
2. Does the sector have significant greenhouse gas emissions?

The calculation of trade and GHG intensity for sector was done as follows:

- **Trade intensity:** first trade intensity is calculated to understand which sectors are most trade exposed. The formula to calculate trade intensity is the following:

$$Trade\ intensity\ (\%) = \frac{exports}{domestic\ production}$$

Exports are expressed as the total value of exports from the sector. Domestic production is defined as the value of the gross domestic production of the sector. The higher the trade intensity, the higher the vulnerability of the sector. Higher trade intensity means more exposure to not only foreign competition, but also international and out-of-jurisdiction climate measures.

- **GHG intensity:** the second threshold looks at GHG intensity, expressed as GHG intensity of value added, or the energy costs over unit of value added.

$$GHG\ intensity\ (grams\ of\ CO_2e/USD) = \frac{GHG\ emissions}{Value\ added}$$

As indicated earlier, data on sectoral GHG emissions was not available for all sectors in Ghana on a sufficiently disaggregated level - ISIC 4-digit level, therefore data was collected for those sectors from different reliable sources.

7.4.Step 3.4. Filter the list of sectors according to their trade intensity

Sub-step 3.4 involved further narrowing down the list to most traded sectors only. The list of sectors was then narrowed down from 20 to 12 sectors. This was done by taking the top 11 sectors according to their trade intensity plus tourism, 12 in total. The activities important for the economy but not highly exported, such as other tree crops (coffee, rubber, cotton), forestry and logging, plantain, maize, livestock, yam, groundnuts, cassava, were left out. The table with the full list of 20 sectors with their respective GHG intensities, trade intensities and vulnerability indicators can be found in the Annex.

Table 6. Major export products from Ghana in 2019 for the 2-digit level identified vulnerable sectors

Sector	Main export products for the sector (2019)
Manufacture of fabricated metal products, except machinery and equipment	<ul style="list-style-type: none"> • 34% Other articles of iron or steel • 20% Table, kitchen or other household articles and parts thereof, of aluminum • 15% Tools, implements, cutlery, spoons, and forks, of base metal
Manufacture of food products:	<ul style="list-style-type: none"> • 35% Fixed vegetable fats & oils (incl. jojoba oil) • 4.1% Tomatoes, prepared/preserved, other than whole/in pieces • 3.7% Gin & Geneva • 3.6% Sauces & preparations therefor • 2.6% Fruit juices (including grape must) and vegetable juices • 2.6% Margarine (excl. liquid margarine)
Manufacture of chemicals and chemical products	<ul style="list-style-type: none"> • 9% Tanning or dyeing extracts • 2,4% Surface-active preparations, washing preparation • 2,2% Beauty/make-up preparations & preparations for the care of the skin, incl. sunscreen/suntan preparations • 1,0% Adhesives based on polymers of 39.01-39.13/based on rubber • 1,7% Industrial monocarboxylic fatty acids other than stearic acid/oleic acid/tall oil fatty acids; acid oils from refining

Manufacture of rubber and plastics products	<ul style="list-style-type: none"> • 40% Articles for the conveyance or packing of goods, of plastics; stoppers, lids, caps, and other closures, of plastics • 30% Tubes, pipes, and hoses of plastics • 20% Tableware, kitchenware, other household articles and hygienic or toilet articles, of plastics
Manufacture of other non-metallic mineral products	<ul style="list-style-type: none"> • 44% Ceramic products • 40% Quicklime, slaked lime, and hydraulic lime
Mining and quarrying without oil and gas and gold	<ul style="list-style-type: none"> • 65% Manganese ores & concentrates • 7% Aluminum ores & concentrates

Source: own elaboration based on GSS, ILOSTAT, BUR/NIR, UN Comtrade, UNWTO and other relevant sources for missing data points (2021)

Table 7 provides a more detailed overview for the 2-digit level identified vulnerable sectors of what are the major exports products in percentage export value from Ghana in 2019.

7.5.Step 3.5. Rank the sectors by using the vulnerability indicator formula

Sub-step 3.5. looks into ranking the sectors according to their Vulnerability Indicator.

- **Vulnerability Indicator:** The ranking and selection of the most vulnerable sectors was done by applying the Vulnerability Indicator which is an adapted methodology based on the EU ETS Phase 4 Carbon Leakage Indicator¹⁰. The idea of the indicators is to simply multiply together the trade intensity and GHG intensity of each sector to get what is called in the Vulnerability indicator. The formula to calculate the indicator is as follows:

$$\text{Vulnerability Indicator} = \underbrace{\left(\frac{\text{Export} + \text{Imports}}{\text{GDP sector} + \text{Imports}} \right)}_{\text{Trade Intensity}} \times \underbrace{\left(\frac{\text{GHG emissions}}{\text{GDP sector}} \right)}_{\text{Emissions Intensity}}$$

Table 7. Top 12 Vulnerable Sectors to International Response Measures

Sector Description		GDP Ghc	Employment by econ. activity	(1) GHG Intensity	(2) Trade Intensity	(3) Vulnerability Indicator
ISIC Rev 4 Code	Description	% Of GDP	% Of tot. workforce	kgCO2e/\$	Indicator	(1) *(2)

¹⁰https://www.moew.government.bg/static/media/ups/articles/attachments/framework_for_disaggregated_assessments213ac68851d7d6ba992e9de22e08b700.pdf

0127, 1073	Cocoa	1,35%	0,36%	2,624	1,70	4,449
0126	Palm oil	0,59%	0,16%	2,635	0,50	1,308
11, 10 (-1073, -1020)	Manufacture of beverages & food products	2,64%	7,95%	0,545	0,51	0,280
03,1020	Fishing	0,93%	0,09%	0,419	0,54	0,226
0610, 0620, 1920	Oil and gas	4,55%	0,03%	0,100	1,82	0,182
05, 07 (- gold of 0729), 08,09	Mining and quarrying without oil and gas and gold	3,19%	0,15%	0,356	0,33	0,118
23	Manufacture of other non-metallic mineral products	0,95%	0,21%	0,103	0,46	0,048
2420, 0729	Gold	7,13%	1,62%	0,027	1,44	0,039
25	Manufacture of fabricated metal products, except mach. and equip.	0,85%	0,52%	0,009	0,50	0,004
22	Manufacture of rubber and plastics products	1,11%	0,09%	0,005	0,54	0,003
20	Manufacture of chemicals and chemical products	2,43%	0,16%	0,005	0,48	0,003
WTO 1.33, 1.36	Tourism (travel, and expenditure by main purpose of trip)	2,77%	3,70%	-	-	-

Source: own elaboration based on GSS, ILOSTAT, BUR/NIR, UN Comtrade, UNWTO and other relevant sources for missing data points (2021)

From the results from the Vulnerability Indicator analysis, the sectors that appear to be most at risk to the potential impacts of international response measures are: cocoa, palm oil, manufacture of beverages & food producers, fishing, and oil & gas.

In Step 4 of the methodology, stakeholder input is going to be considered, to give a second look and include the important sectors that might have been overlooked or discarded during the previous steps.

In Step 5, the relevant mitigation policies in place that are in the countries that constitute the main trading partners of Ghana will help to understand which of these selected sectors will suffer from adverse intended or unintended impacts of response measures in the future.

8. Step 4. Employ stakeholder input to identify vulnerable sectors that might have been missed in previous steps

In this step the aim is to employ stakeholder input and additional filters to identify vulnerable sectors that might have been missed in previous steps. The stakeholder input was gathered during the various online workshops that were organized as the research was progressing.

The two sub-steps under step 4 for identify vulnerable sectors that might have been missed in previous steps are:

Step 4.1: Employment Indicator

Step 4.2: National Planning Data

8.1.Step 4.1. Employment Indicator

During the online workshops held in the past year, one of the feedbacks from local stakeholders was to give special attention to the employment figures of the different sectors and especially for those sectors that didn't score in the top 12 according to the Vulnerability Indicator.

To take into consideration this feedback, the research team looked back at the 20 sectors previously identified and applied an additional employment filter. The employment filter consists in first gathering data on the number of jobs (FTE) created in the sector and express it as a percentage of total workforce. The three filters applied for this step were:

- First, look if the percentage of total workforce for that sector is twice as high or more than the percentage of total GDP for that sector. If yes, then the sector needs to be given special consideration.
- Second, if the sector qualifies for the special consideration, then the sector has to be multiplied to the original vulnerability indicator in order to get the modified vulnerability indicator score for that sector.
- Third, if the modified vulnerability indicator is high enough to get into the top 12 selected sectors, then it will be added to the list and considered for analysis for the next steps.

In the case of Ghana, the sectors that were dropped out in the previous step and were reconsidered for inclusion based on the employment filter were: tree crops (coffee, rubber, cotton), forestry and logging, plantain, maize, livestock, yam, groundnuts, and cassava. From the analysis however, none of the sectors passed the first threshold of percentage of total workforce twice as high or more than the percentage of total GDP for that sector. The table below

represents the findings and considerations based on the employment filter. The sectors in the red square were the ones considered for the employment indicator.

Table 8. Top 20 identified vulnerable sectors with employment indicator

Sector Description		GDP	Employment Indicator			GHG Intensity	Trade Intensity	Carbon Leakage Indicator
ISIC Rev 4 Code	Description	% Of GDP	Empl.	% Of total workforce	% Of total workforce *2	kgCO2e/\$ GDP	%	Indicator
0610 & 0620 & 1920	Oil and gas	4,55%	101.929	1,1%	-	0,100	182%	0,182
0127 & 1073	Cocoa	1,35%	34.800	0,4%	-	2,624	170%	4,449
2420 & 0729	Gold	7,13%	155.755	1,6%	-	0,027	144%	0,039
22	Manufacture of rubber and plastics products	1,11%	9.036	0,1%	-	0,005	54%	0,003
03,1020	Fishing	0,93%	80.589	0,8%	-	0,419	54%	0,226
11 & 10 (-1073, -1020)	Manufacture of beverages & food products	2,64%	761.662	8,0%	-	0,545	0,51	0,280
25	Manufacture of fabricated metal products, except machinery and equipment	0,85%	49.915	0,5%	-	0,009	50%	0,004
0126	Palm oil	0,59%	15.172	0,2%	-	2,635	50%	1,308
20	Manufacture of chemicals and chemical products	2,43%	15.032	0,2%	-	0,005	48%	0,003
023	Manufacture of other non-metallic mineral products	0,95%	20.427	0,2%	-	0,103	46%	0,048
05, 07 (-gold of 0729), 08,09	Mining and quarrying without oil and gas and gold	3,19%	13.573	0,1%	-	0,356	35%	0,124
0129, 0116, 0127	Other tree crops (coffee, rubber, cotton)	1,25%	32.102	0,3%	0,7%	-	9%	0,000
02	Forestry and Logging	1,33%	34.107	0,4%	0,7%	0,505	5%	0,023
0122	Plantain	1,83%	46.992	0,5%	1,0%	0,997	3%	0,029
0119	Maize	0,55%	14.259	0,1%	0,3%	2,347	3%	0,069
14	Livestock	2,47%	63.428	0,7%	1,3%	2,296	1%	0,019
0113	Yam	3,33%	85.644	0,9%	1,8%	0,526	1%	0,003

0111	Groundnuts	1,01%	25.868	0,3%	0,5%	0,762	0,3%	0,002
0113	Cassava	1,40%	36.050	0,4%	0,8%	2,344	0,1%	0,002
WTO 1.33 & 1.36	Tourism (travel, and expenditure by main purpose of trip)	2,77%	354.000	3,7%	-	-	-	

Source: own elaboration based on previous steps data and ILO LFS data (2021)

8.2.Step 4.2. National Planning Data

Another feedback received from one of the stakeholder workshops, was to consider including the sectors that the country is considering for its National Exports Strategy.

In Ghana’s National Export Development Strategy (NEDS) 2020-2029¹¹, Ghana intends to develop the potential of the non-traditional export (NTE) sector through industrialization and intense collaboration between private sector and government. The sectors that are prioritized for production and exports expansion are outlined in the Table 9. Some of the sectors considered for expansion that are carbon intensive and that will be potentially impacted by international response measures are: fish & fishery products, aluminum products articles of plastic, iron & steel products, automobiles & vehicles, garments & textiles, petrochemical products, and machines & machine components.

All these sectors are already included in the analysis, apart from automotive. For the automotive sector, the expansion plan would have to be carefully examined to understand which are the countries that are targeted for exports for this sector and what are the response measures in place for those countries, especially paying attention to countries with ambitious policies in the transport sector that are transition to electric vehicles. Nevertheless, the automotive industry in Ghana is unlikely to face a big threat from international response measures in the next 10 years, unless exports are planned outside of Africa.

¹¹ <https://www.tralac.org/documents/resources/by-country/ghana/4170-ghana-national-export-development-strategy-neds-overview-2020/file.html#:~:text=The%20Ghana%20National%20Export%20Development,industrialized%20economy%20if%20NEDS%20is>

Table 9. Ghana’s National Export Development Strategy (NEDS) 2020-2029



PRIORITY PRODUCTS LIST	
Category I: Existing high-performance products for contributing to the projected target	Category II: Strategic Anchor Industrial Products for industrial transformation
<ul style="list-style-type: none"> Processed Cocoa Cashew (Processed & In-shell) Horticultural Products Oil Seeds (Processed) Fish & Fishery Products Apparel Natural Rubber Sheets Aluminum Products Articles Of Plastic Services 	<ul style="list-style-type: none"> Pharmaceuticals Aluminium Products Iron and Steel Products Automobiles and Vehicles Garments and Textiles Industrial Salt Petro-chemicals Machines and Machine Components Industrial Starch Oil Palm

Source. National Export Development Strategy (NEDS), Ministry of Trade and Industry (2020)

8.3. Differences between Ghanaian and Chilean methodologies

When conducting the analysis, the research team had to adapt the methodology developed by ERCST in 2019 for the Chilean country case study to a different country, in this case Ghana, and consider different elements of the economy and information availability.

Figure 6. Adaptations and differences between Ghanaian and Chilean methodologies

<p>Chile </p> <ul style="list-style-type: none"> • International and domestic response measures • Step 2: <ul style="list-style-type: none"> • GDP level of disaggregation of 111 sectors provided by the Bank of Chile • Step 3: <ul style="list-style-type: none"> • Filtering method: <ul style="list-style-type: none"> • Method 1: Threshold Method • Method 2: Weighted Scoring Method 	<p>Ghana </p> <ul style="list-style-type: none"> • International response measures • Step 2: <ul style="list-style-type: none"> • GDP level of disaggregation of 23 sectors initially and then 71 with GSS support • Step 3: <ul style="list-style-type: none"> • Filtering method: Vulnerability Indicator based on EU ETS Phase 4 Carbon Leakage Indicator
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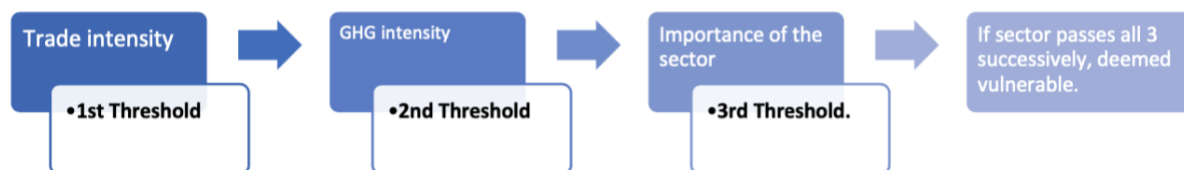
Source. Own elaboration (2021)

One of the main adaptations to the methodology used for Chile, is that in Step 3, for Ghana the Vulnerability Indicator was used instead of the two separate filtering methods: Method 1 - Threshold Method and Method 2 - Weighted Scoring Method.

In the Chile Case Study, two methods were chosen in order to allow room for testing, comparing, and modifying the two approaches, which can reveal whether one is better suited for identifying vulnerable sectors than the other. Nevertheless, at the end there wasn't a strong conclusion on which method is preferable. The results of both methods depended solely on either the thresholds or the weights that were set. Both methods are valid but are also equally subjective. The main way to limit subjectivity is to combine a set of scenarios with different thresholds and/or weights to add robustness to the sector identification process.

More specifically, Method 1 - Threshold Method - involves iterating the sector through three threshold conditions, set in series. This means that the three thresholds have equal weight. For a sector to be classified as vulnerable to the impacts of response measures, it had to pass each of the thresholds.

Figure 7. Method 1 - Threshold Method



Source: ERCST, 2019

Method 2 - Weighted Scoring Method - provides a systematic process for selecting the vulnerable sectors based on the same three criteria from Method 1: trade intensity, GHG intensity and sectoral importance. However, for this method, multiple different sets of weights are applied to the three variables, with trade intensity and GHG intensity receiving higher weights than the importance of the sector.

Figure 8. Method 2 - Weighted Scoring Method

Trade intensity (trade intensity: exports/domestic production). Scored zero to 100, derived by multiplying number by 4, cap at 40.	40%
GHG intensity (grams of CO ₂ e/ USD value added). Scored zero to 40, using logarithmic scale that is capped at 40. Sectors with GHG intensity of 0,5 or higher score 40.	40%
National sectoral significance: value added relative to GDP. Scored zero to 100, derived by multiplying number by 2000, cap at 20.	20%

Source: ERCST, 2019

The main issues linked to the above presented methods and the reason why the team decided to apply the Vulnerability Indicator for this case study are: first of all, for simplicity reasons, the Vulnerability Indicator avoids the extra steps that have to be undertaken in these two methods and secondly, Method 2 - Weighted Scoring Method can become a subjective exercise when manipulating the different weighting scores.

8.4. Main Challenges

In light of the above, the main challenges that were encountered during Step 2 were:

- The publicly available sectoral GDP data for Ghana is at a low level of disaggregation, 23 activities only. With aid of stakeholders from the GSS able to provide us a disaggregation level of 71 activities total. The most disaggregated category was for crops (cocoa, yam, cassava, cocoyam, etc.).
- Varying level of disaggregation ISIC Rev 4 codes, some activities at 4-digit level and others at 2-digit level.
- For the tourism sector, the ISIC classification system does not have one sole sector classification for the sector, rather products and activities are included in other sectors which could be seen as falling under tourism (e.g., transportation, accommodation, and food service activities, etc.)
- Time needed when browsing for missing data and waiting for stakeholder input.

The main challenges that were encountered during Step 3 were:

- Unavailability of disaggregated GHG emissions data for certain sectors of the Ghanaian economy.
- Reliability of GHG emissions data from other sources, excluding the one prepared for the National Inventory Report.
- Lack of employment data at a 4-disaggregation level for certain activities, e.g., crop activities - cocoa and palm oil
- Double concordance is labor intensive and lengthy process with some ISIC Rev.4 categories having more than 500 corresponding HS 2007 exports products.
- Tourism sector doesn't have GHG or trade intensity data as the sector does not report data in a manner comparable to other sectors, either through ISIC or HS Codes.
- Lengthiness of undergoing through the different steps and filtering process for the different sectors.

8.5. Conclusions on sector selection

To sum up, the filtering process undertaken for Steps 3-5 was as follows:

- **Filter 1:** 71 sectors with the highest gross domestic production values were initially listed
- **Filter 2:** 56 sectors were selected by discarding domestic and service activities
- **Filter 3:** 20 sectors selected by highest gross production value
- **Filter 4:** 12 sectors by trade by highest trade intensity values
- **Ranking:** according to the Vulnerability Indicator

From the results of these steps, the sectors that were identified at the top of the vulnerability indicator list and therefore potentially vulnerable to the adverse impact of response measures are: cocoa, palm oil, manufacture of beverages & food producers, fishing, and oil & gas. This however doesn't necessarily mean that all these sectors will have specific international response measures that will affect them since this will mostly depend on the country specific policies where the products are exported to or on the transport method by which these products are distributed – for the international measures as CORSIA/ICAO and IMO.

Therefore, the next step will specifically look at all the possible relevant response measures that are in place in the countries that constitute the main trading partners of Ghana and for each of the identified vulnerable sectors, in order to understand which of these sectors will be impacted by international response measures.

Additionally, the research team included the stakeholder feedback that was gathered from the different workshops in order to try to capture any vulnerable sectors that the methodologies may have missed, or, inversely, whether too many sectors had been incorrectly listed as being vulnerable to response measures. National planning data for export products and employment rates were considered for this step. The result however did not differ from the outcomes of the filtering method and vulnerability indicator; therefore, the lists of sectors did not need to be amended. This does not mean that the stakeholder feedback and considerations were not useful, rather it provided a critical sanity test and ensured that the conclusions of the desk research were validated.

9. Step 5 - Identification of response measures

In order to assess their impacts, the most relevant international response measures need to be identified. The international response measures were identified following a four-step approach:

- Step 5.1:** Identify main export partners of the vulnerable sectors
- Step 5.2:** Match response measures to the vulnerable sectors and countries
- Step 5.3:** Search for response measures in international databases
- Step 5.4:** Filter the results

In this step the main international mitigation policies are mapped and listed. These international response measures can be implemented either on an international level (for example by ICAO and IMO), or in other jurisdictions (e.g., not in Ghana).

The mapping of policies is a labor-intensive task, necessitating significant amounts of desk research and interaction with stakeholders. Existing policy measures, as well as policy measures which are under proposal and have a high probability of being implemented are also included.

Drivers behind these measures and policies may be environmental (concerns about climate change and its impacts or other environmental issues such as air pollution), political (energy security, international pressure, political vision), social (poverty alleviation, combatting energy poverty or public pressure for a less GHG intensive society) or economic (new potential economic and market opportunities by developing cleaner technologies).

Table 10 summarizes our definition of response measures and their impacts. Throughout Step 5 this table will be used for the different intermediated steps when identifying the relevant response measures.

Table 10. List of response measures, potential impacts, and vulnerable sectors to each response measure

Response measures	Impacts in country undertaking the response measure	Possible impacts in other countries	Sectors vulnerable (negative impacts)
Carbon taxes	decreased demand for carbon-emitting goods; increased demand for low-carbon emitting goods	Negative effects: fossil fuel producers, carbon-intensive goods producers. Positive effects: low-carbon goods producers (e.g., renewable energy/EV components)	crude oil, refined oil, natural gas, coal
Subsidies			
<i>for low-carbon transport</i>	decreased demand for goods associated with internal combustion engines.	Negative effects: producers of fossil fuels, lead. Positive effects: producers of EVs, cobalt, lithium, vanadium.	crude oil, refined oil, lead, conventional automobiles

<i>for low-carbon energy production</i>	decreased demand for thermal fuels	Negative effects: coal, natural gas, oil producers. Positive effects: low-carbon energy technology (e.g., PV solar cells) and inputs (e.g., steel and cement for wind turbines)	coal, natural gas
<i>removal of, for fossil fuel production</i>	decreased production of fossil fuels	Positive effects: fossil fuel producers, alternative tech producers. Negative effects: fossil fuel consumers.	crude oil, refined oil, coal, natural gas
<i>removal of, for fossil fuel consumption</i>	decreased consumption of fossil fuels	Negative effects: fossil fuel producers. Positive effects: fossil fuel consumers, alternative tech producers.	crude oil, refined oil, coal, natural gas
<i>for energy efficiency in buildings</i>	decreased energy consumption, increased employment in construction sector	Effects depend on fuel source used in implementing country buildings. If imported fossil fuels used, negative effects on foreign producers.	any fuel source used for residential and commercial heating: gas and coal
Green procurement			
<i>of energy</i>	decreased demand for thermal fuels, increased demand for low-carbon energy technologies	Negative effects: coal, natural gas producers. Positive effects: coal and natural gas consumers (price decrease), producers of alternative energy tech.	coal, natural gas
<i>of automobiles</i>	decreased demand for goods associated with internal combustion engines.	Negative effects: fossil fuel producers. Positive effects: cobalt, lithium, vanadium producers, EV producers.	crude oil, refined oil
Cap and trade schemes	decreased demand for carbon-intensive goods; increased demand for low-carbon goods	Depends on details of scheme, but possible: Negative effects: fossil fuel producers. Positive effects: renewable energy/low-carbon transport tech producers; fossil fuel consumers.	coal, natural gas, steel and associated products, aluminum, cement, basic plastics, nitrate fertilizers, high-GHG electricity, oil, pulp & paper and associated products
Liberalization of trade in environmental goods	boost in consumption of green goods	Positive effects: producers of covered environmental goods	conventional competitors to liberalized green goods
Border carbon adjustment	decreased demand for high-carbon goods (aluminum, steel, cement, plastics, pulp & paper); increased demand for substitutes.	Depends on carbon intensity, and regime details, but likely: Negative effects: aluminum, steel, cement, plastics, pulp & paper. Positive effects for low-carbon producers.	steel and associated products, aluminum, cement, basic plastics, nitrate fertilizers, high-GHG electricity, oil, pulp & paper and associated products
Standards and labelling requirements			
<i>for agricultural goods, involving GHG intensity</i>	depends on details of the scheme, but likely loss of market share for non-certified air-freighted goods, inter alia.	Depends on details of the scheme, but possible: Negative effects for producers of perishable fruits such as berries, high-value horticulture	air-freighted produce; agricultural goods that involve deforestation and/or high use of nitrate fertilizers
<i>mandatory efficiency performance standards for consumer goods, industrial equipment</i>	restricts the market to high-efficiency products; reduces demand for fuel	Negative effects: fossil fuel producers; producers of low-efficiency consumer goods and industrial equipment. Positive effects: fossil fuel consumers; producers of high-efficiency goods/equipment	white goods, machinery
<i>for basic materials, involving GHG intensity</i>	restricts the market to low-GHG intensity products in basic materials; reduces demand for fuel	Negative effects: depending on GHG intensity, may restrict market access for basic materials in metals, minerals, chemicals sectors	steel and associated products, aluminum, cement, basic plastics, nitrate fertilizers, pulp & paper and associated products
International aviation levies	n/a - international	Negative effects: flight-based tourism sectors (e.g., hotels, restaurants); producers of air-freighted (perishable) goods.	national airlines; hotels, restaurants, tour operators
International maritime levies	n/a - international	Negative effects: increased costs of imports and exports using maritime transport	sectors with high share of imported intermediate goods, capital goods; sectors that rely on maritime transport for export

Source: ERCST (2019)

Note that subsidies include: grants, tax incentives, loans, loan guarantees, R&D support, provision of infrastructure.

9.1.Step 5.1. Identify main export partners of the vulnerable sectors

The main trading partners for the vulnerable sectors are identified, enabling to understand in which countries the response measures need to be implemented before they can be relevant for those sectors deemed vulnerable.

Using the UN Comtrade Database, the five main trading partners for each of the identified 12 sectors were identified. This meant reviewing all the export partners for the top export products (HS codes) representing 90% or more of each export category. Table 11 below gives an overview of the results of this process. More detail on this process can be found in the “Methodology description for country case studies” document.

Table 11. Top 5 export partners of Ghana per sector

Product Description		2019 Top 5 Export Partners: Value (USD)	
ISIC Rev 4 Code	Product	Country	Total Value
0127, 1073	Cocoa	Netherlands	692482090
		Japan	296652405
		USA	246818388
		Malaysia	230959617
		Germany	159950759
126	Palm oil	Senegal	60691742
		Benin	17790522
		Nigeria	9288817
		Burkina Faso	8710077
		Niger	5651759
11, 10 (-1073, -1020)	Manufacture of beverages & food products	Burkina Faso	30797933
		Togo	24349174
		Belgium	21775767
		Niger	15801579
		Malaysia	13158888
3,102	Fishing	United Kingdom	55802560
		France	41759247
		Germany	19559674
		United Arab Emirates	10886651
		China	10396100
0610, 0620, 1920	Oil and Gas	China	2376380429
		South Africa	903373960
		India	409213110

		USA	370932192
		United Kingdom	241901848
05, 07 (- gold of 0729), 08,09	Mining and quarrying without oil and gas and gold	China	274977177
		Ukraine	74903046
		Burkina Faso	18615610
		Brazil	9599846
		Canada	9140709
23	Manufacture of other non-metallic mineral products	Burkina Faso	22670305
		Côte d'Ivoire	10675970
		Mali	6762513
		Niger	53119
		Togo	1705857
2420,0729	Gold	Switzerland	2377844886
		India	1768408009
		South Africa	1058886523
		United Arab Emirates	863737888
		China, Hong Kong SAR	211956781
25	Manufacture of fabricated metal products, except mach. and equip.	Germany	4298680
		Nigeria	3818102
		Burkina Faso	3794067
		Benin	3212170
		Togo	2996350
22	Manufacture of rubber and plastics products	Burkina Faso	77760477
		Togo	63641310
		Sierra Leone	54584994
		Mali	7349755
		Niger	3460949
20	Manufacture of chemicals and chemical products	Togo	13067919
		Burkina Faso	12987770
		Côte d'Ivoire	9522436
		Benin	7694532
		Nigeria	6651844

Source. Own elaboration based on UNComtrade data (2021)

For the tourism sector detailed country-level data on arrivals to Ghana was not readily available or accessible to the research team via UNComtrade, therefore it is not included in the above-mentioned table. However, the impacts of international response measures on tourism are considered and analyzed in Step 6 and data on international tourist arrivals and size of expenditures and break down of these expenditures by sector is gathered from the Ghana Immigration Service and Ghana Tourism Authority reports.

After the top 5 export partners per sector are identified, another level of filter involves adding up all the export values of the different sectors per country. This step is important in order to be able understand who are the most important trading partners to Ghana for the identified vulnerable sectors and that Ghana needs to monitor in terms of the response measures being implemented or that could be implemented in those jurisdictions since they would have an

impact on Ghana too. Table 12 summarizes the results, showing that China, Switzerland, India, and South Africa are the most important trade partners for Ghana in terms of total value of exports, for the 12 identified vulnerable sectors.

Table 12. Total exports value for the 12 identified vulnerable sectors by country

Country	Total value exports (USD) 2019
China	2873710487
Switzerland	2377844886
India	2177621119
South Africa	1962260483
UAE	874624539
Netherlands	692482090
USA	617750580
UK	297704408
Japan	296652405
Malaysia	244118505
Germany	183809113
Burkina Faso	175336239
Togo	105760610
Ukraine	74903046
Senegal	60691742
Sierra Leone	54584994
France	41759247
Benin	28697224
Niger	24967406
Belgium	21775767
Côte d'Ivoire	20198406
Nigeria	19758763
Mali	14112268
Brazil	9599846
Canada	9140709

Source: Own elaboration based on UNComtrade Data (2021)

9.2.Step 5.2. Match response measures to the vulnerable sectors and countries

In this step the aim is to understand for which country and sector, which response measure should be looked for. To complete this step, Table 11 with our definition of response measures is used as a basis, along with the research of the identified countries and vulnerable sectors conducted in previous steps.

Table 13. Example for 4 countries of matching response measures to sectors and countries

Country	Type of RM searched for	Sectors
China	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM - standards and labelling requirements for agri. goods involving GHG intensity - for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - Crude and refined oil - Fishing - M&Q without oil and gas and gold (aluminum and manganese) - Gold
Switzerland	-na	- Gold
India	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM 	<ul style="list-style-type: none"> - Crude and refined oil - Gold
South Africa	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM 	<ul style="list-style-type: none"> - Crude and refined oil - Gold

9.3.Step 5.3. Search for response measures in international databases

Response measures in the main trading partners are identified and mapped through extensive desk research.

To have an extensive list of potentially relevant international response measures, a series of databases were mined to map every possible relevant international response measure. The research team identified 17 databases as sources of climate mitigation measures.

1. European Environmental Agency database on climate change mitigation policies and measures in Europe
2. Food and Agriculture Organization FAOLEX Database
3. Global Climate Legislation Database
4. ICAP Carbon market database
5. International Civil Aviation Organization Policy Factsheets
6. International Energy Agency Building Energy Efficiency Policies Database
7. International Energy Agency Global EV Outlook
8. International Energy Agency/IRENA Joint Policies and Measures database
9. International Maritime Organization Policy Factsheets
10. International Trade Centre Sustainable and Standards Map
11. London School of Economics and Political Sciences Climate Change Laws of the World database
12. OECD Database on Policy Instruments for the Environment
13. Organic Export Info (funded by Switzerland)
14. Relevant government websites
15. UNFCCC NDCs registry and IGES NDC database
16. UNFCCC Response Measures Synthesis Report
17. World Bank Carbon Pricing Dashboard
18. World Trade Organization Environmental Database

Note that many of these databases are not limited to climate change mitigation measures. This allows the researcher to also map policies that are not directly related to climate mitigation, and those that are more indirectly climate change related for example as they have climate mitigation co-benefits.

A country reducing fossil fuel subsidies or increasing taxes on fossil fuels might not always list these measures as climate policies, but as fiscal policies as they can help decrease public spending or increase government revenue.

These databases were scanned for national and international direct and indirect climate change policies that could be relevant for the identified Ghanaian sectors.

Each database has differently structured search functions. Certain databases were less relevant than others for the search, as they are not directly related to the vulnerable sectors identified in the previous step, like the IEA Building Energy Efficiency Policy Database. However, these sources

could still be relevant for assessing other countries. For the OECD database, the research team searched by sector and country. This database was particularly useful.

The EEA database specifically dealt with European mitigation policies. The research team was able to filter the relevant measures and policies by specifying which sector to focus on. For the European export partners (Spain, United Kingdom, Belgium, and the Netherlands) this database was very useful.

An excel sheet for every country was built and populated with policies from each of the databases while going through them. These country sheets contained possibly relevant response measures that could be relevant for all sectors, not just the sectors that each country was a major trade partner for. This was done to simplify to the database mining exercise.

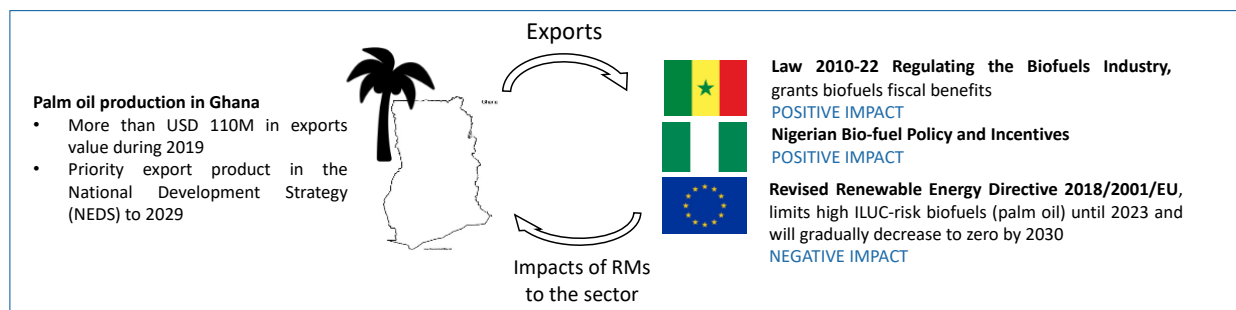
9.4. Step 5.4 Filtering and Results

Step 5.4 and one of the key steps in the methodology, encompasses all the research from the previous steps by giving a clear overview of what are the international or out-of-jurisdiction response measures that could impact, either positively or negatively, the most important sectors of the Ghanaian economy.

With this step, the goal is also to filter the response measures that should be considered in the next step for the quantitative assessment by looking at the types of measures and impacts. The response measures selected will then be analyzed either quantitatively or qualitatively.

The analysis was done for each sector, where the team looked at the relevant response measures for each sector and each relevant country for the sector. Table 14 and 15 show an example of the results from this step for the palm oil and oil & gas sectors. The full list of policies identified for the five main trading partners for each of the sectors identified is included in the Annex.

Figure 9. Example of impacts of response measures for palm oil sector in Ghana



Source: Own elaboration (2021)

Table 14. Response Measures for Palm Oil Sector (ISIC Rev 0126)

Senegal	Nigeria	EU*	Benin, Burkina Faso, Niger
Law 2010-22 Regulating the Biofuels Industry <ul style="list-style-type: none"> Grants biofuels fiscal benefits, revenues generated from biofuel activities are exempted from taxation for 5 yrs 	National Renewable Energy and Energy Efficiency Policy (NREEEP) <ul style="list-style-type: none"> Defines the government's position on how to strengthen renewable energy and energy efficiency in the country 	Revised Renewable Energy Directive 2018/2001/EU <ul style="list-style-type: none"> Limits high ILUC-risk biofuels (palm oil) until 2023 and will gradually decrease to zero by 2030 	na
Renewable Energy Law (No. 2010-21) <ul style="list-style-type: none"> Regulates the renewable energy sector outlining goals, laying the foundation for a feed-in-tariff scheme, and providing tax incentives for development 	Nigerian Bio-fuel Policy and Incentives <ul style="list-style-type: none"> Measures aimed at stimulating market demand for biofuels and promoting their production (e.g. tax exemptions) 	<ul style="list-style-type: none"> Belgium, France, Austria and Netherlands announced ban of palm oil as a raw material for transport biofuel from mid-2022. 	
Decree No. 2013-684 on the establishment, organization and functioning of the National Agency for Renewable Energies <ul style="list-style-type: none"> Promote the use of renewable energy, including bioenergy 			

*Not in the top 5 export countries for this sector, only in top 10 but considered since it is a priority product for the Ghanaian National Export Development Strategy (NEDS)

Source: Own elaboration (2021)

Table 16. Response Measures for Oil & Gas sectors

Table 15. Response Measures for Oil & Gas Sector (ISIC Rev 0610, 0620, 1920)

China	South Africa	India	USA	United Kingdom	International Transportation
NEV Programme China <ul style="list-style-type: none"> by 2025 25% New Energy Vehicle Programme (NEV) (includes PHEV, BEV, FCEV) government introduced a mandatory credit policy for vehicle suppliers to boost domestic sales of NEVs 	Carbon Tax Bill <ul style="list-style-type: none"> Came into effect in 2019 Applies to GHG emissions from the industry, power, buildings and transport sectors Irrespective of the fossil fuel used, with partial exemptions for all these sectors 	National electric car purchase subsidy and income tax deduction on loans. Phase II of Faster Adoption and Manufacturing of Electric Vehicles (FAME II) <ul style="list-style-type: none"> Income tax deduction of \$ 2000 on interest paid on electric vehicle loans deployment of charging stations 	Zero-Emission Program (ZEV) for (PHEV, BEV, FCEV) <ul style="list-style-type: none"> by 2025 3.3 million ZEVs in 11 states by 2050 all passenger vehicle sales to be ZEV in 10 States Managed by The California Air Resources Board (CARB) 	UK carbon Price Floor <ul style="list-style-type: none"> Users liable for payment of the tax for all fossil fuels. The tax covers all fossil fuels 	<ul style="list-style-type: none"> International Maritime Organization (IMO) and other shipping climate change related measures CORSIA/ICAO (for air freight)
National electric car purchase subsidy and exemption of purchase tax (10%) <ul style="list-style-type: none"> Maximum retail price USD 42 400 USD 2 300 if BEV 300 km ≤ range < 400 km USD 3 200 if BEV range ≥ 400 km USD 1 200 PHEV range ≥ 50 km 	Carbon dioxide vehicle emissions tax (2010)	National Electric Mobility Mission Plan (NEMMP) 2020 <ul style="list-style-type: none"> Mix of incentive-based policies accompanied by regulatory reforms, and PPS to encourage EV adoption, expand charging infrastructure and support domestic EV and supply equipment manufacturing capacity and battery manufacturing 	CBAM (under consideration) <ul style="list-style-type: none"> implement a levy on carbon-intensive imports, albeit without a federal domestic carbon price impose carbon adjustment fees or quotas on carbon-intensive goods from countries that are failing to meet their climate and environmental obligations 	UK ETS <ul style="list-style-type: none"> launched on 1 January 2021 UK ETS closely follows the EU Emissions Trading Scheme ("EU ETS") Established by the Greenhouse Gas Emissions Trading Scheme Order 2020 The UK ETS will apply to energy intensive industries, the power generation sector and aviation. 	
Fuel economy standard for light duty vehicles <ul style="list-style-type: none"> Updated for period 2021-25 Standard, to be phased in gradually from 2021, sets a 4L/100 km target for the country's new vehicle fleet in 2025 		Clean air standard	Tax reduction for electric car purchase <ul style="list-style-type: none"> Tax credit up to USD 7 500 (PHEV and BEV) 	United Kingdom (EV30@30 signatory) <ul style="list-style-type: none"> by 2030 50-70% EV by 2035 No sales of new ICEe 	
EV charging infrastructure policies <ul style="list-style-type: none"> rollout of subsidies for EV charging infrastructure at national and subnational level (eg. Shenzhen) The State Grid has announced plans to increase investment in charging stations City of Beijing has outlined a policy to provide up to USD 28 300 in subsidies per station for operators 		National Mission on Transformative Mobility and Battery Storage <ul style="list-style-type: none"> manufacturing scope includes solar equipment, battery storage and charging infrastructure 	Transportation and Climate Initiative (TCI) ETS <ul style="list-style-type: none"> Transport fuel suppliers that produce the covered fuels within these states, as well as suppliers that import them to those states. Program will cap CO2 emissions from the combustion of gasoline and on-road diesel fuel in the participating states 	National electric car purchase subsidy <ul style="list-style-type: none"> Up to USD 3 800 (BEV and PHEV)* Capped at 35% of retail price. Only for cars < USD 63 600 *If < 50 gCO2/km and electric range > 112 km 	

Note: This table has a continuation with more response measures identified for this sector. The full list can be found in the Annex

Source: Own elaboration (2021)

These response measures can affect the exporting sector for example by impacting direct competitors (producing similar products or substitutes) or by directly impacting the exporter (for

example through changes in cost of transportation or need for exporters to comply with monitoring and reporting obligations).

Summing up all the response measures for all the different sectors, the team identified that the Ghanaian economy is potentially vulnerable to the impacts of 80 response measures.

Table 16. Overview of relevant international response measures that could impact sectors deemed most vulnerable

ISIC Rev 4 Code	Sector Description	Number of response measures that could impact the sector
0610, 0620, 1920	Oil and gas	40
0127, 1073	Cocoa	9
3,102	Fishing	9
11, 10 (-1073, -1020)	Manufacture of beverages & food products	7
05, 07 (- gold of 0729), 08,09	Mining and quarrying without oil and gas and gold	6
126	Palm oil	3
2420, 0729	Gold	2
25	Manufacture of fabricated metal products, except mach. and equip.	1
22	Manufacture of rubber and plastics products	1
20	Manufacture of chemicals and chemical products	1
WTO 1.33, 1.36	Tourism (travel, and expenditure by main purpose of trip)	1
23	Manufacture of other non-metallic mineral products	0
Total		80

Source: Own elaboration (2021)

In the list, some of the response measures are duplicate but applied to different sectors. Response measures related to governmental and institutional organic standard were included even though there is no jurisdiction where it is mandatory to label certain products in the food supply as organic, hence they are not legally binding. For the purpose of this study, however the team decided to include this type of response measures since they would usually anyways have an impact on the economy and the product demand, thereupon also the trade patterns related to that product.

Additionally organic guidelines usually don't directly mention climate-related issues however they still have an indirect mitigation impact where organic agricultural systems are applied (e.g., carbon sequestration in soils by using different environmental practices).

9.5. International shipping and aviation climate change measures

International shipping climate change measures - IMO and ETS - and aviation climate change measures - CORSIA/ICAO were also considered to see whether there were any response measures in place or planned in the first place and identify the sectors in Ghana that might be affected by these.

In shipping, currently, the International Maritime Organization (IMO) and the EU ETS are considering different emissions reductions measures in order to decarbonize the sector.

Under the International Maritime Organization (IMO), the MEPC.304(72) resolution sets a target of cutting CO2 emissions from international shipping by at least 50% by 2050, compared to 2008 levels

The candidate measures that could impact Ghanaian exports are:

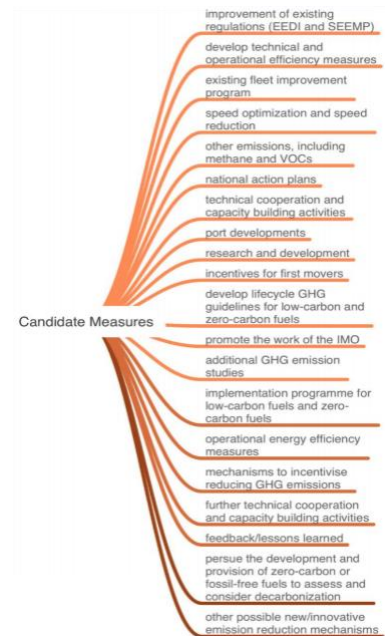
- **Short term measures:** Energy Efficiency Design Index (EEDI), Energy Efficiency Existing Ship Index (EEXI), Ship Energy Efficiency Management Plan (SEEMP), considerations of speed optimization and speed reduction as a measure
- **Medium term measures:** programme for uptake of low-carbon and zero-carbon fuels, possible inclusion of market-based measures

Under the EU Emissions Trading System (EU ETS), the EU strategy to reduce maritime emissions lays out the following goals: **a)** MRV system for emissions from ships using EU ports; **b)** GHG reduction targets for maritime sector; **c)** in medium to long-term also market-based measures (extension of ETS to the maritime sector)

In terms of market-based measures, action is coming from two fronts:

- In Parliament, ENVI committee adopted report with amendments to the EU MRV regulation which included an extension of ETS to maritime sector

Figure 10. Candidate measures IMO



Source: IMO

- As part of the European Green Deal, the Commission will extend ETS to the maritime sector. In order to ensure a smooth transition, the inclusion of the shipping sector in the EU ETS will take place gradually from 2023 to 2025.

For the purpose of the case study, the IMO assessment looked at high-volume high-weight exports streams to find which sectors are vulnerable to international climate shipping measures. As a result, the Ghanaian sectors that appear to be affected are: oil and gas, mining and quarrying without oil and gas and gold (aluminum and manganese), fishing products. Also represented in Table 15.

Figure 11. Net weight exports in 2019 for top 5 export destinations

ISIC Rev 4 Code	Sector	Netweight (kg)	Total value exports 2019 (USD)	Vulnerability to CC related shipping measures (net weight)/(total value)
0610, 0620, 1920	Oil and gas	5772931668	4.301.801.539	134%
05, 07 (- gold of 0729), 08,09	M&Q without oil and gas and gold (alum. and mang.)	4836404102	368.620.778	1312%
3,102	Fishing	80273244	138.404.232	58%
11, 10 (-1073, -1020)	Manuf. of beverages & food products	12672476	34.934.655	36%
0127, 1073	Cocoa	543463047	1.626.863.259	33%
2420,0729	Gold	140223	6.280.834.087	0%
25	Manuf. fabricated metal products	3281	4.298.680	0%

Source: own elaboration based UNComtrade data

In aviation, the ICAO CORSIA scheme for international aviation was looked into. In 2010, ICAO adopted two aspirational objectives: **a)** to improve energy efficiency by 2% per year until 2050; **b)** to achieve carbon neutral growth from 2020 onwards. In 2016, ICAO Member States adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a market-based scheme by which airlines compensate their international flights CO2 emissions by purchasing carbon offsets.

The first two phases of CORSIA implementation are 2021-2023 (pilot) and 2024-2026 where Member States decide to participate on a voluntary basis and a mandatory stage that will begin in 2027. Reduction of international air travel due to COVID-19 led to adopt a safeguard measure for the airlines. This adjustment, aimed at increasing the baseline by around 30%, will likely delay implementation of CORSIA carbon offsets by 3/5 years. ICAO’s Council echoed that the future CORSIA phases could be changed and are subject to flexibility EU confirmed its participation in the CORSIA voluntary phase from 2021 and choose a more ambitious option to calculate its offsetting requirements.

At a first glance, to have a first estimation of which sectors of the Ghanaian economy could be affected, we need to look at export categories that include perishable goods and need to be air

freighted and tourism sector. As such the Ghanaian sectors that could be affected are: fishing products, manufacture of beverages and food products, oil and gas, tourism.

Both for IMO and CORSIA/ICAO, a quantitative assessment of the impacts of these policies in the Ghanaian economy will be presented in the next section.

9.1. Conclusions

We identified several vulnerable sectors that are at risk of impacts:

- Sectors: cocoa, manufacture of beverages and food products (jojoba oil); palm oil; fishing; oil & gas; mining and quarrying without oil and gas and gold (aluminum and manganese)
- Response measures: carbon taxes; subsidies; CBAM; organic standards and labelling requirements for agri. goods and basic materials; aviation and shipping measures

We have done the complete analysis for all the 12 sectors, however some of these sectors don't have any impacts of international response measures or very few response measures that could impact from the countries they export to, which is mostly African countries (Niger, Burkina Faso, Benin, Niger, Togo, Mali). The vulnerable sectors that don't appear at risk of impacts are:

- Sectors: gold; manufacture of other non-metallic mineral products; manufacture of fabricated metal products (articles of iron and steel); manufacture of rubber and plastic products; manufacture of chemicals

While those sectors are not at risk from country-led response measures, some may still be vulnerable via soft-incentives, voluntary commitments, and shareholder pressure:

- Examples of voluntary incentives and measures: SBTi, ICMM Mining Principles, ISO 14001 Environmental Management, organic and sustainability standards for food products (e.g., UTZ, MSC), and others.

While we tried to anticipate future sectoral growth, there may be other sectors of the future whose growth would be inhibited by response measures

We have noted a strong asymmetry of climate targets and mitigation actions taken between countries and regions

Out of the identified response, three were chosen for quantitative assessment and will be tackled in the following section:

- IMO carbon tax for international shipping
- CORSIA under ICAO for international aviation
- EU Border Carbon Adjustment Mechanism

10. Step 6. Impacts of response measures

The previous steps focused on identifying vulnerable sectors and relevant response measures. This step concentrates on analyzing the possible impacts of the mapped response measures on the identified vulnerable sectors. It is up to a country's discretion whether to include positive as well as negative impacts when using this methodology for BUR reporting. Assessing these impacts can be done using both quantitative and qualitative tools. For this case study, only quantitative tools were used to assess the impacts.

The different steps involved in Step 6 of the methodology are:

- Step 6.1:** Set up of model
- Step 6.2:** Add specific response measures to model
- Step 6.3:** Define simulations
- Step 6.4:** Collect data for simulations
- Step 6.5:** Conduct simulations and sensitivity analyses
- Step 6.6:** Analyze results considering assumptions, model strength and limitations

Robust quantitative tools – such as modelling – have the advantage of providing more insight into the expected types of sizes of the impacts of response measures. They can help quantify the impacts somewhat. However, they are more time consuming and costly to implement. Implementing robust and comprehensive modelling exercises can involve significant budgets, specialized staff, and long timeframes in order to build or adapt models to specific local circumstances.

Ideally, a quantitative assessment would be performed for each identified international response measures – focused on the sectors identified before and their role in the overall economy. This assessment should be done before a response measure is implemented (ex-ante) as well as after the functioning of the response measure has started (ex-post). This allows for the predictions obtained through modelling to be tested against real observed impacts.

This is however infeasible to do, not only because of the vast number of potentially impacting response measures, but also because it is very challenging to isolate the impacts of individual policies on global trade, investment and production decisions in the country being assessed.

The goal of the quantitative assessment should be to analyze the consequences of policy-shocks on the economy and trade flows. Using a general equilibrium model can aid in achieving this. This type of analysis looks at the economic system as a whole, whereby the system is recognized as a network with all parts being mutually dependent and in constant interaction. Therefore, any change in the demand or supply of a commodity or its production will set in motion a chain reaction. A change in one sector will reverberate across the wider economy – be it positively or negatively.

10.1. Introduction and highlights

The section aims to assess the impacts of international response measures on Ghana. We consider three response measures that have been identified as relevant in the previous steps of the case study, namely a carbon tax on international water transport (IMO), a carbon tax on international air transport (ICAO/CORSIA), and carbon border adjustment mechanism introduced by the European Union (CBAM).

The analysis aims to assess how international and third country response measures impact on international prices and trade flows, and how this ultimately affects Ghana. To this end the study uses a global computable general equilibrium (CGE) model. A global CGE model links Ghana with other regions of the world and, thus, is suitable to show the desired processes.

By introducing carbon taxes in any form, we add constraints to the system and the economy will therefore shrink. The results include the adjustments involved in response to the policy change, moving from the base situation to a new equilibrium and can be interpreted as effects in the medium run. The analysis is of *ceteris paribus* nature, i.e., the reported changes show the effects of introducing the policies in the current situation, assuming no other changes. The study does not account for possible future developments such as technological change or adjustments over time.

The simulations implement the various measures with carbon taxes of 50 \$/ton CO₂ and 100 \$/ton CO₂. While EU carbon prices are mid 2021 over 50 Euro/ton, the carbon price might seem elevated for international transport compared to current price scenarios. A CGE model is all about relative relationships and changes in relative relationships. A simulation applying a lower tax of the same nature will render a lower size of effects but does not change signs and relative impacts. Thus, the findings with respect to affected sectors and reported changes relative to other sectors or regions remain valid.

In a first set of simulations, the study analyses effects of a carbon tax of 50 \$/ton (and 100 \$/ton) on international water transport services (IMO).

- The IMO carbon tax increases transport costs, making imports more expensive and decreasing demand for exports. The exchange rate of Ghana depreciates to incite exports and maintain the current balance. Overall, the effects of the IMO carbon tax on the economy of Ghana are small.
- There are noticeable impacts on sectoral level, i.e., Ghana's oil sector, where exports and production of oil decrease by 0.4% (0.8/0.9%).
- IMO carbon taxes depress production and wages, household income and consumption fall. As a result, agri-food consumption and the corresponding prices go down. Triggered by increasing import prices, consumer prices for manufacturing rise slightly.

The second set of simulations depicts a uniform carbon tax on international maritime transport of 50 \$/ton (and 100 \$/ton).

- This carbon tax increases the price on international air transport worldwide by 4.5% (9.1%). Increasing costs of air transport are expected to affect tourism and for Ghana implies a decrease in tourist arrivals of 3-5% (7-10%).
- Domestic service supply contracts by 0.3-0.4% (0.5-0.7%).
- For the economy as a whole negative impact dominate, GDP and household consumption decreases due to income losses from shrinking production.
- Manufacturing and services prices increase, the latter being dominated by air transport fares.
- Agri-food consumer prices fall, triggered by decreasing demand. This has a positive effect on poor consumers but renders negative for farmers. In addition, the decrease in tourism affects over proportionally low and unskilled workers, and income of low and unskilled workers decreases stronger compared to skilled labor.

A third simulation introduces a carbon border adjustment mechanism by the EU of 50 \$/ton (and 100 \$/ton) on the carbon content of imports in specific sectors.

- Ghana exports to the EU of fertilizer, and iron and steel go down, but Ghana can increase its exports in aluminum to the EU, benefitting from a lower CO₂ intensity in the production process compared to other regions.
- Considering all export destinations by Ghana, there is no notable change in exports in the targeted sectors. Decreasing trade with the EU is compensated by increasing exports to other regions, e.g., South and Southeast Asia in the case of iron and steel.

10.2. General Description of the Model

For this step of the case study [ANNARES \(McDonald, 2021\)](#) was used, a global CGE model that is calibrated with an augmented version of the [GTAP v10 database for the year 2014](#) (Aguiar et al., 2019), implemented in comparative static mode. Global CGE models employ economic theory to show how different sectors and agents are linked within and between economies¹². They simultaneously determine prices and quantities in multiple inter-connected markets. Thus, these models are constructed to explore the economic impact of various policy changes.

ANNARES employs a global social accounting matrix (SAM) database, that represents a comprehensive database and portrays input-output, national and external accounts in a consistent framework. The global database is represented by a series of regional SAMs that are linked through their trading relationships and current account transactions. Thus, the model captures heterogeneities of technologies, energy products, emissions rates (in satellite accounts), economic structures, wealth and inter regional income distribution across countries.

The database used in this study details 36 sectors and Ghana and 12 aggregate regions as detailed in the table below.

Table 17. Regional and sector aggregation

13 Regions:	36 sectors				
<ul style="list-style-type: none"> ▪ Ghana ▪ Africa LDCs ▪ Rest of Africa ▪ European Union ▪ Rest of Central Europe ▪ North America ▪ Latin America and Caribbean ▪ Oceania ▪ East Asia ▪ South and Southeast Asia ▪ Western Asia ▪ LDCs Asia and Oceania 	Agri-food: <ul style="list-style-type: none"> ▪ Oil seeds ▪ Crop agriculture^l ▪ Fishing ▪ Livestock agriculture ▪ Vegetable oil and fats^l ▪ Meat and dairy ▪ Other food products 	Energy-related sectors: <ul style="list-style-type: none"> ▪ Coal ▪ Extraction of crude oil ▪ Extraction of natural gas ▪ Petroleum and coal products ▪ Gas manufacture and distribution ▪ Electricity 	Manufacturing: <ul style="list-style-type: none"> ▪ Textiles ▪ Chemicals and products ▪ Basic pharmaceuticals ▪ Rubber and plastic products ▪ Mineral products^{d)} ▪ Iron and steel ▪ Aluminum and other metals ▪ Metal products ▪ Electronics and equipment ▪ Machinery, Motor, and 	Tourism related services <ul style="list-style-type: none"> ▪ Land a. pipeline transport ▪ Water transport ▪ Air transport ▪ Accommodation, Food, and service activities ▪ Recreational and other services Other services: <ul style="list-style-type: none"> ▪ Construction ▪ Water supply and distribution ▪ Trade services 	

¹² Please refer to the technical Annex and www.cgemod.com for a detailed documentation of the model.

<ul style="list-style-type: none"> ▪ <i>Eastern Europe and Former Soviet</i> 	<p>Non-energy mining and quarrying</p> <ul style="list-style-type: none"> ▪ <i>Other mining and extraction^{c)}</i> 	<p><i>transport vehicles</i></p> <ul style="list-style-type: none"> ▪ <i>Other manufacturing</i> 	<ul style="list-style-type: none"> ▪ <i>Financial, communication and business services</i> ▪ <i>Education and health services</i> ▪ <i>Public administration and defense</i>
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a) *Including cocoa*

b) *Including palm oil*

c) *Mining of metal ores (including aluminum and gold), other mining and quarrying, and its related support activities.*

d) *Products made of glass, sand, gravel, stone, or clay, including cement*

Production is represented by a nested production structure, represented by a mix of imperfect substitution and fixed shares. Energy use in the model allows for substitution in production between different energy inputs, e.g., fossil fuels and electricity where the production of commodities involves emissions, i.e., CO2 emissions, each of which can be subject to emissions tax instruments. Energy data and related emission data are sourced from GTAP, originally compiled by the International Energy Agency ([GTAP 10 Satellite Data](#)), and detail quantities of energy commodities used (MTOE) and CO2 emissions associated with each energy commodity and using agent in each region.

Imports and domestic products are imperfect substitutes, and imports from different partners are assumed imperfect substitutes. Similarly, exports and domestic supply, and exports to different regions are imperfect substitutes.

The model features various taxes, including taxes on energy inputs and carbon emissions. For the purpose of this study the model features two newly introduced policies, first, a special tax instrument on carbon emissions related to international transport, and second, a policy instrument depicting carbon border adjustment mechanism (CBAM).

The strength of CGE models lies in its ability to link various markets, sectors, or economies. It shows how policy changes, or changes in general, affect other areas of the economic system, beyond the sector or country where the change occurs. Thus, highlighting the importance of linkages between sectors and countries. CGE models are theoretical consistent and being based on empirical data they incorporate unique features of an economic system. CGE models are therefore suited to analyze effects of policies, i.e., policies that affect multiple sectors or countries and/or result in changes of behavior. They are also useful for “what if”-type of questions in ex-ante scenarios. They are used widely in international trade, public finance, regional economics, and environmental economics.

The data requirements of CGE models are substantial. This applies to the database and parameters used in the model. The models require a complete and consistent database, e.g., Imports of country A from B need to be equal to exports of country B to A. Thus, transactions must be reconciled, and the global SAM database will deviate from National Account data published by statistical offices. Global CGE models cover all sectors in all countries, hence, sector detail is limited. By covering all sectors in an economy, a CGE model may miss key features of critical sectors in a specific country. Uncertainty with respect to parameters employed are met with thorough sensitivity analysis (Annex), varying key parameters and assumptions.

The study uses a global CGE that allows to trace effects from events occurring in the rest of the world to Ghana. The use of a global model requires the use of a global database, limiting data that can be used (i.e., reference year) and sectoral detail. A more detailed analysis of Ghana would require the link of the global model with a single country model, which was out of scope in this study.

10.3. Simulations

This study includes three simulations, each involving two or more scenarios:

1. IMO carbon tax (maritime transport)
2. ICAO/CORSIA carbon tax (air transport)
3. EU CBAM tax

The model is static; thus, results constitute the effect from moving from the base situation to a new equilibrium. In the model production factors are flexible, they move between sectors in response to changes in the relative wages or returns until a new equilibrium is reached. These adjustments take time, and the period covered has medium run character. In addition, the model is set in a way to ensure welfare effects are materialized inside this period, e.g., regional investment volumes are fixed.¹³

1. IMO carbon tax (maritime transport)

A uniform carbon tax on international maritime transport, implemented as tax on exports of maritime transport services. This implies, that the tax revenue accrues to the region exporting maritime transport. The amount charged on each unit of international maritime transport depends on the carbon content used for the transport service in the specific region where the transport service originates.

¹³ For details, please refer to the section on closures in the Annex.

Two scenarios are considered:

- *IMO-50*: Tax of 50\$ per ton CO₂
- *IMO-100*: Tax of 100\$ per ton CO₂

2. ICAO/CORSIA carbon tax (air transport)

The policy is implemented similarly to the IMO carbon tax as tax levied on the export of air transport services. The amount charged on each unit of international air transport is defined by the carbon content embedded in the service of the specific region.

Increasing costs of air transport are expected to affect tourism. The model is, in form of a pre-run, run with IMO carbon taxes. This pre-run renders price changes in air transport, which are used to derive for Ghana a decrease in tourist arrivals. This decrease in arrivals to Ghana are translated in a decrease in demand for Ghana exports of tourism related services using information on tourism receipts¹⁴.

Two scenarios are considered:

- *ICAO/CORSIA -50*: Tax of 50\$ per ton CO₂
- *ICAO/CORSIA_-100*: Tax of 100-\$ per ton CO₂

The effect of price changes on tourist arrivals is derived using elasticities derived in Scheelhase and Grimme (2007). To account for uncertainty in price elasticities, each scenario is run twice, with a set of lower bound (business -0.5, leisure -1.1) and upper bound (business -0.9, leisure -1.5) elasticities as reported in Scheelhase and Grimme (2007).

3. EU CBAM tax:

CBAM is implemented as specific import tax on the carbon content used in the production of each good imported into the EU. CBAM is assumed to apply worldwide, there is no exemption for LDCs and covers the following sectors, Cement, Iron & Steel, Aluminum, Fertilizers. Carbon content captures emissions scope 1 and is defined by the respective average of the origin region by sector, there is no crediting for foreign carbon pricing.

The size of CBAM is proposed to be determined by EU ETS carbon prices, following recent price developments we run two scenarios:

¹⁴ Please refer for details to the Annex

- *CBAM-50* – an import tax of 50\$ per ton CO₂
- *CBAM-100* – an import tax of 100\$ per ton CO₂

The majority of sectors subject to EU CBAM are part of a larger sector in the model database. They are taken into account proportionally to their import value to the EU: Cement represents 4% of EU imports in the sector “mineral products”; Aluminum accounts for 55% of EU imports from Ghana in the sector “aluminum and other metals” and 12% for EU imports from the rest of the world; and fertilizers represent 2% of EU “chemical products” imports. Iron and steel is represented by its own sector in the model database.

10.4. Results

The results cover effects moving from one equilibrium to another and represent a medium run period.

Table 18. Effects on emissions

<i>CO₂ Emissions</i>	<i>change in Million tons</i>	<i>percent change in global emissions</i>
<i>IMO-50</i>	-7.6	-0.03
<i>IMO-100</i>	-15.2	-0.05
<i>ICAO-50</i>	-5.7	-0.02
<i>ICAO-100</i>	-11.0	-0.04
<i>CBAM-50</i>	-0.1	0.00
<i>CBAM-100</i>	-0.2	0.00

Note: All below two decimal places is considered within the bounds of error

Table 19. Macroeconomic effects for Ghana (real, in % change to base)

	<i>IMO-50</i>	<i>IMO-100</i>	<i>ICAO-50-low el.</i>	<i>ICAO-50-high el.</i>	<i>ICAO-100-low el.</i>	<i>ICAO-100-high el.</i>	<i>CBAM-50</i>	<i>CBAM-100</i>
<i>Exchange rate ^{a)}</i>	0.1	0.2	0.3	0.3	0.5	0.6	0.0	0.0
<i>Imports</i>	-0.1	-0.2	-0.3	-0.4	-0.5	-0.7	-0.0	-0.0
<i>Exports</i>	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.0	-0.0
<i>GDP</i>	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0
<i>Household consumption</i>	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	0.0	0.0
<i>Government consumption</i>	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
<i>Production</i>	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.0	-0.0

Notes: a) positive changes represent a depreciation of the exchange rate, negative changes an appreciation. All below one decimal place is considered within the bounds of error

Table 20. Effects on consumer prices by commodity group (% change to base)

	IMO-50	IMO-100	ICAO-50-low el.	ICAO-50-high el.	ICAO-100-low el.	ICAO-100-high el.	CBAM-50	CBAM-100
<i>agri-food</i>	-0.0	-0.1	-0.1	-0.2	-0.3	-0.4	0.0	0.0
<i>energy and water</i>	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0
<i>manufacturing</i>	0.1	0.1	0.1	0.1	0.2	0.2	-0.0	-0.0
<i>services</i>	-0.0	-0.1	0.2	0.4	0.5	0.8	-0.0	-0.0

Note: All below one decimal place is considered within the bounds of error

a. IMO carbon tax

A carbon tax on international maritime transport of 50 \$/ton CO₂ (100 \$/ton CO₂)¹⁵ reduces emissions by 7.6 (15.2) Million tons CO₂, which denotes a decrease of 1.3% (2.7%) of direct emissions of water transport. The price on international maritime transport worldwide increases by 3.4% (6.8%).

Overall effects of the IMO carbon tax on the economy of Ghana are small (Table 3). As transport costs increase this has an upward effect on import prices and demand for exported goods decreases, the exchange rate depreciates by 0.1% (0.2%) to incite exports and maintain the current balance. Finally, imports and exports on aggregate decrease by 0.1% (0.1-0.2%). Household consumption decreases 0.1%. Income from the IMO tax balances downward effects for the government and government consumption does not change. Effects on production have a negative trend, however, noticeable only with a tax of 100 \$/ton.

Table 21. Effects of IMO carbon tax on Ghana trade flows and production, by sector (%change to base)

	<i>Imports</i>				<i>Exports</i>				<i>Production</i>			
	Prices		Quantities		Prices		Quantities		Prices		Quantities	
	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100
<i>Oil seeds</i>	-0.1	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	-0.0
<i>Crop agriculture</i>	0.2	0.3	-0.3	-0.5	-0.0	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	-0.0
<i>Fishing</i>	-0.1	-0.1	-0.0	-0.0	0.0	0.1	0.1	0.1	-0.1	-0.1	-0.0	-0.0
<i>Extraction of crude oil</i>	0.0	0.0	0.1	0.1	-0.0	-0.1	-0.4	-0.9	-0.0	-0.1	-0.4	-0.8
<i>Other mining and extraction (incl. gold and aluminum)</i>	0.3	0.6	0.1	0.2	-0.1	-0.2	-0.1	-0.2	-0.1	-0.2	-0.1	-0.2

¹⁵ Two alternatives are presented at the same time throughout this section of the report. Without brackets is the 50\$ tax option and with brackets is the 100\$ tax alternative.

<i>Vegetable oils and fats</i>	0.1	0.3	-0.2	-0.4	-0.0	-0.0	0.1	0.2	-0.0	-0.0	0.1	0.2
<i>Meat and dairy</i>	0.0	0.1	-0.2	-0.4	-0.0	-0.0	0.1	0.2	-0.1	-0.1	0.0	0.0
<i>Other food</i>	0.1	0.2	-0.2	-0.3	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.0	-0.1
<i>Chemical products</i>	0.1	0.2	-0.1	-0.3	0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0
<i>Rubber, plastic products</i>	0.1	0.2	-0.1	-0.3	-0.0	-0.1	-0.1	-0.2	0.0	0.0	-0.0	-0.1
<i>Mineral products</i>	0.3	0.6	-0.1	-0.1	-0.0	-0.1	0.2	0.3	0.0	0.1	0.3	0.6
<i>Aluminum, other metals (incl. gold)</i>	0.0	0.0	0.0	-0.1	-0.0	-0.0	0.2	0.4	-0.0	-0.0	0.2	0.4
<i>Metal products</i>	0.1	0.2	-0.2	-0.3	0.0	0.0	0.2	0.3	-0.0	-0.1	0.1	0.2
<i>Water transport</i>	2.4	4.9	-2.2	-4.3	-0.5	-1.0	-0.6	-1.1	-0.0	-0.1	-0.2	-0.3

Effects on sectoral level are detailed in Table 5¹⁶. Import prices increase for the majority of sectors, triggered by the depreciation of the exchange rate. The quantity imported decreases consequently. Effects are strongest for Ghana’s oil sector, exports, and production of oil decrease by 0.4% (0.8/0.9%), reflecting a strong export dependence of Ghana’s oil sector. Other sectors experiencing a negative effect on production, up to 0.2% (0.4%), are the transport services, trading services, petroleum and coal products and mining. The production effect of water transport is in the range of the aforementioned sectors, despite being subject to the simulated policy and experiencing a pronounced drop in exports. International water transport is relatively small in this sector. Benefitting from increasing import prices and increasing competitiveness on export markets from the depreciation of the exchange rate, the majority of manufacturing sectors can increase its domestic market share and increase production, up to 0.3% (0.6%).

The overall production decrease causes a decrease in household income, reflected in decreasing consumption (Table 3). Changes of consumer price indices by commodity group can give an indication about the distributional impact of the policy (Table 4). Prices for food and services decrease 0.1% (100\$/ton). Policies have a shrinking effect on production, wages fall, -0.1%, and with them household income and consumption. As a result, agri-food consumption and the corresponding prices fall. Triggered by increasing import prices, consumer prices for manufacturing increase 0.1%. The IMO carbon tax does not impact on government expenditure and, thus, volumes of health, education and other government services do not change.

b. ICAO/CORSIA carbon tax

A carbon tax on international air transport of 50 \$/ton CO₂ (100 \$/ton CO₂) reduces emissions by 5.7 (11.0) Million tons CO₂, reducing direct emissions of air transport by 0.4% (0.9%), and increases the price on international air transport worldwide by 4.5% (9.1%).

¹⁶ Refer to Annex Table A1 for results for all sectors covered in this analysis.

For tourism in Ghana this increase in the price of air transport implies a decrease in tourist arrivals of 3-5% (7-10%). The range reflects the application of a lower (*low elasticity*) and upper bound (*high elasticity*) on how strong tourists respond to price changes¹⁷.

The impacts of the change in air transport are similar to the effects described for water transport in the previous section. However, higher air fares reduce tourism, and this is where the differences between the two scenarios arise. Decreasing tourist arrivals decrease the amount of tourism receipts, constituting an export of services. In consequence, the exchange rate depreciates by 0.3% (0.5-0.6%) to balance the current account (Table 3).

Services export demand decreases, reflecting the decrease in tourism; prices for services exports decrease 4.1-5.7% (6.7-9.1%) decreasing services exports in real terms by 4.7-7.3% (9.6-14.7%) (Table 6). Domestic service supply contracts by 0.3-0.4% (0.5-0.7%).

The depreciation of the exchange rate raises import prices in all sector groups, except air transport that is targeted by the policy, by 0.1-0.2% (0.2-0.4%). Ghanaian exports become more attractive, and exports of agri-food products increase 0.3-0.4% (0.5-0.7%) and manufacturing exports increase 0.8%-1% (1.4%-1.9%).

Table 22. Effects of ICAO/CORSIA carbon tax on prices and quantities by sector (%change to base)

	Exports				Imports				Production			
	Prices		Quantities		Prices		Quantities		Prices		Quantities	
	Low el.	High el.	Low el.	High el.	Low el.	High el.	Low el.	High el.	Low el.	High el.	Low el.	High el.
<i>ICAO-50</i>												
<i>Agri-food</i>	0.1	0.1	0.3	0.4	0.1	0.1	-0.3	-0.4	-0.1	-0.2	0.0	0.1
<i>Oil</i>	0.1	0.2	-0.3	-0.2	0.1	0.1	0.0	-0.1	0.1	0.2	-0.2	-0.2
<i>Manufacturing</i>	0.0	0.0	0.8	1.0	0.2	0.2	-0.3	-0.4	0.0	0.0	0.4	0.5
<i>Air transport</i>	-2.8	-2.6	-2.7	-2.7	4.0	4.1	-3.5	-3.6	0.0	0.0	-0.3	-0.5
<i>Services</i>	-4.1	-5.7	-4.7	-7.3	0.1	0.1	-0.3	-0.4	-0.1	-0.1	-0.3	-0.4
<i>ICAO-100</i>												
<i>Agri-food</i>	0.1	0.1	0.5	0.7	0.2	0.2	-0.6	-0.7	-0.2	-0.4	0.1	0.1
<i>Oil</i>	0.2	0.3	-0.5	-0.5	0.1	0.2	0.0	-0.2	0.2	0.3	-0.4	-0.4
<i>Manufacturing</i>	0.0	-0.0	1.4	1.9	0.3	0.4	-0.5	-0.6	0.0	-0.0	0.7	1.0
<i>Air transport</i>	-5.5	-5.2	-5.3	-5.3	8.1	8.2	-6.7	-6.9	0.0	0.1	-0.6	-0.8
<i>Services</i>	-6.7	-9.1	-9.6	-14.7	0.2	0.2	-0.5	-0.7	-0.1	-0.1	-0.5	-0.7

Note: All below one decimal place is considered within the bounds of error

¹⁷ For details, please refer to the technical description of scenarios in the annex.

Oil exports are strongly impacted by the tax on international air transport, which decreases global demand for oil. Abstracting from tourism, oil exports would decrease by 0.4 (0.8%). The depreciation connected to decreasing tourism softens this effect and oil export decrease by 0.3-0.2% (0.5-0.5%). Note how the greater the decline in tourism, the smaller the impact on oil.

For the economy as a whole negative impact dominate and imports decrease 0.3-0.4% (0.5-0.7%) and exports decrease 0.1% (0.2%) (Table 3). GDP decreases 0.1% and household consumption decreases 0.2-0.3% (0.4-0.5%) reflecting decreasing production which leads to income losses (Table 3). Government consumption, surprisingly, increases slightly. Government income and the value of expenditure decreases similar to GDP, however, prices for services decline and thus the volume of services consumption increases.

Consumer prices can indicate distributional effects of the simulated policy (Table 4). Agri-food consumer prices and production prices decrease 0.1-0.2% (0.3-0.4%), triggered by decreasing income from shrinking production. This has a positive effect on poor consumers but renders negative for farmers. Manufacturing and services prices increase, the latter being dominated by air transport fares. In addition, the decrease in tourism affects over proportionally low and unskilled workers, and income of low and unskilled workers decreases stronger, 0.3-0.4% (0.6-0.8%), compared to skilled labor, which decreases 0.2% (0.3-0.4%).

c. CBAM

In the medium-term EU CBAM priced 50\$/ton (100\$/ton) decreases CO2 emissions by 100 (200) thousand tons and creates a tax income for the EU of 0.9 bio \$ (1.8 bio \$). Fertilizer and aluminum represent only a share in a larger sector and effects are therefore small for these two cases. Ghana does not export cement to the EU, the analysis therefore does not include that sector. There is no noticeable impact on production or welfare in Ghana on aggregate or sectoral level.

On global level the EU policy is redirecting trade flows. Overall, the EU CBAM decreases imports of the EU (Table 7) in the targeted sectors. The effect on global trade is very small with a negative trend. Decreasing world market prices, in turn, increase demand in the rest of the world, including Ghana, levelling global demand. This is most clearly depicted by iron and steel, where imports decrease in the EU 0.3% (0.5%) but increase in all other regions. On global level, trade in iron and steel decreases by 0.04% (0.08%).

Table 23. CBAM Effects on Imports and Exports by region, targeted sectors (% change)

	Ghana	Africa LDCs	Rest of Africa	European Union	Rest of Central Europe	North America	Latin America and Caribbean	Oceania	East Asia	LDCs Asia a. Oceania	South and Southeast Asia	Eastern Europe	Western Asia
CBAM-50													
Imports													
Chemical products (incl. fertilizer)	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	-0.06	-0.01
Iron and steel	0.02	0.01	0.05	-0.25	0.04	0.02	0.03	0.03	0.03	0.03	0.06	0.10	0.02
Aluminum, other metals	0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.01	0.01	-0.02	-0.09	0.00
Exports													
Chemical products (incl. fertilizer)	0.00	0.00	0.02	-0.02	0.00	-0.01	0.00	0.01	0.00	-0.01	0.01	0.08	0.00
Iron and steel	-0.03	-0.03	-0.67	0.42	-0.25	-0.04	-0.21	0.00	-0.07	-0.15	-0.81	-1.02	-0.18
Aluminum, other metals	0.00	0.00	0.00	-0.04	0.00	-0.01	0.00	0.00	0.00	-0.01	0.01	0.14	-0.01
CBAM-100													
Imports													
Chemical products (incl. fertilizer)	0.01	0.00	-0.02	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.01	0.00	-0.11	-0.01
Iron and steel	0.05	0.02	0.09	-0.48	0.07	0.05	0.07	0.05	0.05	0.06	0.11	0.20	0.05
Aluminum, other metals	0.01	0.00	-0.03	-0.02	0.00	0.01	-0.01	0.00	0.01	0.02	-0.03	-0.18	0.00
Exports													
Chemical products (incl. fertilizer)	0.00	-0.01	0.03	-0.04	0.00	-0.01	0.01	0.01	-0.01	-0.02	0.02	0.14	0.01
Iron and steel	-0.05	-0.07	-1.30	0.84	-0.51	-0.08	-0.42	0.00	-0.15	-0.30	-1.52	-1.98	-0.35
Aluminum, other metals	0.00	0.00	-0.01	-0.07	-0.01	-0.01	0.00	0.01	-0.01	-0.01	0.01	0.28	-0.02

Note: All below two decimal places is considered within the bounds of error

Table 24. CBAM Effects on Ghana Exports to partner regions (% change)

	CBAM-50		CBAM 100											
	EU		EU	Africa LDCs	Rest of Africa	Rest of Central Europe	North America	Latin America and Caribbean	Oceania	East Asia	LDCs Asia a. Oceania	South and Southeast Asia	Eastern Europe	Western Asia
Chemical products	-0.04		-0.08	0.00	-0.01	0.04	0.02	0.00	0.00	0.01		-0.00	-0.12	0.00

(incl. fertilizer)											
Iron and steel	-0.49	-1.00	-0.08	-0.00			-0.02			0.02	-0.06
Aluminum, other metals	0.03	0.06	0.01	-0.00	0.02	0.01	-0.01	0.00	0.00	-0.04	-0.02

Note: All below two decimal places is considered within the bounds of error

Ghana exports to the EU in ‘chemical products’ (incorporating fertilizer) decrease by 0.04% (0.08%) and iron and steel decrease by 0.5% (1%) (Table 8). Ghana can increase its exports in ‘aluminum and other metals’ (aluminum) to the EU, benefitting from a lower CO2 intensity in the production process compared to other regions (Annex Table A3). Considering all export destinations by Ghana, there is no change in Chemical products (incl. fertilizer) and Aluminum exports, and a slight negative trend for iron and steel. Decreasing trade with the EU is compensated by increasing exports to other regions, e.g., South and Southeast Asia in the case of iron and steel.

11. Domestic and international tools to address the impacts

The adverse and unintended impacts of climate change policies need to be identified and quantified in order to be understood. They also need to be addressed and managed to support the transition to a low-carbon society in a sustainable way.

As this case study aims to support the global transition, it seeks to also highlight whether domestic tools and international cooperative approaches to mitigate impacts are available and adequate. This section highlights any domestic tools and international tools that are helping or could help the country address the impacts of the implementation of response measures as much as possible.

This step is important for reporting under BURs and BTRs, as countries can highlight which support, they could use with respect to addressing impacts.

Impacts can be addressed ex-ante and ex-post and tools can be applied in both instances

An ex-ante tool for addressing impacts is designing or adapting the policy to mitigate some impacts. Policy design can have a large impact on whether a response measure has unintended negative impacts, how and for whom they arise. Ex-ante tools can be considered to be a form of risk management. They ensure that the identified adverse impacts of a policy or action are prevented. These tools are at times already a part of the response measure, built into its framework.

Both the ICAO and IMO in the development of their market-based mechanisms (MBMs) held discussions on the inclusion of measures to mitigate the impacts of these MBMs. This included de minimis thresholds for inclusion in CORSIA and slower compliance timetables for developing or vulnerable countries, offset mechanisms and recycling revenues.

Identifying impacts ex ante has the clear benefit of allowing for the management of impacts before they occur and allows for the incorporation of tools which can mitigate the identified risk at an early stage. That said, ex-post identification allows for focused and well-apportioned efforts to address the impacts that have already occurred.

Ex-post mitigation tools address impacts after they have materialized. This means the tools can be more precise and effective by addressing only the observed impacts. This decreases the risk of not fully addressing the impacts or overshooting the mitigation.

11.1. 6.1. Domestic Tools

At domestic level, there are several tools that can be used to mitigate the impacts of climate change mitigation policies.

- 1) Domestic safety nets
- 2) Just transition efforts
- 3) Economic diversification
- 4) National climate funds
- 5) Domestic/National Carbon Markets

It must be noted however, that even though most of these tools are aimed at counteracting or alleviating the adverse effects of response measures on a specific jurisdiction, response measures can also have positive impacts or co-benefits, which can be then taken advantage of by using these tools and mechanisms. For example, economic diversification efforts or the creation of a national just transition framework can create new opportunities in the economy.

Positive impacts, commonly referred as 'co-benefits', can include, for example, cleaner environment, increased energy security, and the creation of new jobs. The Intergovernmental Panel on Climate Change (IPCC) defines co-benefits as:

“The positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society or the environment. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as ancillary benefits.”

1. Domestic safety nets

Domestic safety nets are an important tool to protect the low-income segment of the society from the impacts of economic shocks, natural disasters, and other crises.

In case of large job losses (for example, because of the closure of a major coal plant or and oil and gas facility), plant operators can receive support from governments to help mitigate the effects on workers. For example, the cost of social packages for Polish iron and steel workers who lost their jobs during the restructuring of the sector in the 1990s and early 2000s was shared by the companies, the Polish Ministry of Economy, and the EU. The packages included benefits for early retirement, support for training and retraining, and alternative job creation.

Currently in Ghana exists a Productive Safety Net Project supported by the World Bank (GPSNP)¹⁸ which aims to support the government to strengthen safety net systems that improve the productivity of the poor. Such a national safety net program, if in place, could help address the impacts of international climate change mitigation policies that might generate an economic shock in for certain sectors of the Ghanaian economy.

Box 1. UNFCCC definition of a Just Transition

Under the UNFCCC, just transition was first identified as a key area of work under the work programme and forum on response measures adopted and established at the 17th Conference of the Parties (COP17) in 2011.

In 2015, the issue of just transition was included into the Paris Agreement through a commitment of parties to consider "the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities."

2. Just transition efforts

With the green transition, certain energy-intensive sectors and regions will have an irreversible decline in economic output and employment level, as well as adverse effects on household income and on different social groups. Some of the most affected sectors include extraction of coal, oil, natural gas, peat, oil shale, lignite, and other greenhouse gas-intensive industrial processes.

The establishment of a national just transition framework or program is an ancillary tool to mitigate the impacts of response measures and the transition to a low carbon economy.

¹⁸ <https://projects.worldbank.org/en/projects-operations/project-detail/P164603>

A Just Transition entails¹⁹:

- Encouraging social dialogue among all stakeholders;
- Developing skills and retraining for green jobs;
- Developing green enterprises;
- Promoting active labor policies;
- Providing social protection;
- Minimizing hardship for workers;
- Introducing appropriate public policies to address the needs of workers;
- Consulting with all stakeholders to develop mechanisms for just transition;
- Ensuring a country-driven process; and
- Assessing response measures during their design and implementation phases in order to identify possible consequences for employment, economic growth in developing countries, in both a quantitative and a qualitative manner.

In Ghana, the sectors that bring the most concerns in terms of the potential job losses due to the impacts of response measures, are the oil and gas sectors.

Ghana's existing efforts in ensuring a Just Transition include:

- Training on the social and employment implications of climate policies and NDC
- National dialogue on decent work and just transition
- Development of a Green Jobs Assessment Model (GJAM), by the ILO and in collaboration with the EPA, for better evidence-based decision making

Cooperation between different governance levels is crucial. To facilitate a just transition, all stakeholders, including policy makers and members of civil society, will need to work together to identify potential negative outcomes at local, regional, and national levels, while paying specific attention to the most vulnerable cohorts in society.

This however cannot be achieved without international assistance, both in terms of financial and capacity needs. De facto, the investment needs to upskill, reskill, and relocate workers is enormous. Under section 6.2.x we put forward the international financial aid that are available.

Lastly, it has to be noted also that informal employment in Ghana is overwhelming. The International Labor Organization (ILO) estimated that 86.2% of workers in the country are informal in nature²⁰. It is therefore difficult to estimate the exact impacts of job losses due to transition policies, which may have an even larger impact than possibly anticipated.

¹⁹ <https://unfccc.int/sites/default/files/resource/Just%20transition.pdf>

²⁰ https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_626831.pdf

Box 2. Supporting a Just Transition in South Africa

Accounting for about 89% of South Africa’s electricity generation and 74% of its total primary energy supply*, coal has been a critical part of South Africa’s economy for decades. The coal sector in South Africa provides employment for around 200,000 people through mining, power stations, and transport.

In a transitioning world the main issues linked to the coal sector are: a) its environmental impacts (e.g., air and water pollution), b) it represents a significant amount of the country’s GHG emissions and c) market and policy signals indicate an inevitable decline of the coal sector.

To tackle this, in 2012 the South Africa’s National Planning Commission, included in its National Development Plan to 2030 a chapter on just transitions that proposed a framework for a National-level Social Dialogue**.

In 2016, Eskom, the largest electricity company of the country, announced that it would decommission six coal power plants, which would result in significant job losses and as a consequence has led to numerable labor protests. As a response, Eskom established a Just Energy Transition (JET) office and laid out a US\$10 billion Green Energy transition plan***. The plan will develop 8,017 MW of renewable energy projects with projects ranging from wind power to solar, hydropower and gas.

At the end of 2020, the Presidential Climate Change Commission (P4C) was established, and under which just transition towards a low-carbon, inclusive, climate change resilient economy and society is a key pillar.

In the past decade, South Africa has proven to be able been dealing efficiently with issues tied to ensuring a Just Transition by introducing it in national plans, anticipatory skills development at national level, and inclusive cross-sectoral dialogues at all levels.

*Statistics²¹

**National Development Plan²² and National-level Social Dialogue²³

***US\$10B will be sourced from different sources of funding including international assistance

3. Economic diversification

Under the UNFCCC, economic diversification refers to moving an economy away from reliance on a narrow range of high emitting sectors that are affected by response measures taken to combat climate change. The case of fossil fuel-exporting countries is most commonly highlighted – as the demand for fossil fuels declines, economies that are heavily reliant on fossil fuel exports will need to diversify to other economic activities. Economies that rely on the export of carbon

²¹ <https://www.iea.org/countries/south-africa>

²² <https://www.gov.za/sites/default/files/Executive%20Summary-NDP%202030%20-%20Our%20future%20-%20make%20it%20work.pdf>

²³ <https://oneworldgroup.co.za/wp-content/uploads/2019/10/NPC-JT-Vision-and-Pathways-draft-2-final.pdf>

intensive goods, which could be subject to climate change measures such as border carbon adjustments, will also need to diversify.

According to our analysis in previous steps, the carbon-intensive sectors that appear at risk of impacts of international response measures are mining and quarrying without oil and gas and gold (aluminum and manganese), fishing, tourism, oil and gas and manufacture of beverages and food products.

As market and policy signals indicate, in the future certain sectors will be more important than others in the green economy. Thus, Ghana should plan accordingly and with a long-term vision to address the sectors that might suffer in the future.

Some tools for addressing high-emitting sectors are: improving energy efficiency and technology deployment in the industry and fisheries sectors, using alternative fuels, deploying carbon capture and usage (CCU) and carbon capture and storage (CCS) in the oil & gas industry; moving to a more circular economy.

In Ghana's National Export Development Strategy (NEDS) 2020-2029²⁴ the sectors that are prioritized for production and exports expansion are outlined below. Some of the sectors that are carbon intensive and that will be potentially impacted by international response measures are: fish & fishery products, aluminum products articles of plastic, iron & steel products, automobiles & vehicles, garments & textiles, petrochemical products, and machines & machine components.

4. National Climate Funds

A national climate fund is a financial mechanism that allows countries to collect, blend, and manage all the incoming revenue streams, both international and national, related to climate change into one, centralized fund. This, in turn, competitively allocates through a variety of instruments resources to a variety of "green" projects in the country. These increasingly popular national entities have been playing a crucial role as an interlocutor between the national policies for pursuing low carbon development and the international mechanisms that deliver this aid. A Ghanaian National Climate Fund could have as one focus the support for sectors impacted by the implementation of response measures.

²⁴ <https://www.tralac.org/documents/resources/by-country/ghana/4170-ghana-national-export-development-strategy-neds-overview-2020/file.html#:~:text=The%20Ghana%20National%20Export%20Development,industrialized%20economy%20if%20NEDS%20is>

11.2. 6.2 International Tools

Mitigation requires international cooperation. Beyond the previously mentioned option of revising response measures to reduce negative impacts, at the international level several tools and mechanisms are in place to provide support to countries to help them cope with the impacts of climate change mitigation policies:

- 1) Financial aid
- 2) Capacity-building
- 3) Inclusion of impact mitigation measures in international climate change policies

1. Financial aid

The primary international tool used to mitigate impacts, especially for developing countries, is financial aid. International financial aid comes mainly from:

- Development cooperation agencies
- Bilateral support and finance institutions
- Multilateral finance institutions and development banks
- UNFCCC programmes and aid

The main funds and initiatives from which Ghana could leverage support to mitigate the impacts of response measures are:

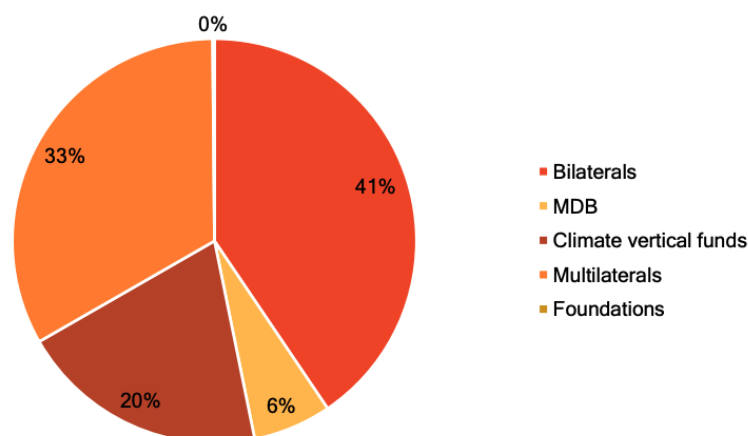
- AF – Adaptation Fund (GEF acts as secretariat and WB as trustee)
- ACCF – Africa Climate Change Fund
- AREI – African Renewable Energy Initiative
- ASAP – Adaptation for Smallholder Agriculture Programme
- CAFI – Central African Forest Initiative
- CDM – Clean Development Mechanism (implemented under the Kyoto Protocol)
- CIF – Climate Investment Funds (implemented through WB, ADB, AfDB, EBRD, and IDB)
- CTF – Clean Technology Fund (implemented through WB, ADB, AfDB, EBRD, and IDB)
- FCPF – Forest Carbon Partnership Facility
- FIP – Forest Investment Program (implemented through WB, ADB, AfDB, EBRD, and IDB)
- GCCA – Global Climate Change Alliance
- GCF – Green Climate Fund
- GEF – Global Environment Facility
- GEEREF – Global Energy Efficiency and Renewable Energy Fund (hosted by EIB)
- IKI - International Climate Initiative

- JI – Joint Implementation (implemented under the Kyoto Protocol)
- LDCF – Least Developed Countries Fund (hosted by the GEF)
- PMR – Partnership for Market Readiness
- PPCR – Pilot Program on Climate Resilience (implemented through World Bank, ADB, AfDB, EBRD, and IDB)
- SCCF – Special Climate Change Fund (hosted by the GEF)
- SCF – Strategic Climate Fund (implemented through WB, ADB, AfDB, EBRD, and IDB)
- SREP – Scaling Up Renewable Energy Program for Low Income Countries (implemented through WB, ADB, AfDB, EBRD, and IDB)
- UN-REDD – United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation

In Ghana international donor funding is also one of the key strategies to mitigate the high cost for the government to engage in climate change mitigation activities. Some of international sources of support used in the country include²⁵ the GEF, the GCF, NAMA and REDD projects from UNDP, UNFCCC and UNEP, World Bank projects, Africa Development Bank project, European Investment Bank projects, CDM projects, support from development agencies such as GIZ or AFD and bilateral support and loans from Germany, Korea, Sweden, and other countries.

In terms of sources of financial commitment, the bilateral and the multilateral continue to dominate.

Figure 12. Distribution of the financial commitment to principal climate marker and projects with climate components by sources for the period 2015-2020



Source: Ghana BUR3 (2021)

²⁵ This list is not exclusive

A few examples of the projects in Ghana that come from international aid include: Ghana Industrial Energy Efficiency Readiness project, Accelerated Solar Action Programme (ASAP), Regional Off-Grid Electrification Project (ROGEP), Leveraging Energy Access Finance Framework project, between others.

Additionally, Ghana has taken an early leap into the Article 6 market. It is cooperating under two Article 6.2 pilots involving the Governments of Switzerland and Sweden. Regarding the Article 6.2 pilot with Switzerland, in November 2020, both countries signed a bilateral agreement to pave the way for developing and implementing the National Clean Energy Access Programme (NCEP) to generate Internationally Transferred Mitigation Outcomes (ITMOs). The NCEP may cover mitigation activities in decentralized renewable energy, clean cooking solutions, waste management and agriculture.

It is worth mentioning that Ghana has initiated a programme to explore green bonds' potential for SDGs and NDC financing in 2019 and has another project for green credit lines to support local banks and energy businesses in Ghana.

Even though there are a multiplicity of international funding programmes and initiatives in Ghana, this is not enough to meet the projected climate finance needs towards a sustainable transition. In October 2021, Ghana submitted its Transmittal Letter of Interim Updated Nationally Determined Contribution²⁶, stating that it will require between US\$ 9.3 and US\$ 15.5 billion of investment to implement the 47 nationally determined contribution measures from 2020 to 2030. The international financial commitments to achieve Ghana's climate objectives for the period 2015-2020 amounted to US\$ 1.54 billion, this is a much lower figure compared to the estimated figure of US\$ 9.3 and US\$ 15.5 for the 2020-2030 period.

A lack of funding has been continually identified as adding to the challenge of implementing ambitious climate change policies and projects, and managing the impacts of those policies, in developing countries. A clear example of this, are the conditional-upon-funding measures Parties submit in their NDCs under the Paris Agreement, with more than half of all NDCs including these conditional components (ecbi, 2018). As a matter of fact, in the Interim Updated Letter, Ghana stated that it would require US\$5.4 billion to meet the 31 conditional programmes of action to be mobilized from the public, international and private sector sources.

Additionally, a number of international tools, from the above-mentioned list remain underutilized and should be taken into account and utilized to mitigate the impacts of response measures in Ghana.

²⁶https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Ghana%20First/Ghana_Transmittal%20Letter_Interim%20Updated%20NDC.pdf

Lastly, blended finance is another innovative key tool that could help to address the needs of Ghana to mitigate the effects of response measures. Blended finance helps nations meet the SDGs and the goals of the Paris Climate Agreement, while also addressing the risks and barriers faced by investors when pursuing the opportunities these afford. It brings together Public - national and international - and philanthropic capital that catalyzes private investment in developing countries. The three main characteristics of this measure are: investments must have a financial return; they have to address SDGs or key development challenges and donor and philanthropic financing is catalytic in the equation.

2. Capacity-building

International cooperation in capacity building is another tool that plays a large role in assisting jurisdictions to tackle negative impacts of response measures. As mentioned under point 6.1.x, Ghana is undertaking capacity building efforts in raising awareness on climate change issues and risks, better understanding the social and employment implications of climate policies and the NDC – linked to just transition issues, sustainable practices in different sectors such as cocoa and for a variety of projects, such as the ones under the REDD.

In a study, where the ERCST project team looked at the cocoa sustainability labelling in Ghana (add link), proved the critical value of outside trainers and capacity-building in the case of food labelling for the cocoa and palm oil industries to help small producers overcome the extra challenges to become certified and to help them reap the benefits of complying with labelling schemes. Outside actors (such as those promoting the labelling schemes and other NGOs) also help small producers to organize themselves into cooperative groups.

In the food labelling cases surveyed, this type of capacity-building measure was highly effective at allowing smaller producers to take advantage of the opportunities offered by the various standards and labels. Without them, there arguably would have been much less participation, and the only standard-compliant production would take place in large plantations.

A similar effort might focus on Ghanaian exporters that need assistance to set up GHG emissions accounting regimes to comply with response measures such as the EU's proposed CBAM, or on accrediting local certifiers to verify GHG data reported under the CBAM regime.

3. Inclusion of impact mitigation measures in international climate change policies and projects

Lastly, the inclusion of impact mitigation mechanisms or built-in measures when designing international climate change policies can also help to mitigate or soften the impacts of response

measures for those countries that are deemed to be the most vulnerable. Some examples of these measures are:

- Offset mechanisms
- Recycling revenues for assisting affected developing and vulnerable countries
- De minimis thresholds (DMT)
- Effective timing and slower phase-in for developing and vulnerable countries
- Crediting for foreign policies – e.g., EU CBAM
- National exemptions for vulnerable countries

Both the ICAO and IMO in the development of their market-based mechanisms (MBMs) held discussions on the inclusion of measures to mitigate the impacts of these MBMs. This included de minimis thresholds for inclusion in CORSIA and slower compliance timetables for developing or vulnerable countries, offset mechanisms and recycling revenues.

11.3. Conclusions Step 6

Any unforeseen, and unintended adverse impacts of climate change mitigation policies need to be assessed earlier rather than later, in order to ensure that the tools and measures for their mitigation have been identified and prepared, ultimately enhancing efficient policymaking, decreasing the overall potential costs, and ensuring buy-in for the low-carbon transition is not lost among stakeholders.

At the moment, the discussion on tools to address impacts are very much in a qualitative stage, as those climate change policies that can be considered stringent are either very young or being implemented. However, as the global transition picks up speed – as it should in the coming decade – the impacts of response measures could increase in step with the policy response to climate change. If policies are not well implemented and designed, this could bring the impacts of response measures to the top of political agendas.

12. Conclusion and main findings

To sum up, the main findings from the research and the case study are:

- 12 sectors of the Ghanaian economy have been identified as most vulnerable to the impacts of response measures with 80 international response measures impacting them
- China, Switzerland, India, and South Africa are the most important trade partners for Ghana for the 12 identified vulnerable sectors. The total value of exports from Ghana to those countries amounted to USD 9.4 Billion in 2019
- Other countries that are implementing increasingly ambitious mitigation policies and that are also important trading partners to Ghana for the identified vulnerable sectors are: Netherlands, USA, UK, Japan, Germany, France, Belgium, and Canada
- Not all the 12 identified vulnerable sectors are at risk of impacts from country-led response measures. Mainly due to strong asymmetry of climate targets and mitigation actions taken between countries and regions
- The identified vulnerable sectors that are at risk of impacts: cocoa, manufacture of beverages and food products (jojoba oil); palm oil; fishing; oil & gas; mining and quarrying without oil and gas and gold (aluminum and manganese).
 - The response measures that could potentially have an impact on these sectors are: carbon taxes; subsidies; CBAM; organic standards and labelling requirements for agri. goods and basic materials; aviation and shipping measures
- The identified vulnerable sectors that don't appear at risk of impacts: gold; manufacture of other non-metallic mineral products; manufacture of fabricated metal products (articles of iron and steel); manufacture of rubber and plastic products; manufacture of chemicals.
 - While those sectors are not at risk from country-led response measures, some may still be vulnerable via soft-incentives, voluntary commitments, and shareholder pressure
 - Some examples of voluntary incentives and measures are: SBTi, ICMM Mining Principles, ISO 14001 Environmental Management, organic and sustainability standards for food products (e.g., UTZ, MSC), and others
- Three international response measure were chosen for quantitative assessment: IMO, CORSIA/ICAO, and EU CBAM.
 - Overall, the effects of the IMO carbon tax on economy of Ghana are small. Nevertheless, there are noticeable impacts on sectoral level, i.e., Ghana's oil

sector, where exports and production of oil decrease by 0.4% (0.8/0.9%)²⁷ and consumer prices for manufacturing rise slightly

- ICAO/CORSIA will have a stronger impact than IMO. Increasing costs of air transport are expected to affect tourism and decrease in tourist arrivals of 3-5% (7-10%)²⁸ in Ghana. In addition, the decrease in tourism affects over proportionally low and unskilled workers, and income of low and unskilled workers decreases stronger compared to skilled labor
- For EU CBAM macroeconomic effects are too small to be meaningful, but they could reshuffle export destination patterns. Ghana exports to the EU of fertilizer, and iron and steel will go down, but Ghana can increase its exports in aluminum to the EU, benefitting from a lower CO2 intensity in the production process compared to other regions.
- Even though currently there are a multiplicity of international funding programmes and initiatives in Ghana, this is not enough to meet the projected climate finance needs towards a sustainable transition and mitigate the impacts of response measures. De facto, in its Transmittal Letter for the Updated NDC that it will require \$1,24 Billion per year to achieve its climate targets in the next 10 years, this is way above the climate investments from the past 5 years which were only \$3,08 Million per year
- Ghana should leverage support from available international tools: financial aid, capacity building and inclusion of impact mitigation measures in international climate policies
- At domestic level, Ghana could implement several tools including: national exemptions for vulnerable countries, domestic safety nets, just transition efforts, economic diversification, national climate funds and domestic and national carbon markets
- If Ghana wants to stay competitive in the international market, it has to consider and prepare in advance for the potential impacts of international climate mechanisms.

This methodology describes a time and labor-intensive process, that will need to be adapted somewhat to the national circumstances of any country trying to use it for reporting on response measures under BUR or BTR. Each country will be different, depending on national circumstances, economic structure, key sectors, strength of institutions and experience with consulting with stakeholders.

The main issues for many, especially developing countries, could be lack of access to comprehensive, detailed, and recent data that can be used to not only identify vulnerable

²⁷ Two alternatives presented for the impacts, without brackets is the 50\$ tax option and with brackets is the 100\$ tax alternative

²⁸ Same as previous footnote

sectors, but also built upon for a quantitative and qualitative assessment of the impacts of response measures.

The identification of key sectors and relevant response measures, and assessing their impacts is a laborious process, however it can be simplified to be more useful for countries with less capacity to perform a more exhaustive and comprehensive exercise. In addition, an approach that takes a more macro approach to this analysis would also be possible and is discussed below as an important alternative approach.

There are three main ways to simplify this methodology: (1) limit the number of sectors that are deemed vulnerable, for example by focusing on the top 3 or 5 sectors. (2) limit the number of response measures analyzed, for example focusing on the top 5 or top 10 response measures per sector. (3) Limit the data collection and analysis step and rely on stakeholder input to complement the analysis and ensure relevant sectors and policies are included in the country case study.

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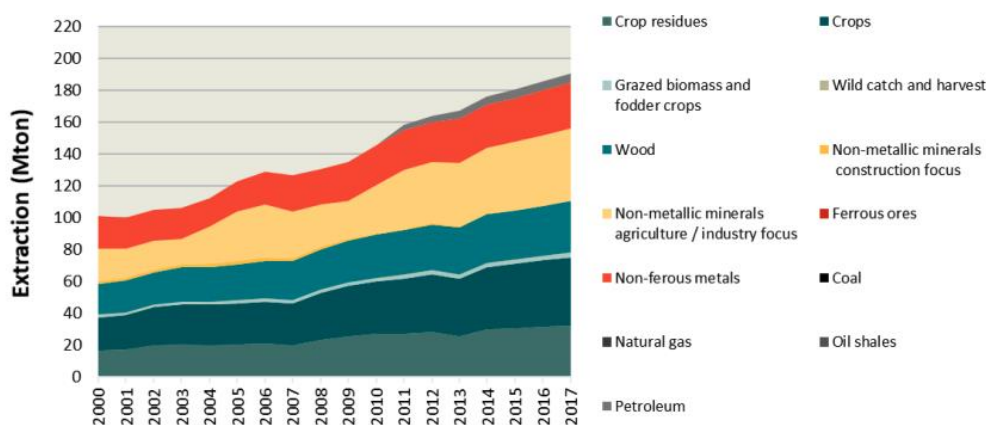
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15. Annexes

15.1. Research and tables Step 1-4

Figure 13. Resource extraction in Ghana by type for the period 2000-2017



Source: (UN Department of Economic and Social Affairs - Statistics Division 2020)

Table 25. Ghanaian sectors ranked by GDP value added

Sector	GDP 2019 (M Gh¢)	GDP 2019 (Gh¢)	% Of GDP	Year	Source
Trade; Repair of Vehicles, Household Goods	50.824	50.824.155.201	15,56%	2019	GSS
Gold	23.282	23.282.459.517	7,13%	2019	GSS
Transport and Storage	23.278	23.278.057.090	7,13%	2019	GSS
Construction of buildings	16.774	16.774.347.210	5,14%	2019	GSS
Oil and gas	14.848	14.848.170.410	4,55%	2019	GSS
Financial and Insurance activities	12.788	12.788.063.721	3,92%	2019	GSS

Hotels and Restaurants	12.211	12.210.599.783	3,74%	2019	GSS
Yam	10.870	10.869.651.703	3,33%	2019	GSS
Public Administration & Defense; Social Security	10.829	10.828.844.944	3,32%	2019	GSS
Education	10.712	10.712.408.781	3,28%	2019	GSS
Mining and quarrying without oil and gas and gold	10.402	10.401.531.302	3,19%	2019	GSS
Information and Communication	9.794	9.793.855.453	3,00%	2019	GSS
Tourism (travel, and expenditure by main purpose of trip)	9.047	9.047.391.760	2,77%	2018	UNWTO
Real Estate	8.790	8.789.791.741	2,69%	2019	GSS
Manufacture of beverages & food products	8.629	8.629.209.988	2,64%	2019	GSS
Livestock	8.050	8.050.081.181	2,47%	2019	GSS
Manufacture of chemicals and chemical products	7.945	7.944.885.530	2,43%	2019	GSS
Health and Social Work	6.996	6.996.406.511	2,14%	2019	GSS
Plantain	5.964	5.963.992.606	1,83%	2019	GSS
Professional, Administrative & Support Service act.	4.840	4.839.645.444	1,48%	2019	GSS
Cassava	4.575	4.575.306.826	1,40%	2019	GSS
Cocoa	4.417	4.416.716.859	1,35%	2019	GSS
Electricity	4.333	4.332.521.120	1,33%	2019	GSS
Forestry and Logging	4.329	4.328.693.413	1,33%	2019	GSS
Other tree crops	4.074	4.074.282.384	1,25%	2019	GSS
Manufacture of rubber and plastics products	3.626	3.625.764.065	1,11%	2019	GSS
Specialized construction activities	3.364	3.364.014.674	1,03%	2019	GSS
Groundnuts	3.283	3.283.025.707	1,01%	2019	GSS
Other Service Activities	3.208	3.207.963.967	0,98%	2019	GSS
Manufacture of other non-metallic mineral products	3.110	3.110.427.568	0,95%	2019	GSS
Fishing	3.035	3.034.769.555	0,93%	2019	GSS
Manufacture of fabricated metal products, except machinery and equipment	2.782	2.781.838.675	0,85%	2019	GSS
Oil palm	1.926	1.925.602.750	0,59%	2019	GSS
Maize	1.810	1.809.750.600	0,55%	2019	GSS
Manufacture of pharmaceuticals, medicinal chemical and botanical products	1.584	1.583.635.249	0,48%	2019	GSS
Manufacture of machinery and equipment N.E.C.	1.533	1.532.619.644	0,47%	2019	GSS
Cocoyam	1.518	1.518.368.233	0,46%	2019	GSS

Other manufacturing	1.500	1.499.888.796	0,46%	2019	GSS
Manufacture of basic metals	1.476	1.475.776.888	0,45%	2019	GSS
Water and Sewerage	1.458	1.458.019.503	0,45%	2019	GSS
Rice (Paddy)	1.423	1.423.267.158	0,44%	2019	GSS
Tomato	1.022	1.022.299.334	0,31%	2019	GSS
Civil engineering	875	874.625.517	0,27%	2019	GSS
Repair and installation of machinery and equipment	873	873.024.338	0,27%	2019	GSS
Manufacture of electrical equipment	865	864.575.763	0,26%	2019	GSS
Manufacture of coke and refined petroleum products	602	601.681.264	0,18%	2019	GSS
Onions	583	583.437.002	0,18%	2019	GSS
Printing and reproduction of recorded media	576	576.452.924	0,18%	2019	GSS
Pepper	536	536.233.531	0,16%	2019	GSS
Citrus	520	519.958.895	0,16%	2019	GSS
Cowpea	467	467.150.975	0,14%	2019	GSS
Sorghum	420	419.618.283	0,13%	2019	GSS
Manufacture of paper and paper products	401	401.419.128	0,12%	2019	GSS
Pineapple	391	390.750.268	0,12%	2019	GSS
Manufacture of wood and of products of wood and cork, except furniture;	377	377.389.954	0,12%	2019	GSS
Manufacture of textiles/Manufacture of wearing apparel	351	350.585.814	0,11%	2019	GSS
Soybean	231	230.719.741	0,07%	2019	GSS
Shallots	205	205.020.213	0,06%	2019	GSS
Millet	173	173.423.010	0,05%	2019	GSS
Manufacture of furniture	166	166.380.114	0,05%	2019	GSS
Okro	132	132.224.661	0,04%	2019	GSS
Coconut	129	129.171.359	0,04%	2019	GSS
Mango	113	112.588.314	0,03%	2019	GSS
Garden eggs	96	96.182.222	0,03%	2019	GSS
Banana	94	94.462.733	0,03%	2019	GSS
Cashew	78	78.312.935	0,02%	2019	GSS
Manufacture of computer, electronic and optical products	51	51.208.506	0,02%	2019	GSS
Manufacture of leather and related products	19	19.120.158	0,01%	2019	GSS
Pawpaw	14	13.723.907	0,00%	2019	GSS
Shea nut	4	3.500.897	0,00%	2019	GSS

Manufacture of motor vehicles, trailers, and semi-trailers/Manufacture of other transport equipment	0	-245.693	0,00%	2019	GSS
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Source: GSS (2021)

Table 26. Ghana imports and export data with trade intensities per sector

Sector Description			ISIC Rev 3.1 Code		HS 2007 Code		Trade			
ISIC Rev 4 Code	Description		ISIC Rev 3.1 Code	Description	HS 2007 Code	Description	Exports	Imports	GDP 2019 (Ghc)	Trade Intensity
2420 & 0729	Gold	Manufacture of basic precious and other non-ferrous metals & Mining of other non-ferrous metal ores	2720 & 1320	Manufacture of basic precious and non-ferrous metals & Mining of non-ferrous metal ores, except uranium and thorium ores	710811, 718012, 718013, 710900, 711100, 261690	Gold (incl. gold plated with platinum), non-monetary, in powder form; Gold (incl. gold plated with platinum), in unwrought forms (excl. powder); Gold (incl. gold plated with platinum), non-monetary, in semi-manufactured forms; Base metals/silver, clad with gold, not further worked than semi-manufactured; Base metals/silver/gold, clad with platinum, not further worked than semi-manufactured; Precious metal ores & concentrates (excl. silver ores & concentrates)	6.325.133.892	116.442	23.282.459.517	1,44
0610 & 0620 & 1920	Oil and gas	Extraction of crude petroleum & Extraction of natural gas; Manufacture of refined petroleum products	1110 & 2320	Extraction of crude petroleum and natural gas; manufacture of refined petroleum products	2705, 2709-2713, 3403	Oils and other products of the distillation of high temperature coal tar; similar products in which the weight of the aromatic constituents exceeds that of the non-aromatic constituents; Petroleum oils and oils obtained from bituminous minerals, crude; Petroleum oils and oils obtained from bituminous minerals, other than crude; preparations not elsewhere specified or included, containing by weight 70 % or more of petroleum oils or of oils obtained from bituminous minerals, these oils being the basic con; Petroleum gases and other gaseous hydrocarbons; Petroleum jelly; paraffin wax, micro-crystalline petroleum wax, slack wax, ozokerite, lignite wax, peat wax, other mineral waxes, and similar products obtained by synthesis or by other processes, whether or not colored.	5.315.954.391	280.425.855	14.848.170.410	1,82
0113	Yam	Growing of vegetables and melons, roots, and tubers	0111	Growing of sugar beet, roots, and tubers	(partial) 71490	Arrowroot, salep, Jerusalem artichokes & similar roots & tubers with high starch/inulin content, n.e.s., fresh/chilled/frozen/dried, whether/not sliced/in the form of pellets; sago pith	12.738.177	23.904	10.869.651.703	0,006

05, 07 (-precious metals of 0729), 08,09	Mining and quarrying without oil and gas and gold	Other mining and quarrying	10-14 (- part of 1320)	Mining and quarrying	25, 26 (all - 261690), 710221, 710231, 710310, 710210, 270111, 270112, 270119, 270120, 270210, 270220, 270300	All mining and quarrying excluding oil & gas and gold	420.429.165	402.896.788	10.401.531.302	0,35
	Aluminum				260600	Aluminum ores & concentrates	35.973.987	0	72.810.719	0,002
0729	Manganese	Mining of other non-ferrous metal ores	1320	Mining of non-ferrous metal ores, except uranium and thorium ores	260200	Manganese ores & concentrates, incl. ferruginous manganese ores & concentrates with a manganese content of 20%/more, calc. on the dry weight	349.539.029	61.058	6.803.666.006	0,27
WTO	Tourism								9.047.391.760	
0127 & 0163 & 1073	Cocoa	Growing of beverage crops; post-harvest crop activities; Manufacture of cocoa, chocolate, and sugar confectionery	0113, 1543, 0140	Growing of fruit, nuts, beverage, and spice crops; Manufacture of cocoa, chocolate, and sugar confectionery; Post harvest crop activities (except preliminary processing of tobacco)	18	Cocoa and cocoa preparations	2.714.504.313	2.421.149	8.491.282.384	1,70
14	Livestock	Animal production	012	Farming of animals	1	Live animals; animal products	28.900	12.517.752	8.050.081.181	0,01
20	Manufacture of chemicals and chemical products	Manufacture of basic chemicals	24	Manufacture of chemicals and chemical products: manufacture of basic chemicals, plastics in primary forms, synthetic rubbers, man-made fibers, fertilizers, paints & varnishes, other chemical products, soap, and detergents (excluded manufacture of pharmaceuticals, medicinal chemicals, and botanical products)	1518,1520, 2707,28 (- 284330), 2901-2934, 2942, 300670, 31-38, 3901-3914, 4002, 4402, 5402-5405, 5501-5504, 710410, 710420, 8523	All products under the described categories of Isic Rev 3 (subtracted 284330 Gold comps.)	82.801.939	1.199.354.934	7.944.885.530	0,48

					32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments, and other coloring matter; paints and varnishes; putty and other mastics; inks	27.680.219	59.114.168	675.315.270	0,47
0122	Plantain	Growing of tropical and subtropical fruits	0113	Growing of fruit, nuts, beverage, and spice crops	80300	Bananas, incl. plantains, fresh/dried	33.212.954	22.096	5.963.992.606	0,03
11 & 10 (-1073, -1020)	Manufacture of beverages and food products	Manufacture of beverages and food products (excluding 1073 Manufacture of cocoa, chocolate, and sugar confectionery, 1020 Processing and preserving of fish, crustaceans, and mollusks)	15 (-1543, -1512)	Manufacture of food products and beverages (excluding: 1543 Manufacture of cocoa, chocolate and sugar confectionery, palm oil, 1603Extracts and juices of meat, fish or crustaceans, mollusks, or other aquatic invertebrates.)	2, 401-408,710-712, 811, 812, 90112, 90121, 90122,90210, 90230, 100620-100640, 11, 120810, 120890, 1501-1517, 1601, 1602, 1701-1703, 19, 20-23, 350219, 350110, 350510, 4101, 4102, 510119 (-1511, -1504)	All products under the described categories (excluding: Palm oil and its fractions, whether or not refined, but not chemically modified, Fats and oils and their fractions, of fish or marine mammals, whether or not refined, but not chemically modified)	208.576.362	1.287.543.520	8.629.209.988	0,51
					151590	Fixed vegetable fats & oils (excl. of 1515.11-1515.50, incl. jojoba oil) & their fractions, whether/not refined but not chemically modified	73.620.914	244.052	3.020.223.496	0,13
0113	Cassava	Growing of vegetables and melons, roots, and tubers	0111	Growing of cereals and other crops N.E.C.	71410	Manioc (cassava)	218.240	413.398	4.575.306.826	0,0007
02	Forestry and Logging	Forestry and Logging	0200	Forestry, logging, and related service activities	604, 13, 1401, 440110, 440130, 4403, 4404	Forestry and logging products	19.074.898	18.835.820	4.328.693.413	0,05
0129, 0116, 0127	Other tree crops (coffee, rubber, cotton)	0129 Growing of other perennial crops, 0116 Growing of fiber crops, 0127 Growing of beverage crops	0111, 0113	Growing of cereals and other crops N.E.C., Growing of fruit, nuts, beverage, and spice crops	120720, 4001, 520100, 90111	Cotton seeds, whether/not broken, Cotton, not carded or combed, Natural rubber, balata, gutta-percha, guayule, chicle, and similar natural gums, in primary forms or in plates, sheets or strip, Coffee, not roasted, not decaffeinated	67.109.693	2.126.006	4.074.282.384	0,09

22	Manufacture of rubber and plastics products	Manufacture of plastics and synthetic rubber in primary forms	25	Manufacture of rubber and plastics products	3916-3926, 4005-4016, 5906, 650610, 650691, 853670, 940592	All products under the described categories of Isic Rev 3	223.483.369	316.303.438	3.625.764.065	0,54
					3923	Articles for the conveyance or packing of goods, of plastics; stoppers, lids, caps, and other closures, of plastics.	88.848.995	23.765.525	1.450.305.626	0,38
					3917	Tubes, pipes and hoses, and fittings therefor (for example, joints, elbows, flanges), of plastics.	67.980.063	23.288.017	1.087.729.220	0,40
					3924	Tableware, kitchenware, other household articles and hygienic or toilet articles, of plastics.	44.587.457	12.366.289	725.152.813	0,38
0111	Groundnuts	Growing of cereals (except rice), leguminous crops and oil seeds	0111	Growing of cereals and other crops N.E.C.	1202,200811	Groundnuts, prepared/preserved, whether/not containing added/sugar/other sweetening matter/spirit, N.E.C., Groundnuts, not roasted or otherwise cooked, whether or not shelled or broken.	800.180	806.514	3.283.025.707	0,003
023	Manufacture of other non-metallic mineral products	Manufacture of other non-metallic mineral products	026	Manufacture of other non-metallic mineral products	252020, 2522, 252310, 2715, 281810, 3801, 3816, 382450, 68, 69, 70, 854610, 854620, 940591	All products under the described categories of Isic Rev 3	43.920.045	424.401.210	3.110.427.568	0,46
					2522	Quicklime, slaked lime, and hydraulic lime, other than calcium oxide and hydroxide of heading 28.25.	17.324.449	17.041.662	1.226.921.415	0,14
					69	Ceramic products	19.227.451	88.814.804	1.361.692.449	0,31

03, 1020	Fishing	Fishing and aquaculture; Processing and preserving of fish, crustaceans, and mollusks?	05, 1512	Fishing, aquaculture, and service activities incidental to fishing; Processing and preserving of fish and fish products	3, 1603-1605, 2301, 1504	Fish and crustaceans, mollusks and other aquatic invertebrates; Extracts and juices of meat, fish or crustaceans, mollusks or other aquatic invertebrates; Prepared or preserved fish; caviar and caviar substitutes prepared from fish eggs; Crustaceans, mollusks and other aquatic invertebrates, prepared or preserved; Flours, meals and pellets, of meat or meat offal, of fish or of crustaceans, mollusks or other aquatic invertebrates, unfit for human consumption; greaves; Fats and oils and their fractions, of fish or marine mammals, whether or not refined, but not chemically modified	201.055.916	233.846.415	3.034.769.555	0,54
25	Manufacture of fabricated metal products, except machinery and equipment	Manufacture of fabricated metal products, except machinery and equipment	28	Manufacture of fabricated metal products, except machinery and equipment	7308-7326, 7413, 7415, 7418, 7419, 7508, 7610-7616, 8007, 82, 83, 8401-8404	Fabricated metal products, except machinery and equipment	27.152.406	468.686.485	2.781.838.675	0,50
					7326	Other articles of iron or steel.	9.305.655	110.104.608	953.389.949	0,41
					7615	Table, kitchen or other household articles and parts thereof, of aluminum; pot scourers and scouring or polishing pads, gloves, and the like, of aluminum; sanitary ware and parts thereof, of aluminum.	5.340.359	1.940.081	547.134.468	0,07
					82	Tools, implements, cutlery, spoons, and forks, of base metal; parts thereof of base metal	4.207.089	52.702.918	431.027.839	0,42
0126	Oil palm	Growing of oleaginous fruits	0111	Growing of cereals and other crops N.E.C.	1511, 151321, 151329	Palm oil and its fractions, whether or not refined, but not chemically modified, Palm kernel/babassu oil, crude, Palm kernel/babassu oil, other than crude, & fractions thereof, whether/not refined but not chemically modified	110.159.980	139.006.939	1.925.602.750	0,50

0119	Maize	Growing of other non-perennial crops	0111	Growing of cereals and other crops N.E.C.	1005, 110220, 110313, 110319, 110423, 110812, 151521, 151529	Maize (corn), Maize (corn) flour, Groats/meal of maize (corn), Groats/meal of cereals other than wheat & maize (corn), Corn (maize), worked other. than into flour/groats/meal (e.g., hulled/pearled/sliced/kibbled), Maize (corn) starch, Maize (corn) oil, crude, Maize (corn) oil, other than crude, & fractions thereof, whether/not refined but not chemically modified	424.481	9.891.443	1.809.750.600	0,03
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Source: own elaboration based on UNComtrade data (2019)

Table 27. Ghana GHG emissions by sector

Total Emissions (Gg CO2e) ²	
Categories	2016
National Emissions	42.920,20
1 - Energy	15.788,02
1.A - Fuel Combustion Activities	15.763,82
1.A.1 - Energy Industries	5.146,67
1.A.1.a - Main Activity Electricity and Heat Production	4.797,73
1.A.1.a.i - Electricity Generation	4.797,73
1.A.1.b - Petroleum Refining	253,24
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	95,70
1.A.1.c.i - Manufacture of Solid Fuels	95,50
1.A.1.c.ii - Other Energy Industries	0,20
1.A.2 - Manufacturing Industries and Construction	1.957,59
1.A.2.a - Iron and Steel	4,54
1.A.2.c - Chemicals	7,89
1.A.2.d - Pulp, Paper and Print	4,32
1.A.2.e - Food Processing, Beverages and Tobacco	886,41
1.A.2.i - Mining (excluding fuels) and Quarrying	697,07

1.A.2.j - Wood and wood products	32,31
1.A.2.k - Construction	163,90
1.A.2.l - Textile and Leather	101,05
1.A.2.m - Non-specified Industry	60,11
1.A.3 - Transport	7.165,83
1.A.3.a - Civil Aviation	57,22
1.A.3.a.ii - Domestic Aviation	57,22
1.A.3.b - Road Transportation	6.051,41
1.A.3.b.i - Cars	2.906,51
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	135,62
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	2.770,89
1.A.3.b.ii - Light-duty trucks	947,08
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	38,12
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	908,96
1.A.3.b.iii - Heavy-duty trucks and buses	1.259,13
1.A.3.b.iv - Motorcycles	938,69
1.A.3.c - Railways	1.055,77
1.A.3.d - Water-borne Navigation	1,42
1.A.3.d.ii - Domestic Water-borne Navigation	1,42
1.A.4 - Other Sectors	1.493,72
1.A.4.a - Commercial/Institutional	62,82
1.A.4.b - Residential	1.019,32
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	411,58
1.A.4.c.i - Stationary	0,43
1.A.4.c.ii - Off-road Vehicles and Other Machinery	171,47
1.A.4.c.iii - Fishing (mobile combustion)	239,67
1.B - Fugitive emissions from fuels	24,20
1.B.2 - Oil and Natural Gas	24,20
1.B.2.a - Oil	24,16
1.B.2.a.i - Venting	-

1.B.2.a.ii - Flaring	8,35
1.B.2.a.iii - All Other	15,81
1.B.2.a.iii.4 - Refining	15,81
1.B.2.b - Natural Gas	0,04
1.B.2.b.i - Venting	-
1.B.2.b.ii - Flaring	0,00
1.B.2.b.iii - All Other	0,04
1.B.2.b.iii.1 - Exploration	-
1.B.2.b.iii.2 - Production	0,00
1.B.2.b.iii.3 - Processing	0,00
1.B.2.b.iii.4 - Transmission and Storage	0,00
1.B.2.b.iii.5 - Distribution	0,04
1.B.2.b.iii.6 - Other	-
2 - Industrial Processes and Product Use	1.041,21
2.A - Mineral Industry	334,08
2.A.1 - Cement production	21,85
2.A.4 - Other Process Uses of Carbonates	312,23
2.A.4.b - Other Uses of Soda Ash	0,02
2.A.4.c - Non-Metallurgical Magnesia Production	-
2.A.4.d - Other (please specify) (3)	312,22
2.C - Metal Industry	92,05
2.C.1 - Iron and Steel Production	3,87
2.C.3 - Aluminum production	88,18
2.D - Non-Energy Products from Fuels and Solvent Use (6)	2,08
2.D.1 - Lubricant Use	2,08
2.F - Product Uses as Substitutes for Ozone Depleting Substances	613,00
2.F.1 - Refrigeration and Air Conditioning	613,00
2.F.1.a - Refrigeration and Stationary Air Conditioning	613,00
3 - Agriculture, Forestry, and Other Land Use	22.923,47
3.A - Livestock	3.482,67

3.A.1 - Enteric Fermentation	2.407,92
3.A.2 - Manure Management (1)	1.074,75
3.B - Land	12.872,05
3.B.1 - Forest land	(4.668,07)
3.B.1.a - Forest land Remaining Forest land (net sink)	(3.562,51)
3.B.1.b - Land Converted to Forest land (net sink)	(1.105,57)
3.B.2 - Cropland	8.331,46
3.B.2.a - Cropland Remaining Cropland	(506,42)
3.B.2.b - Land Converted to Cropland	8.837,88
3.B.3 - Grassland	8.804,18
3.B.3.a - Grassland Remaining Grassland	-
3.B.3.b - Land Converted to Grassland	8.804,18
3.B.4 - Wetlands	30,48
3.B.4.a - Wetlands Remaining Wetlands	-
3.B.4.b - Land Converted to Wetlands	30,48
3.B.5 - Settlements	173,75
3.B.5.a - Settlements Remaining Settlements	-
3.B.5.b - Land Converted to Settlements	173,75
3.B.6 - Other Land	200,25
3.B.6.a - Other land Remaining Other land	-
3.B.6.b - Land Converted to Other land	200,25
3.C - Aggregate sources and non-CO2 emissions sources on land (2)	6.568,75
3.C.1 - Emissions from biomass burning	969,40
3.C.2 - Liming	-
3.C.3 - Urea application	36,37
3.C.4 - Direct N2O Emissions from managed soils (3)	4.142,82
3.C.5 - Indirect N2O Emissions from managed soils	1.141,94
3.C.6 - Indirect N2O Emissions from manure management	58,90
3.C.7 - Rice cultivations	219,32
4 - Waste	3.167,50

4.A - Solid Waste Disposal	1.155,22
4.A.1 - Managed Waste Disposal Sites	924,18
4.A.2 - Unmanaged Waste Disposal Sites	231,04
4.A.3 - Uncategorized Waste Disposal Sites	-
4.B - Biological Treatment of Solid Waste	105,56
4.C - Incineration and Open Burning of Waste	78,86
4.C.1 - Waste Incineration	3,90
4.C.2 - Open Burning of Waste	74,97
4.D - Wastewater Treatment and Discharge	1.836,54
4.D.1 - Domestic Wastewater Treatment and Discharge	1.213,88
4.D.2 - Industrial Wastewater Treatment and Discharge	622,66

Source. Fourth National GHG Inventory Report from Ghana (2016)

Table 28. Matching response measures to country and sector

Country	Type of RM searched for	Sectors
China	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM - standards and labelling requirements for agri. goods involving GHG intensity - for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - Crude and refined oil - Fishing - M&Q without oil and gas and gold (aluminum and manganese) - Gold
Switzerland	-na	- Gold

India	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM 	<ul style="list-style-type: none"> - Crude and refined oil - Gold
South Africa	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM 	<ul style="list-style-type: none"> - Crude and refined oil - Gold
United Arab Emirates	<ul style="list-style-type: none"> - standards and labelling requirements for agri. goods involving GHG intensity 	<ul style="list-style-type: none"> - Fishing - Gold
Netherlands	<ul style="list-style-type: none"> - standards and labelling requirements for agri. goods involving GHG intensity 	<ul style="list-style-type: none"> - cocoa
USA	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM - standards and labelling requirements for agri. goods involving GHG intensity 	<ul style="list-style-type: none"> - Crude and refined oil - cocoa
United Kingdom	<ul style="list-style-type: none"> - carbon taxes - subsidy for low carbon transport - removal of subsidy for fossil fuel production - removal of subsidy for fossil fuel consumption - subsidy for energy efficiency in buildings - green procurement for automobiles - CBAM - standards and labelling requirements for agri. goods involving GHG intensity 	<ul style="list-style-type: none"> - Crude and refined oil - fishing
Japan	<ul style="list-style-type: none"> - standards and labelling requirements for agri. goods involving GHG intensity 	<ul style="list-style-type: none"> - cocoa

Malaysia	- standards and labelling requirements for agri. goods involving GHG intensity	- cocoa - manufacture of beverages and food products
Germany	- standards and labelling requirements for agri. goods involving GHG intensity - international maritime levies - international aviation levies - CBAM - standards and labelling requirements for basic materials involving GHG intensity	- cocoa - fishing - manufacture of fabricated metal products (iron and steel, aluminum)
Burkina Faso	- CBAM - standards and labelling requirements for basic materials involving GHG intensity - standards and labelling requirements for agri. goods involving GHG intensity	- palm oil - manufacture of beverages and food products - manufacture of other non-metallic mineral products - M&Q without oil and gas and gold - manufacture of fabricated metal products - manufacture of rubber and plastic products - manufacture of chemicals and chemical products
Togo	- CBAM - standards and labelling requirements for basic materials involving GHG intensity - standards and labelling requirements for agri. goods involving GHG intensity	- manufacture of beverages and food products - manufacture of fabricated metal products - manufacture of other non-metallic mineral products - manufacture of rubber and plastic products - manufacture of chemicals and chemical products
Ukraine	- CBAM - standards and labelling requirements for basic materials involving GHG intensity	- Crude and refined oil - M&Q without oil and gas and gold (aluminum and manganese)
Senegal	- standards and labelling requirements for agri. goods involving GHG intensity	- palm oil
Sierra Leone	-CBAM - standards and labelling requirements for basic materials involving GHG intensity	- manufacture of rubber and plastic products
France	- standards and labelling requirements for agri. goods involving GHG intensity	- fishing

Benin	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for agri. goods involving GHG intensity - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - manufacture of fabricated metal products (iron and steel, aluminum) - palm oil
Niger	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for agri. goods involving GHG intensity - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - manufacture of rubber and plastic products - manufacture of other non-metallic mineral products (lime, used for paper and plastics) - palm oil - manufacture of beverages & food products
Belgium	<ul style="list-style-type: none"> - standards and labelling requirements for agri. goods involving GHG intensity 	<ul style="list-style-type: none"> - manufacture of beverages and food products
Côte d'Ivoire	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - manufacture of other non-metallic mineral products (lime, used for paper and plastics)
Nigeria	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for agri. goods involving GHG intensity - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - manufacture of fabricated metal products (iron and steel, aluminum) - palm oil
Mali	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - manufacture of rubber and plastic products - manufacture of other non-metallic mineral products (lime, used for paper and plastics)
Brazil	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - M&Q without oil and gas and gold
Canada	<ul style="list-style-type: none"> - CBAM - standards and labelling requirements for basic materials involving GHG intensity 	<ul style="list-style-type: none"> - M&Q without oil and gas and gold

15.2. Results Step 5 in detail

Sector 1: Cocoa (ISIC Rev 0127,1073)

Netherlands	Japan	USA	Malaysia	Germany	Other international
EU regulation 2018/848 on organic production and labelling of organic products	JAS Organic Label based on JAS Act (Act on Japanese Agricultural Standards)	USDA National Organic Program (NOP)	Standard MS 1529:2001, Skim Organik Malaysia (SOM)	EU regulation 2018/848 on organic production and labelling of organic products	Voluntary certifications for cocoa: <ul style="list-style-type: none"> • UTZ and Rainforest Alliance • ISO 34101-1, Sustainable and traceable cocoa
EU Multi-stakeholder Dialogue for Sustainable Cocoa (until July 2021) <ul style="list-style-type: none"> • Feed into relevant EC initiatives: Circular Economy Action Plan, Farm to Fork, env. due diligence 	Platform for Sustainable Cocoa in Developing Countries <ul style="list-style-type: none"> • Established by the gov. in January 2020 			EU Multi-stakeholder Dialogue for Sustainable Cocoa (until July 2021) <ul style="list-style-type: none"> • Feed into relevant EC initiatives: Circular Economy Action Plan, Farm to Fork, env. due diligence 	Voluntary fair trade certifications <ul style="list-style-type: none"> • Fairtrade Labelling Organisations (FLO) • Fair Trade Ecocert • Fair for Life • Fairtrade International
Gov. letter of intent on 100% sustainable cocoa in the NL by 2025 <ul style="list-style-type: none"> • Dutch Initiative on Sustainable Cocoa (DISCO) 					

Sector 2: Manufacture of beverages & food products (ISIC Rev 11, 10)

Belgium	Malaysia	Burkina Faso, Togo, Niger	International transportation
EU regulation 2018/848 on organic production and labelling of organic products	Standard MS 1529:2001, Skim Organik Malaysia (SOM)	na	CORSIA/ICAO (for air freight)

Sector's main products:

- 35% Fixed vegetable fats & oils (incl. jojoba oil)
- 4.1% Tomatoes, prepared/preserved, other than whole/in pieces
- 3.7% Gin & Geneva

Note: governments provide regulations for organic standards and oversee their compliance however there is no jurisdiction where it is mandatory to label the whole food supply of the country as organic. Additionally organic guidelines usually don't mention directly climate-related issues however they still have an indirect mitigation impact where organic agricultural systems are applied (e.g. carbon sequestration in soils by using different env. practices).

Sector 3: Palm Oil (ISIC Rev 0126)

<u>Senegal</u>	<u>Nigeria</u>	<u>EU*</u>	<u>Benin, Burkina Faso, Niger</u>
<p>Law 2010-22 Regulating the Biofuels Industry</p> <ul style="list-style-type: none"> Grants biofuels fiscal benefits, revenues generated from biofuel activities are exempted from taxation for 5 yrs 	<p>National Renewable Energy and Energy Efficiency Policy (NREEEP)</p> <ul style="list-style-type: none"> Defines the government's position on how to strengthen renewable energy and energy efficiency in the country 	<p>Revised Renewable Energy Directive 2018/2001/EU</p> <ul style="list-style-type: none"> Limits high ILUC-risk biofuels (palm oil) until 2023 and will gradually decrease to zero by 2030 	na
<p>Renewable Energy Law (No. 2010-21)</p> <ul style="list-style-type: none"> Regulates the renewable energy sector outlining goals, laying the foundation for a feed-in-tariff scheme, and providing tax incentives for development 	<p>Nigerian Bio-fuel Policy and Incentives</p> <ul style="list-style-type: none"> Measures aimed at stimulating market demand for biofuels and promoting their production (e.g. tax exemptions) 	<ul style="list-style-type: none"> Belgium, France, Austria and Netherlands announced ban of palm oil as a raw material for transport biofuel from mid-2022. 	
<p>Decree No. 2013-684 on the establishment, organization and functioning of the National Agency for Renewable Energies</p> <ul style="list-style-type: none"> Promote the use of renewable energy, including bioenergy 			

*Not in the top 5 export countries for this sector, only in top 10 but considered since it is a priority product for the Ghanaian National Export Development Strategy (NEDS)

Sector 4: Fishing (ISIC Rev 3,102)

<u>United Kingdom</u>	<u>France</u>	<u>Germany</u>	<u>United Arab Emirates</u>	<u>China</u>	<u>International transportation</u>		
Food (Provisions relating to Labelling) (England, Wales, NI) Regulations 2003 (S.I. No. 2647 of 2003)	Farm to Fork Strategy (EGD) - Aims to reward farmers, fishers and other operators in the food chain who have undergone the transition to sustainable practices. Shift to sustainable fish and seafood production must also be accelerated	Farm to Fork Strategy (EGD) - Aims to reward farmers, fishers and other operators in the food chain who have undergone the transition to sustainable practices. Shift to sustainable fish and seafood production must also be accelerated	Emirates Organic Foods Certification Scheme - Federal law no. (5) Year 2009 for Organic Foods and their inputs.	Directions on Issuing the Organic Labelling Approval Operations Document of Imported Aquatic Products and Aquatic Processed Products	<ul style="list-style-type: none"> • International Maritime Organization (IMO) and other shipping climate change related measures • CORSIA/ICAO (for air freight) 		
				Rules of the Environmental Protection Administration of the Executive Yuan (Taiwan) governing the environmental protection labelling product application and review			
				Measures for the Administration of Organic Product Certification (AQSIQ Decree No. 155)	<table border="1"> <thead> <tr> <th>Other international</th> </tr> </thead> <tbody> <tr> <td>Marine Stewardship Council (MSC) label</td> </tr> </tbody> </table>	Other international	Marine Stewardship Council (MSC) label
Other international							
Marine Stewardship Council (MSC) label							

Note: governments provide regulations for organic standards and oversee their compliance however there is no jurisdiction where it is mandatory to label the whole food supply of the country as organic. Additionally, organic guidelines usually don't mention directly climate-related issues however they still have an indirect mitigation impact where organic fishing practices are applied.

Sector 5: Oil & Gas (ISIC Rev 0610, 0620, 1920)

China	South Africa	India	USA	United Kingdom	International Transportation
<p>NEV Programme China</p> <ul style="list-style-type: none"> - by 2025 25% New Energy Vehicle Programme (NEV) (includes PHEV, BEV, FCEV) - government introduced a mandatory credit policy for vehicle suppliers to boost domestic sales of NEVs 	<p>Carbon Tax Bill</p> <ul style="list-style-type: none"> - Came into effect in 2019 - Applies to GHG emissions from the industry, power, buildings and transport sectors irrespective of the fossil fuel used, with partial exemptions for all these sectors 	<p>National electric car purchase subsidy and income tax deduction on loans. Phase II of Faster Adoption and Manufacturing of Electric Vehicles (FAME II)</p> <ul style="list-style-type: none"> - Income tax deduction of \$ 2000 on interest paid on electric vehicle loans - deployment of charging stations 	<p>Zero-Emission Program (ZEV) for (PHEV, BEV, FCEV)</p> <ul style="list-style-type: none"> - by 2025 3.3 million ZEVs in 11 states - by 2050 all passenger vehicle sales to be ZEV in 10 States - Managed by The California Air Resources Board (CARB) 	<p>UK carbon Price Floor</p> <ul style="list-style-type: none"> - Users liable for payment of the tax for all fossil fuels. - The tax covers all fossil fuels 	<ul style="list-style-type: none"> • International Maritime Organization (IMO) and other shipping climate change related measures • CORSIA/ICAO (for air freight)
<p>National electric car purchase subsidy and exemption of purchase tax (10%)</p> <ul style="list-style-type: none"> - Maximum retail price USD 42 400 - USD 2 300 if BEV 300 km ≤ range < 400 km - USD 3 200 if BEV range ≥ 400 km - USD 1 200 PHEV range ≥ 50 km 	<p>Carbon dioxide vehicle emissions tax (2010)</p>	<p>National Electric Mobility Mission Plan (NEMMP) 2020</p> <ul style="list-style-type: none"> - Mix of incentive-based policies accompanied by regulatory reforms, and PPS to encourage EV adoption, expand charging infrastructure and support domestic EV and supply equipment manufacturing capacity and battery manufacturing 	<p>CBAM (under consideration)</p> <ul style="list-style-type: none"> - implement a levy on carbon-intensive imports, albeit without a federal domestic carbon price - impose carbon adjustment fees or quotas on carbon-intensive goods from countries that are failing to meet their climate and environmental obligations 	<p>UK ETS</p> <ul style="list-style-type: none"> - launched on 1 January 2021 - UK ETS closely follows the EU Emissions Trading Scheme ("EU ETS") - Established by the Greenhouse Gas Emissions Trading Scheme Order 2020 - The UK ETS will apply to energy intensive industries, the power generation sector and aviation. 	
<p>Fuel economy standard for light duty vehicles</p> <ul style="list-style-type: none"> - Updated for period 2021-25 - Standard, to be phased in gradually from 2021, sets a 4L/100 km target for the country's new vehicle fleet in 2025 		<p>Clean air standard</p>	<p>Tax reduction for electric car purchase</p> <ul style="list-style-type: none"> - Tax credit up to USD 7 500 (PHEV and BEV) 	<p>United Kingdom (EV30@30 signatory)</p> <ul style="list-style-type: none"> - by 2030 50-70% EV - by 2035 No sales of new ICEe 	
<p>EV charging infrastructure policies</p> <ul style="list-style-type: none"> - rollout of subsidies for EV charging infrastructure at national and subnational level (eg. Shenzhen) - The State Grid has announced plans to increase investment in charging stations - City of Beijing has outlined a policy to provide up to USD 28 300 in subsidies per station for operators 		<p>National Mission on Transformative Mobility and Battery Storage</p> <ul style="list-style-type: none"> - manufacturing scope includes solar equipment, battery storage and charging infrastructure 	<p>Transportation and Climate Initiative (TCI) ETS</p> <ul style="list-style-type: none"> - Transport fuel suppliers that produce the covered fuels within these states, as well as suppliers that import them to those states. - Program will cap CO2 emissions from the combustion of gasoline and on-road diesel fuel in the participating states 	<p>National electric car purchase subsidy</p> <ul style="list-style-type: none"> - Up to USD 3 800 (BEV and PHEV)* - Capped at 35% of retail price. Only for cars < USD 63 600 - *If < 50 gCO2/km and electric range > 112 km 	

Sector 5: Oil & Gas (ISIC Rev 0610, 0620, 1920)(2)

China	India	USA	United Kingdom
National ETS (started operating 2021) -The scope is expected to be gradually expanded to cover seven other sectors in addition to power: petrochemical, chemical, building materials, steel, nonferrous metals, paper, and domestic aviation - There is no specific timeline for this expansion	State Level policies supporting EV deployment and taxes on motor vehicles - financial incentives, duty waivers, exemptions from permit fees, streamlined registration processes and supporting infrastructure to encourage EV uptake and charging station deployment.	US Electrify Forward Act (2020) - accelerate domestic manufacturing of batteries, power electronics and other technologies in plug-in vehicles, encourage the installation of EV charging infrastructure, modify and reauthorize the Advanced Technology Vehicles Manufacturing Incentive Program	Considerations of a CBAM
Subnational ETS Pilots - The existing Chinese regional ETS pilots are gradually transitioning into the national ETS	Exploring options such as energy efficiency regulations and fuel diversification to reduce its oil import dependence by 10% in 2022	Oregon ETS (under consideration) - Emissions cap and reductions for large emitters and transportation fuels	Various incentives for Ultra Low Emissions Vehicles (ULEVs)
Law on the Prevention and Control of Atmospheric Pollution		Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, Corporate Average Fuel Economy (CAFE) standards (NHTSA/EPA, 2020) - Revised version are a roll back from the current federal standard that passed in 2012	
Energy Conservation Law - Industrial and Transport Energy Conservation - Encourages to develop and promote the use of clean fuels and alternative fuels of oil		State level policies supporting the commercial deployment of alternative fuel vehicles and/or their supporting infrastructure - Statewide subsidies, tax credits, or waivers or reductions on inspections that explicitly support EV purchase for private individuals, low-interest loans, leasing	
Subsidies for energy-saving automobiles		Federal tax credit for purchase of EVs not extended (tax exemption of USD2500-7500)	
China’s 14th Five-Year Plan (14th FYP, 2021 to 2025) - sets a 18% “CO2 intensity” and 13.5% “energy intensity” reduction target - Relevant climate targets: “Reduction in energy consumption per unit of GDP(%)”; “Reduction of CO2 emissions per unit of GDP (%)” (binding) - construction of 8 large-scale clean energy “bases” (coastal nuclear power, electricity transmission routes, power system flexibility, oil-and-gas transportation and storage capacity)		California’s Low Emission Vehicles (LEV III) pollutant emissions and GHG regulations California’s e Innovative Clean Transit Regulation to reduce emissions from HDV and other state level initiatives fro medium and heavy duty vehicles Extension of federal tax credit on charging infrastructure 2019 State level charging infrastructure incentives California Cap and Trade Programme (CaT) - Emissions from industry, power, transport and buildings sectors and includes industrial process emissions - Industry operators (> 25,000 tCO2e) are liable for reporting their covered emissions at a facility level.	

Sector 6: Mining and quarrying without oil and gas and gold (ISIC Rev 05, 07 (- 0729), 08,09)

<u>China</u>	<u>Brazil</u>	<u>Canada</u>	<u>Ukraine and Burkina Faso</u>	<u>International transportation</u>
China Environmental Labelling Program (CELP) - Aims to promote green purchase and green manufacturing in China - Covers sectors as automobile, electrical, construction, textile packaging, chemical	Brazil ETS (under consideration)	CBAM (under consideration) - The gov. will soon launch a consultation process on a carbon border adjustment mechanism (CBAM)	na	International Maritime Organization (IMO) and other shipping climate change related measures
National ETS -The scope is expected to be gradually expanded to cover petrochemical, chemical, building materials, steel, nonferrous metals, paper, and domestic aviation				
Subnational ETS Pilots - existing Chinese regional ETS pilots are gradually transitioning into the national ETS				

Sector's main products:

- 65% Manganese ores & concentrates
- 7% Aluminium ores & concentrates

Sector 7: Manufacture of other non-metallic mineral products (ISIC Rev 23)

Burkina Faso	Côte d'Ivoire	Mali	Niger	Togo
na	na	na	na	na

Sector's main products:

44% Ceramic products

40% Quicklime, slaked lime and hydraulic lime

- Quicklime has wide range of uses, including in the production of iron and steel, paper and pulp, treatment of water and flue gases and other uses in the mining industry. Databases don't provide description of the final use of the product in the export country.

Sector 8: Manufacture of fabricated metal products, except mach. and equip. (ISIC Rev 25)

Germany	Nigeria	Burkina Faso	Benin	Togo	International Transportation
EU Carbon Border Adjustment Mechanism (CBAM)	na	na	na	na	International Maritime Organization (IMO) and other shipping climate change related measures

Sector's main products:

- Other articles of iron or steel 34%
- Table, kitchen or other household articles and parts thereof of aluminium 20%
- Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal 15%

Sector 9: Manufacture of rubber and plastic products (ISIC Rev 22)

<u>Burkina Faso</u>	<u>Togo</u>	<u>Sierra Leone</u>	<u>Mali</u>	<u>Niger</u>
na	na	na	na	na
<u>Other international</u>				
<ul style="list-style-type: none"> Carbon Border Adjustment Mechanism in the EU and under consideration in other countries, European Strategy for Plastics, EU Circular Economy Action Plan 				

Sector's main products:

- 40% Articles for the conveyance or packing of goods, of plastics; stoppers, lids, caps and other closures, of plastics
- 30% Tubes, pipes and hoses of plastics
- 20% Tableware, kitchenware, other household articles and hygienic or toilet articles, of plastics

Sector 10: Manufacture of chemicals and chemical products (ISIC Rev 20)

<u>Togo</u>	<u>Burkina Faso</u>	<u>Côte d'Ivoire</u>	<u>Benin</u>	<u>Nigeria</u>
na	na	na	na	na
<u>Other international</u>				
<ul style="list-style-type: none"> Carbon Border Adjustment Mechanism in the EU and under consideration in other countries 				

Sector's main products:

- 9% Tanning or dyeing extracts
- 2,4% Surface-active, washing and cleaning preparations
- 2,2% Beauty/make-up preparations, incl. sunscreen/sun tan preparations

15.3. Detailed results Step 6

Annex Table A1 Effects of IMO carbon tax on Ghana trade flows and production, all sectors (%change to base)

	<i>Imports</i>				<i>Exports</i>				<i>Production</i>			
	<i>Prices</i>		<i>Quantities</i>		<i>Prices</i>		<i>Quantities</i>		<i>Prices</i>		<i>Quantities</i>	
	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100	IMO-50	IMO-100
<i>Oil seeds</i>	-0.1	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	-0.0
<i>Crop agriculture</i>	0.2	0.3	-0.3	-0.5	-0.0	-0.1	-0.0	-0.0	-0.1	-0.1	-0.0	-0.0
<i>Fishing</i>	-0.1	-0.1	-0.0	-0.0	0.0	0.1	0.1	0.1	-0.1	-0.1	-0.0	-0.0
<i>Livestock agriculture</i>	0.3	0.5	-0.3	-0.5	0.0	0.1	0.0	0.1	-0.1	-0.1	-0.0	-0.0
<i>Extraction of crude oil</i>	0.0	0.0	0.1	0.1	-0.0	-0.1	-0.4	-0.9	-0.0	-0.1	-0.4	-0.8
<i>Other mining and extraction (incl. gold, aluminum)</i>	0.3	0.6	0.1	0.2	-0.1	-0.2	-0.1	-0.2	-0.1	-0.2	-0.1	-0.2
<i>Vegetable oils and fats</i>	0.1	0.3	-0.2	-0.4	-0.0	-0.0	0.1	0.2	-0.0	-0.0	0.1	0.2
<i>Meat and dairy</i>	0.0	0.1	-0.2	-0.4	-0.0	-0.0	0.1	0.2	-0.1	-0.1	0.0	0.0
<i>Other food</i>	0.1	0.2	-0.2	-0.3	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.0	-0.1
<i>Textiles, leather</i>	0.1	0.2	-0.2	-0.4	0.0	0.1	0.1	0.3	-0.0	-0.0	0.0	0.1
<i>Petroleum and coal products</i>	0.0	0.1	-0.2	-0.3	0.0	0.0	-0.2	-0.5	0.1	0.1	-0.2	-0.4
<i>Chemical products</i>	0.1	0.2	-0.1	-0.3	0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0
<i>Basic pharmaceutical products</i>	0.0	0.1	-0.1	-0.2	0.0	0.1	0.1	0.1	-0.0	-0.0	0.0	0.0
<i>Rubber and plastic products</i>	0.1	0.2	-0.1	-0.3	-0.0	-0.1	-0.1	-0.2	0.0	0.0	-0.0	-0.1
<i>Mineral products</i>	0.3	0.6	-0.1	-0.1	-0.0	-0.1	0.2	0.3	0.0	0.1	0.3	0.6
<i>Iron and steel</i>	0.2	0.4	-0.1	-0.2	-0.0	-0.1	0.1	0.3	-0.0	-0.0	0.2	0.4
<i>Aluminum and other metals (incl. gold)</i>	0.0	0.0	0.0	-0.1	-0.0	-0.0	0.2	0.4	-0.0	-0.0	0.2	0.4
<i>Metal products</i>	0.1	0.2	-0.2	-0.3	0.0	0.0	0.2	0.3	-0.0	-0.1	0.1	0.2
<i>Electronics, equipment</i>	0.1	0.2	-0.1	-0.1	0.0	0.1	0.1	0.2	0.0	0.1	0.0	0.1
<i>Machinery, motor, and transport vehicles</i>	0.1	0.2	-0.1	-0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1
<i>Other manufacturing</i>	0.1	0.2	-0.2	-0.3	-0.0	-0.1	0.0	0.0	-0.0	-0.0	0.1	0.1
<i>Electricity</i>	0.0	0.0	-0.0	-0.0	0.0	0.1	0.0	0.0	0.0	0.0	-0.0	-0.0
<i>Water supply and distribution</i>	0.0	0.0	-0.1	-0.2	0.0	0.1	0.1	0.2	-0.0	-0.1	-0.0	-0.0
<i>Construction</i>	0.0	0.1	-0.0	-0.1	0.0	0.0	0.0	0.1	-0.0	-0.0	0.0	0.0
<i>Other transport</i>	-0.0	-0.0	-0.2	-0.3	0.1	0.1	-0.1	-0.1	-0.0	-0.1	-0.1	-0.3
<i>Water transport</i>	2.4	4.9	-2.2	-4.3	-0.5	-1.0	-0.6	-1.1	-0.0	-0.1	-0.2	-0.3
<i>Air transport</i>	-0.0	-0.1	-0.1	-0.3	0.1	0.1	-0.1	-0.2	-0.0	-0.0	-0.2	-0.3
<i>Trade services</i>	0.0	0.0	-0.1	-0.2	0.0	0.1	0.0	0.0	-0.0	-0.1	-0.1	-0.1
<i>Accommodation and food serv.</i>	0.0	0.1	-0.1	-0.2	0.0	0.0	0.0	0.0	-0.0	-0.1	-0.0	-0.1
<i>Financial Communication and business services</i>	0.0	0.0	-0.1	-0.2	0.0	0.1	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1
<i>Education and health services</i>	0.0	0.0	-0.0	-0.1	0.0	0.1	0.1	0.1	-0.0	-0.1	0.0	0.0
<i>Recreational and other services</i>	0.0	0.0	-0.1	-0.2	0.0	0.0	0.0	0.1	-0.0	-0.1	-0.0	-0.1
<i>Public administration, defense</i>	0.0	0.0	-0.0	-0.1	0.0	0.0	0.1	0.1	-0.1	-0.1	0.0	0.0

Note: All below one decimal place is considered within the bounds of error

Annex Table A2 IMO-100 Effects on Ghana exports, aggregate and by partner region

IMO-100	Exports	Africa LDCs	Rest of Africa	Rest of Central Europe	North America	Latin America a. Caribbean	Oceania	East Asia	LDCs Asia a. Oceania	South and Southeast Asia	Eastern Europe	Western Asia	Africa LDCs
Oil seeds	-0.0		0.3	0.4	0.4	0.3	0.1		0.5		-0.1	0.1	0.3
Crop agriculture	-0.0	-0.4	0.4	0.1	0.1	0.0	0.1	-0.0	-0.3	0.3	-0.1	0.1	-0.1
Fishing	0.1	-0.0		0.1	0.2	0.1	-0.0	-0.1	0.1		0.1	0.1	0.0
Livestock agriculture	0.1			0.1	0.1	0.1			0.2				-0.0
Extraction of crude oil	-0.9		-1.1	-0.9	-0.7	-0.1	-0.5		-0.8	-0.4	-0.2	-0.5	-0.5
Other mining and extraction (incl. gold, aluminum)	-0.2	-0.2	0.0	-0.1	-0.1		0.1		-0.3		-0.1	-0.0	
Vegetable oils and fats	0.2	0.2	0.4	0.1	0.5	0.2		0.3	0.6		-0.1		-0.3
Meat and dairy	0.2	0.1	0.2	0.5	0.5	0.4			0.4		0.3	0.1	0.1
Other food	-0.0	-0.2	0.1	0.0	0.0	-0.1	0.0	-0.1	-0.1	0.1	-0.1	-0.2	-0.2
Textiles, leather	0.3	0.1	0.2	0.4	0.5	0.4	0.2	0.0	0.3		0.3	0.1	0.2
Petroleum, coal products	-0.5	-0.5	-0.3										
Chemical products	-0.0	-0.1	0.2	0.2	0.2	0.2	0.2	0.0	-0.1		0.2	-0.0	0.2
Basic pharma. products	0.1	0.0	0.1	0.4	0.3	0.2	0.1	-0.0	0.3		0.3	0.0	0.1
Rubber, plastic products	-0.2	-0.1	0.3	-0.3	-0.3	-0.2	0.2	0.1	0.4		-0.6	0.0	0.2
Mineral products	0.3	0.3	0.7				0.6						-0.0
Iron and steel	0.3	0.3	0.8	0.5			0.6				0.1		0.5
Aluminum, other metals (incl. gold)	0.4	0.3	0.6	0.3	0.4	0.6	0.6	0.4	0.5		0.5		0.4
Metal products	0.3	0.1	0.6	0.5	0.5	0.5	0.4	0.2	0.6		0.5	0.2	0.4
Electronics, equipment	0.2	0.1	0.2	0.3	0.3	0.2	0.1	-0.0	0.2		0.2	0.0	0.2
Mach., motor transp. vehicles	0.1	0.0	0.1	0.2	0.2	0.1	0.1	-0.1	0.2		0.2	-0.0	0.1
Other manufacturing	0.0	0.2	0.3	-0.1	0.2	-0.2	0.4	0.2	-0.0		0.2	0.2	-0.0
Electricity	-0.0	-0.1	-0.1	0.1	0.1	0.1	-0.1		0.0	0.0	0.0	-0.2	-0.1
Water supply, distribution	0.2			0.3	0.3	0.1			0.1				
Construction	0.1			0.1					0.1			-0.0	0.0
Other transport	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.3	-0.1	-0.1	-0.1	-0.3	-0.3
Water transport	-1.1			-0.7	-1.5	-2.4	-1.6	-2.2	-1.7		-1.5	-2.0	-1.5
Air transport	-0.2		-0.2	-0.1	-0.1	-0.1	-0.2	-0.4	-0.1		-0.2	-0.3	-0.3
Trade services	0.0		-0.1	0.1	0.1	0.0	-0.1	-0.2	0.0		-0.0	-0.1	-0.2
Accommodation and food serv.	0.0								0.0				
Fin. Comm., business serv.	-0.0	-0.1	-0.1	0.1	0.1	0.0	-0.1	-0.2	0.0	-0.0	0.0	-0.1	-0.2
Education, health services	0.1	0.0	0.1	0.3	0.2	0.1	0.1	-0.1	0.2	0.1	0.4	-0.0	0.1
Recreational, other serv.	0.1	-0.1	-0.0	0.1	0.1	0.1	-0.0	-0.2	0.1		0.1	-0.1	-0.1
Public admin., defense	0.1	0.0	0.1	0.4	0.3	0.1	0.1	-0.1	0.2	0.1	0.6	-0.0	0.1

Note: All below one decimal place is considered within the bounds of error

Annex Table A3. Scope 1 CO₂-emission intensity, by region (in tons CO₂ per million \$ of output)

	<i>Ghana</i>	<i>Africa LDCs</i>	<i>Rest of Africa</i>	<i>European Union</i>	<i>Rest of Central Europe</i>	<i>North America</i>	<i>Latin America and Caribbean</i>	<i>Oceania</i>	<i>East Asia</i>	<i>LDCs Asia a. Oceania</i>	<i>South and Southeast Asia</i>	<i>Eastern Europe</i>	<i>Western Asia</i>
<i>Chemical products</i>	0.037	0.014	0.022	0.009	0.005	0.011	0.016	0.017	0.023	0.055	0.023	0.037	0.058
<i>Mineral products</i>	0.065	0.053	0.058	0.024	0.022	0.035	0.042	0.024	0.080	0.087	0.174	0.082	0.073
<i>Iron and steel</i>	0.014	0.018	0.067	0.012	0.014	0.021	0.039	0.011	0.033	0.026	0.141	0.072	0.036
<i>Aluminum, other metals (incl. gold)</i>	0.001	0.002	0.019	0.004	0.001	0.005	0.016	0.028	0.008	0.003	0.022	0.007	0.018

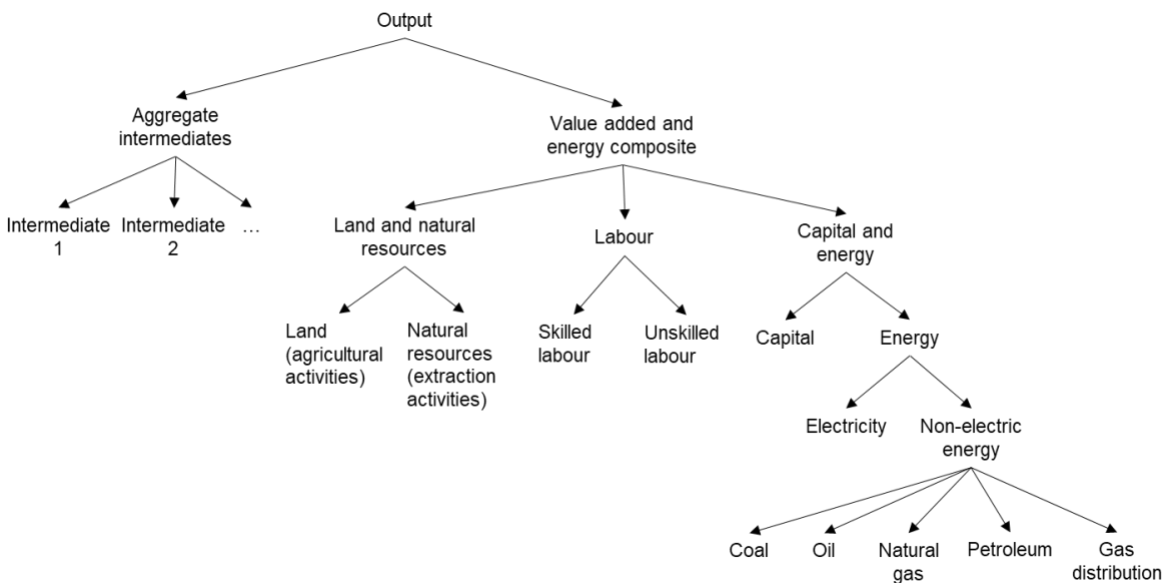
Source: GTAP v10 (Aguiar et al. 2019)

15.4. Technical model description

ANNARES is a global CGE model deriving from the GLOBE model family (McDonald and Thierfelder)²⁹. The focus of the model is on international trade relationships.

The model differentiates activities and commodities. Activities produce commodities drawing on intermediate inputs and factors of production. They are maximizing profits using nested production specifications, detailed in Figure A1. Output is formed by a value added and energy composite, and aggregate intermediate inputs using Constant Elasticity of Substitution (CES) technology. Intermediates are used in fixed shares employing Leontief production functions. Value added and energy products are depicted by a multi-level nested CES technology, where land and natural resources are combined with a labor composite and a composite of capital and a detailed energy nesting (Figure A1).

Figure A14 Production nesting



The elasticity of substitution in the first level is set to 0.5. The production nesting follows the approach of the GTAP-E model (McDougall and Golub, 2009), in consequence, the model applies elasticities similar to the GTAP-model.

Trade is depicted by a two-level nested CES structure on the import side, allowing for imperfect substitution, first, between domestic and imported commodities and, second, imperfect substitution between different source regions. The model incorporates an additional feature allowing to import commodities from regions that account only for a small share to be imported in fixed shares. Thus, large terms of trade effects can be avoided. The feature is not used in the

²⁹ Refer to www.cgemod.org for a detailed model documentation and genealogy.

current study³⁰. Similar to the import side, the export side assumes imperfect substitution, first, between domestic sales and exports, and second, between different export destinations using Constant Elasticity of Transformation (CET) functions. Consequently, domestic producers are responsive to prices in the different markets – the domestic market and all other regions in the model – and adjust their volumes of sales according to relative prices.

The elasticities used in the trade functions are sourced from GTAP, which differ by commodity (group) but are not region specific. The first level is half the value used in the second level and export elasticities mirror import elasticities.

Households maximize utility subject to preferences represented by a Cobb Douglas function, having first paid income taxes and having saved a fixed proportion of after-tax income. A special region, the Globe region, serves as distributor for values where full bilateral information is not available, as is the case with transport margins. Regions export transport services to the artificial Globe region, which redistributes margins according to its uses.

The model incorporates various tax instruments, such as import tariffs, VAT, factor taxes or taxes on income. Tax revenues constitute income to the government and are used to satisfy government expenditures.

CO2 emissions are sourced from GTAP and enter the model as side account. Emissions are related to household consumption and the use of energy commodities in the production process. A tax on CO2 emissions allows to put a price on the use of CO2, entering the respective price equations for use of intermediates in the production process and household consumption.

15.5. Scenario technical details

a. The carbon tax instrument on international transport (IMO and ICAO/CORSIA)

The carbon tax on international transport is implemented as specific export tax, such is levied on the volume of exports. This setup makes sure the tax is also levied on transport services serving international transport margins.

The carbon tax ($TECARB_{c,r}$) is subject to the tax per ton of CO2 ($TEC_{a,r}$) and the carbon content used to supply the specific service ($a=c$), defined as the emissions ($CO2EMIT_{a,r}$) per unit of output ($QX_{a,r}$) in region r . The coefficient $ioqxcq_{a,c,r}$ governs the transfer between activities and commodities (1:1 mapping in the GTAP database).

$$TECARB_{c,r} = \sum_a \left[ioqxcq_{a,c,r} * TEC_{a,r} * \frac{CO2EMIT_{a,r}}{QX_{a,r}} \right]$$

The carbon tax enters the export price equation in form of a specific tax.

$$PER_{c,w,r} = [PWE_{c,w,r} * (1 - TE_{c,w,r}) - TECARB_{c,r}] * ER_r$$

³⁰ The small shares feature is, however, used for the tourism shock, see the scenario description for more detail.

Where $PER_{c,w,r}$ is the bilateral domestic export price of commodity c exported by region r to region w , $PWE_{c,w,r}$ the international export price, $TE_{c,w,r}$ an ad-valorem export tax and ER_r the exchange rate.

The associated tax revenue ($ECARB TAX_r$) is determined by the quantity exported ($QER_{c,w,r}$).

$$ECARB TAX_r = \sum_{c,w} QER_{c,w,r} * TECARB_{c,r} * ER_r$$

b. Tourism (ICAO/CORSIA):

Increasing costs of air transport are expected to affect tourism. The simulations on international air transport therefore include a shock of tourism. Tourism constitutes an export of services, and tourism is shocked by decreasing export demand according to the size of tourism in identified tourism sectors. The procedure follows four steps:

1. Determine the change in the price of air transport:
The model is run, applying carbon taxes of international air transport in size of 50\$/ton CO2 and 100\$/ton CO2. This pre-run renders the price increase of air transport associated with the carbon tax (4.5% and 9.1%).
2. Determine the change in the number of arrivals:
The responsiveness of tourism arrivals to changes in air transport prices is depicted by the price elasticity for demand for air travel. Elasticities are sourced from Scheelhaase and Grimme (2007), who report different elasticities for leisure and business as indicated below:

Table A1: Tourism details

	Price elasticity of demand		breakdown between business and leisure travelers
	Lower bound	Upper bound	
<i>business travelers</i>	-0.5	-0.9	0.58
<i>leisure travelers</i>	-1.1	-1.5	0.42

Source: Scheelhaase and Grimme (2007), Ghana Tourism Authority and 2019 Tourism Report

International tourist arrivals and size of expenditures and break down of these expenditures by sector is sourced from the Ghana Immigration Service and Ghana Tourism Authority and 2019 Tourism Report³¹. The report details the purpose of visit. This information is used to derive a breakdown between business travelers to Ghana and leisure travelers to Ghana as depicted in Table A1. Business travelling includes travelling for the purpose of business, conference, conventions, study/teaching and official govt

³¹ <https://visitghana.com/wp-content/uploads/2021/04/Ghana-Tourism-Report-2019-min.pdf>

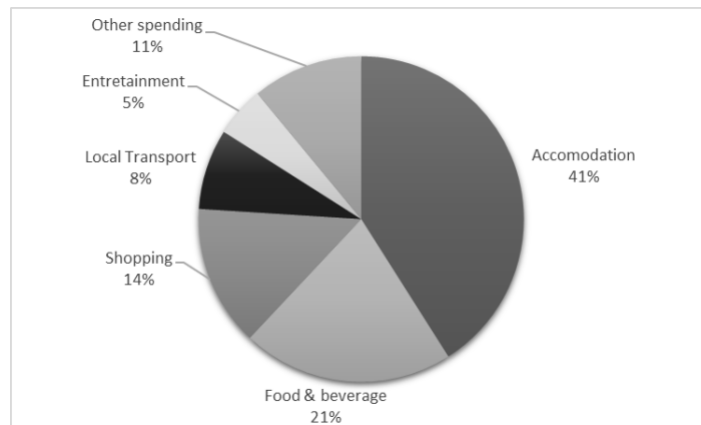
affairs and leisure travelling includes culture, holidays, visit family/friends, sports, health, and other purposes.

The combination of the price change (1.) with elasticities and number of travelers in each group renders the change in the number of arrivals to Ghana.

3. Sectoral breakdown:

The Ghana Tourism report details the average amount travelers spend per sector, as detailed in Figure A2.

Figure A15: Sectoral breakdown of tourist expenditures in Ghana



Source: Ghana Tourism Authority and 2019 Tourism Report

This information is used to derive the decrease of expenditures by sector.

4. Derive factor of reduction of exports:

The decrease in spending by sector is reducing Ghana's exports in the respective sectors. For modelling reasons, the decrease in each sector cannot be larger than 80% of exports in this sector, which has been the case for accommodation and food services. The remainder is reallocated to other tourism sectors.

The derived factors by which exports are reduced are used to decrease demand for Ghana's tourism services in the rest of the world. Technically tourism imports from Ghana are set as small shares imports and the respective import coefficient is shifted accordingly, thus, decreasing demand

c. The carbon border adjustment mechanism (CBAM)

CBAM is implemented as specific import tariff depending on the sector's CO2 content of the source region (emissions scope 1).

The commodity c , origin region w and region r specific carbon tax ($TMCARB_{w,c,r}$) is subject to the tax per ton of CO2 ($TMC_{w,c,r}$) and the carbon content used to produce the specific commodity in its origin region ($CO2EMIT_{a,w}$) expressed per unit produced ($QX_{a,w}$). The coefficient $ioqxcqx_{a,c,w}$ governs the transfer between activities and commodities (1:1 mapping in the GTAP database).

$$TMCARB_{w,c,r} = TMC_{w,c,r} \sum_a \left[ioqxcqx_{a,c,w} * \frac{CO2EMIT_{a,w}}{QX_{a,w}} \right]$$

The carbon tax enters the import price equation in form of a specific tax.

$$PMR_{w,c,r} = [PMM_{w,c,r} * (1 + TM_{w,c,r}) + TMCARB_{w,c,r}] * ER_r$$

Where $PMR_{w,c,r}$ is the bilateral domestic import price of commodity c imported by region r from region w , $PMM_{w,c,r}$ the import price fob, $TM_{w,c,r}$ an ad-valorem import tariff and ER_r the exchange rate.

The associated tax revenue ($MCARB TAX_r$) is determined by the quantity imported ($QMR_{w,c,r}$).

$$MCARB TAX_r = \sum_{c,w} QMR_{w,c,r} * TMCARB_{w,c,r} * ER_r$$

15.6. Closures

The macroeconomic closure conditions reflect assumptions about macroeconomic behavior, determining the way the model adjusts. Changes in investment and borrowing or lending relocate welfare changes to the future. For example, today's investment is paid from savings and thus sacrifices consumption today; money saved today, however, transfers income to the future. In order to internalize all welfare effects, the closure setup avoids changes in investment and borrowing of countries. The base closure setup assumes a fixed external balance, assuming that foreign borrowing does not change, the exchange rate adjusts to relative changes between regions. The investment volume is fixed. The government account clears adjusting government expenditures, tax rates and the government balance are fixed. Extraction activities use predefined capital, Fix capital sectors. All factors in all other activities are mobile and fully employed. The Consumer Price Index (CPI) serves as numeraire.

The relevance of these macroeconomic conditions on the model results are evaluated running the scenarios with alternative closure settings. The results are detailed in Table A2

Fix Savings rate

Multiplicative Savings rates are fixed. The size of savings is determined by changes in income and investment adjusts to changes in savings.

Effects are small (noticeable only on two-digit percentage change). The closure setup allows to transfer some negative effects to the future, as savings and subsequently investment decrease. Effects in this closure setup are consequently less negative.

Flexible income tax – constant volume of government expenditure

The internal balance and the government expenditure volume is held constant. Tax revenue generated can reduce taxes elsewhere in the economy. In this setting, changes in tax revenues are redistributed to households, allowing the income tax rates to change. The advantage of this assumption is that it is not economically distorting.

In this setting effects are less negative compared to the base closure, e.g., production effects are slightly less negative. Avoiding distortions from changing government expenditure the economy as whole is better off.

Fix Exchange rate– flexible current account balance

A flexible current account balance flexible allows regions to increase their international borrowing.

For Ghana this means in the conducted simulations, that effects are less negative, and the rest of the world is financing a part of the negative welfare effects. There is no change in the exchange rate, imports drop less, and exports decrease stronger. However, the price is increasing foreign debt.

Table A2. Macroeconomic effects, varying closure setup (% change)

	<i>IMO-50</i>				<i>IMO-100</i>			
	fixINV- base	fixSAV	flexTYH	fixER	fixINV- base	fixSAV	flexTYH	fixER
<i>Exchange rate</i>	0.09	0.09	0.08		0.17	0.17	0.15	
<i>Imports</i>	-0.13	-0.13	-0.12	-0.07	-0.25	-0.26	-0.24	-0.15
<i>Exports</i>	-0.06	-0.05	-0.05	-0.13	-0.11	-0.11	-0.10	-0.25
<i>GDP</i>	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01
<i>Hhd. consumption</i>	-0.07	-0.07	-0.07	0.00	-0.15	-0.14	-0.14	-0.01
<i>Govt. consumption</i>	0.01	0.01	0.00	0.03	0.01	0.01	0.00	0.05
<i>Investment</i>	0.00	-0.03	0.00	0.00	0.00	-0.06	0.00	0.00
<i>Production</i>	-0.03	-0.03	-0.03	-0.04	-0.07	-0.07	-0.07	-0.08
	<i>ICAO-50-tLO</i>				<i>ICAO-50-tHI</i>			
	fixINV- base	fixSAV	flexTYH	fixER	fixINV- base	fixSAV	flexTYH	fixER
<i>Exchange rate</i>	0.26	0.27	0.26		0.34	0.35	0.34	
<i>Imports</i>	-0.28	-0.29	-0.28	-0.04	-0.37	-0.39	-0.38	-0.05
<i>Exports</i>	-0.06	-0.05	-0.05	-0.45	-0.08	-0.07	-0.07	-0.61
<i>GDP</i>	-0.03	-0.03	-0.03	-0.01	-0.05	-0.06	-0.06	-0.02
<i>Hhd. consumption</i>	-0.22	-0.21	-0.22	0.14	-0.30	-0.29	-0.30	0.18
<i>Govt. consumption</i>	0.03	0.03	0.00	0.15	0.04	0.04	0.00	0.19
<i>Investment</i>	0.00	-0.05	0.00	0.00	0.00	-0.07	0.00	0.00
<i>Production</i>	-0.09	-0.09	-0.09	-0.11	-0.12	-0.12	-0.11	-0.14
	<i>ICAO-100-tLO</i>				<i>ICAO-100-tHI</i>			
	fixINV- base	fixSAV	flexTYH	fixER	fixINV- base	fixSAV	flexTYH	fixER
<i>Exchange rate</i>	-0.52	-0.54	-0.52	-0.07	-0.67	-0.70	-0.68	-0.11
<i>Imports</i>	-0.17	-0.17	-0.15	-0.89	-0.25	-0.24	-0.23	-1.17
<i>Exports</i>	-0.08	-0.09	-0.09	-0.04	-0.14	-0.14	-0.14	-0.08
<i>GDP</i>	-0.40	-0.39	-0.40	0.25	-0.54	-0.53	-0.55	0.29
<i>Hhd. consumption</i>	0.06	0.06	0.00	0.26	0.06	0.06	0.00	0.32
<i>Govt. consumption</i>	0.00	-0.09	0.00	0.00	0.00	-0.12	0.00	0.00
<i>Investment</i>	-0.17	-0.17	-0.16	-0.20	-0.21	-0.21	-0.21	-0.26
<i>Production</i>	-0.52	-0.54	-0.52	-0.07	-0.67	-0.70	-0.68	-0.11
	<i>CBAM-50</i>				<i>CBAM-100</i>			
	fixINV- base	fixSAV	flexTYH	fixER	fixINV- base	fixSAV	flexTYH	fixER
<i>Exchange rate</i>	0.01	0.01	0.01		0.02	0.03	0.03	
<i>Imports</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Exports</i>	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00
<i>GDP</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Hhd. consumption</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Govt. consumption</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

<i>Investment</i>	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
<i>Production</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

15.7. Sensitivity analysis

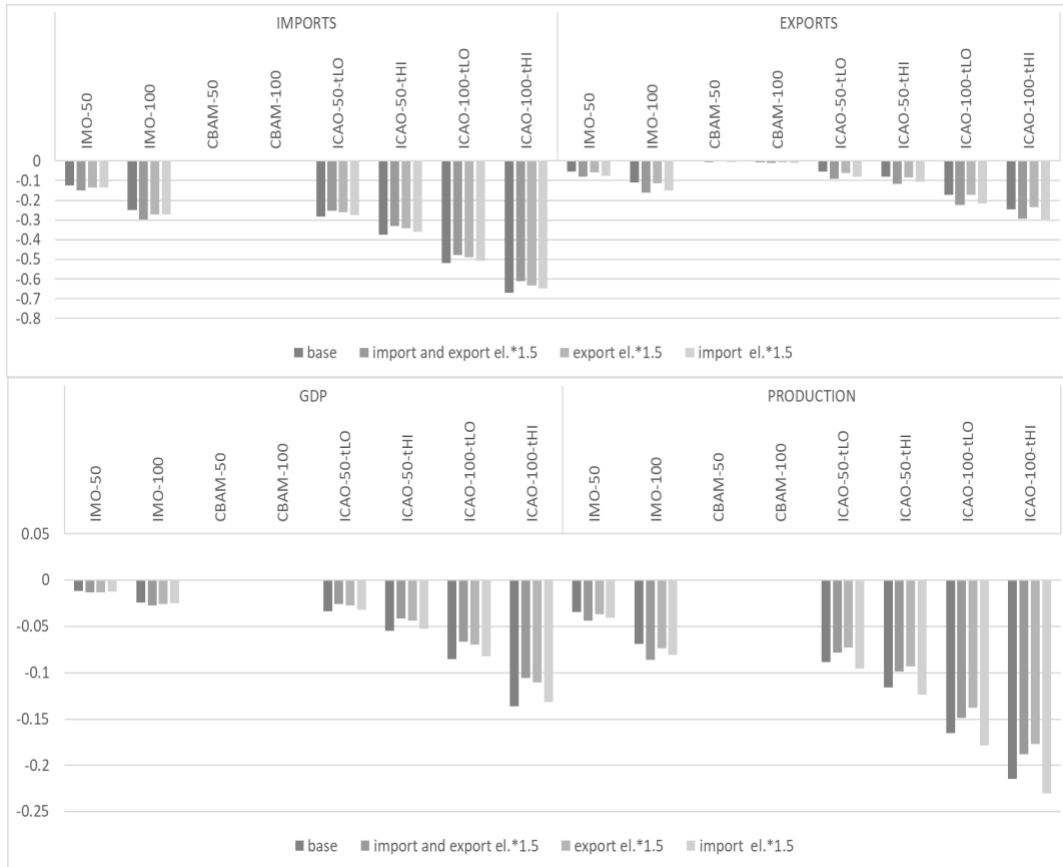
a. Trade elasticities

Simulations are run with several variations of trade elasticities,

1. increasing and decreasing import and export elasticities by 50% and 5%
2. increasing and decreasing export elasticities only by 50% and 5%
3. increasing and decreasing import elasticities only by 50% and 5%

Trade elasticities variation of +/-50% changes macroeconomic effects between 10-30% in the majority of cases. Table A2 depicts effects from a 50% increase in trade elasticities. Trade is naturally stronger influenced by variations in trade elasticities compared to other variables. IMO effects are stronger negative the larger the trade elasticities, export elasticities are less important. I.e., relevant for the amount exported – decrease stronger the larger the elasticity and thus substitutability of Ghanaian exports with products from other regions. Smaller elasticity the same, just other direction (not depicted in Figure A3). ICAO effects are smaller the stronger the trade elasticity, here, i.e., more elastic export elasticities result in smaller negative effects. CBAM, effects are too small to be meaningful.

Figure A16 Sensitivity to trade elasticities. Macroeconomic effects, % changes.



b. Production elasticities

A similar change in opposite directions, lower and higher, from standard elasticities returns deviations from reported results in a comparable range with opposite signs. We therefore only report results for lower production elasticities as used in the main text of this study (Figure A4). Halving the first level elasticity renders production effect less negative, by about 30%. Second and subsequent level elasticities are considerably less relevant, in combination, production effects are up to 35% smaller. This is also reflected in exports, where effects are about the same size. Imports and GDP are not considerably affected.

Figure A17 Sensitivity to production elasticities. Macroeconomic effects, % changes

