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REDUCTION OF GHG EMISSIONS FROM SHIPS

Further work on food security

Note by the Secretariat

SUMMARY

Executive summary:	This document reports on the outcome of further work on assessing the potential impacts of the policy combinations of a basket of candidate mid-term measures on food security.
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 6
Related documents:	MECP 82/7/4 and MEPC 82/17

Introduction

1 This document is submitted as per the relaxed deadline agreed by the Chair of the Committee in accordance with paragraph 6.9 of the *Organization and method of work of the Maritime Safety Committee and the Marine Environment Protection Committee and their subsidiary bodies* (MSC-MEPC.1/Circ.5/Rev.5).

2 Following consideration of the findings of the report of the comprehensive impact assessment (CIA) of the basket of candidate mid-term GHG reduction measures, MEPC 82 approved in general the report of the Steering Committee on the conduct of the CIA (MEPC 82/7/4); noted the outcomes of the various tasks of the CIA; and agreed to carry out further work on assessing the potential impacts of the possible policy scenarios assessed under the CIA on food security, in particular on essential food commodities and critical agricultural input, as one of the factors influencing food security, and notably in net food importing developing countries (MEPC 82/17, paragraph 7.58).

3 In this context, MEPC 82 agreed to the following terms of reference for further work to be carried out between MEPC 82 and MEPC 83:

.1 WMU to carry out a literature review assessing the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security, notably possible cost increases and price volatility of essential food commodities; and to invite Member States and international organizations to share relevant literature with WMU in this regard;

.2 the Secretariat to liaise with relevant (regional) UN Agencies, such as FAO and the World Food Programme, to identify the potential impacts of an increase in maritime transport costs on food security, as one of the factors influencing food security; and

.3 the Secretariat to organize a one-day GHG-Expert Workshop (GHG-EW 6) ahead of ISWG-GHG 18 on "Further development of the basket of candidate measures" to facilitate the understanding of the possible impacts of the basket of candidate measures on food security; and to invite WMU, relevant (regional) UN Agencies and nominated experts to present their findings/views during the workshop.

4 The outcome of this work is presented in the annexes to this document as follows:

.1 annex 1 contains the report on the review of relevant literature assessing the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security, carried out by WMU;

.2 annex 2 contains a summary of the liaison work carried out by the Secretariat with relevant UN Agencies and international organizations to identify the potential impacts of an increase in maritime transport costs on food security, as one of the factors influencing food security; and

.3 annex 3 contains a summary of information abstracted from relevant publications, referred to by a number of UN agencies and international organizations, with relevance for assessing the potential impacts potential impacts of an increase in maritime transport costs on food security, as one of the factors influencing food security.

5 The Secretariat is organizing an Expert Workshop (GHG-EW 6) on Further development of the basket of candidate measures to facilitate the understanding of possible impacts on food security, to take place on 13 February 2025 (Circular Letter No.4945), and has invited WMU, relevant UN Agencies and nominated experts to present their views on the matter. The report will be submitted to the Committee immediately after the holding of the workshop.

Action requested of the Committee

6 The Committee is invited to consider the information contained in this document and take action, as appropriate.

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REPORT ON THE REVIEW OF EXISTING LITERATURE TO ASSESS THE POTENTIAL IMPACTS OF INCREASED MARITIME TRANSPORT COSTS RESULTING FROM GHG EMISSIONS REDUCTION MEASURES IN INTERNATIONAL SHIPPING ON FOOD SECURITY

REVIEW OF ACADEMIC LITERATURE TO ASSESS THE IMPACT ON FOOD SECURITY OF CHANGES IN MARITIME TRANSPORT COSTS RESULTING FROM GHG EMISSIONS MITIGATION MEASURES

WORLD MARITIME UNIVERSITY

INTERNATIONAL MARITIME ORGANIZATION

Document Title: **REVIEW OF ACADEMIC LITERATURE TO ASSESS THE IMPACT ON FOOD SECURITY OF CHANGES IN MARITIME TRANSPORT COSTS RESULTING FROM GHG EMISSIONS MITIGATION MEASURES**			
Responsible Organization: World Maritime University (WMU)			
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01	Draft	2 December 2024	Professor Dr. Aykut I. Ölçer, Dr. Fabio Ballini, Dr. Dr. Dong Cheng, Dr. Monica Canepa, Dr. Anas Alamoush, Dr. Peyman Ghaforian Masodzadeh, and Dr. Frank van Tongeren as expert consultant
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Disclaimer

Whilst this report has been commissioned by the International Maritime Organization (IMO), the information contained within this report represents the results of the literature review only. It should not be interpreted as representing the views of the IMO.

This research is being undertaken solely to assist the IMO's Marine Environment Protection Committee (MEPC) in making evidence-based decisions. Any information included in this report is provided solely for analytical purposes and should not be interpreted as suggestions or recommendations for how the IMO mid-term GHG reduction measures should be designed.

Contents

List of Acronyms

BDI	Baltic Dry Index
CCFI	China Containerized Freight Index
CCHIP	Community Childhood Hunger Identification Project
CPI	Consumer Price Index
CSI	Coping Strategies Index
ETS	Emissions Trading System
FAO	Food and Agriculture Organization of the United Nations
FEU	Forty-foot Equivalent Unit
FIB	Food Import Bill
FIES	Food Insecurity Experience Scale
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHI	Global Hunger Index
GTAP	Global Trade Analysis Project
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
HFSS	Household Food Security Survey Module
IFSA	International Food Security Assessment
IMF	International Monetary Fund
IPC	Integrated Food Security Phase Classification
LDCs	Least Developed Countries
LLDCs	Landlocked Developing Countries
MEPC	Marine Environment Protection Committee
MGO	Marine Gas Oil
NEIG	Non-Energy Industrial Goods
NFIDCs	Net Food Importing Developing Countries
NGOs	Non-Governmental Organizations
NHANES	National Health and Nutrition Examination Survey
OECD	Organization for Economic Co-operation and Development
PICTs	Pacific Island Countries and Territories
PoU	Prevalence of Undernourishment
PPI	Producer Price Index
SAFEX	South African Futures Exchange
SCFI	Shanghai Containerized Freight Index
SDGs	Sustainable Development Goals
SEMC	South-Eastern Mediterranean countries
SIDS	Small Island Developing States
SSA	Sub-Saharan Africa
TEU	Twenty-foot Equivalent Unit
UNCTAD	UN Trade and Development
UNICEF	United Nations International Children's Emergency Fund
WFP	World Food Program
WTO	World Trade Organization
WUE	Water use efficiency

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Executive summary

Context

Following the consideration of the findings of the report of comprehensive impact assessment of the basket of candidate mid-term GHG emissions reduction measures at the eighty-second session of the Marine Environment Protection Committee (MEPC 82), the Committee agreed to carry out between MEPC 82 (October 2024) and MEPC 83 (April 2025) further work on assessing the potential impacts on food security, in particular on essential food commodities, of the possible policy scenarios of mid-term measures assessed under the comprehensive impact assessment (see also document MEPC 82/17, paragraph 7.58).

In accordance with the terms of reference agreed by MEPC 82 for further work on food security, WMU was requested to carry out a literature review assessing the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security, notably possible cost price increases and price volatility of essential food commodities.

This document firstly provides an overview of relevant concepts, metrics, and key data related to food security to set the scene for the review. The review then looks into how different economic, trade, geopolitical, and climate change induced disruptions to maritime supply chains as well as how atmospheric emission mitigation policies for international shipping have impacted food security, food prices/price volatility, and for what duration, before looking in more detail into the relation between increases in maritime transport costs and food security, and providing an overview of identified gaps.

The review aims to provide an indication of the magnitude of maritime transport costs and freight rates increases resulting from pasts events and their consecutive impacts on food security to provide a context for assessing how an increase of maritime transport costs resulting from the implementation of the mid-term GHG reduction measures could affect food security, as one of the determining factors.

The literature review does not contain any new modelling or assessments, nor is based on the outcomes of the various tasks of the comprehensive impact assessment. It merely reviewed existing data, notably on food and agricultural imports and exports.

The literature review represents the views of the authors and should not be interpreted as representing the views of the IMO. Any information included in this report is provided solely for analytical purposes and should not be interpreted as suggestions or recommendations for how the IMO mid-term GHG reduction measures should be designed.

The authors further recognized that the subject of food security is a vast and complex topic, determined by many macro and micro-economic, agricultural, trade, and environmental policies, as well as geopolitical and environmental impacts. Overall, there is only very limited available literature that addresses the specifics of an increase of maritime transport costs resulting from GHG emissions mitigation measures as one of the factors determining food security.

Methodology

A systematic literature review was conducted to assess the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security. This

review was supplemented by a search using the Scopus database and Google Scholar to identify pertinent materials directly related to the research query. Additionally, MEPC 82 invited Member States and international organizations to submit relevant literature to be taken up in the assessment and these sources were also considered, as appropriate.

The findings reported in this study are mostly the result of a systematic literature review and its primary focus is to present results from peer reviewed studies that were published following comprehensive academic review. A preliminary list of relevant search terms or keywords was used to identify relevant studies.

Concepts, definitions and key data on food security

Section 2 of the literature review provides an overview of relevant literature on key concepts explaining food security, its key pillars, main determinants, metrics of food security, as well as key data on imports and exports of food commodities and agricultural inputs, broken down by commodities and region. On the basis of the literature reviewed under the section, the authors identified the following key observations:

- Food security is understood to exist when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life; food insecurity is understood as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways";
- Food security is generally defined by four dimensions or pillars: availability (physical presence of food - *is the supply of food adequate?*), access (economic and physical access to food - *can people obtain the food they need?*), utilization (ability to utilize food effectively - *do people have enough intake of nutrients?*), and stability (continuous and unaffected access to food - *can people access food at all times?*);
- The key determinants for food security include factors, such as population growth**,** market access, income levels, climate change, sustainable management of natural resources, (maritime) transport costs, political stability and governance, variations and volatility in food prices, transport infrastructure, education, and collaborative initiatives and communication; each influencing food security outcomes across diverse contexts;
- Food security can be assessed at the household, national or global level, and is a multi-dimensional problem that depends on the relationship between domestic production, imports, exports and food stocks;
- Food security can also be affected by impacts on key agricultural input as agricultural productivity depends on access to, availability, and efficient use of inputs, such as water, seeds, fertilizer, pesticides, agricultural technology and on digital agricultural technologies;
- Food price fluctuations particularly influence poorer households, which spend relatively larger parts of their income on food. Thus, some countries and regions are more vulnerable to such price fluctuations;
- Essential food commodities are categorized into three groups: staple foods (e.g., cereals, roots, pulses), fruits and vegetables, and animal-based foods (e.g., dairy, meat, fish);
- There are three main types of maritime supply chains for food commodities transported by sea: bulk carriers, reefers or refrigerated cargo vessels, and container ships; for non-perishable

commodities such as grains, bulk carriers help transport food products in an economically efficient way, without compromising freshness; perishable commodities such as fruits and vegetables and animal-based foods, require refrigerated cargo vessels to ensure freshness during transport; container ships play a significant role in the transportation of transformed or processed food products;

- Food imports have been steadily increasing to complement domestic production and allow access to wider variety of food and dietary diversification; trends in Africa, the Americas, Asia, Europe and Oceania show that imports are dominated by cereals, while the imports of fruits, dairy, and vegetables varies by region; and
- Fertilizer markets are subject to shocks, including climate shocks, economic recessions and trade disputes that can affect the supply, demand and prices of fertilizers; the principal producers, importers and exporters or fertilizers are by nutrient type, namely Nitrogen (N), Phosphorus (P) and Potassium (K); their production is concentrated in some countries; fertilizer prices have increased between 2021 and 2022, raising fears over availability and affordability; the continued or rising trend of fertilizer imports in all regions highlights how essential these nutrients are for food security and crop productivity.

Maritime supply chains and international shipping: impacts of economic, geopolitical, and environmental policies and disruptions on food security

Section 3 assesses how different economic, trade, geopolitical, and climate change induced disruptions to maritime supply chains as well as atmospheric emission mitigation policies for international shipping have impacted food security, food prices/price volatility, and for what duration, as described in the relevant literature reviewed under this section. This information provides an indication of the magnitude of maritime transport costs and freight rates increases resulting from these pasts events and the consecutive impacts on food security. On the basis of the literature reviewed under the section, the authors identified the following key observations:

- Global food insecurity is significantly influenced by rising food prices, driven by inflation, geopolitical events, disruptions in trade, climate change induced events, with low-income, food-importing countries, and poorer households, especially in Sub-Saharan Africa and the Middle East, most affected and most vulnerable to price fluctuations;
- Oil market fluctuations and oil prices influence food price movements, although market integration, exchange rate policies, and other policy interventions can mitigate these effects; rising fuel prices can considerably impact food security by increasing production and transportation costs, which are contributors to food price surges;
- Trade policy interventions, including import tariffs and import quota, export taxes and export bans, influence global agricultural commodity prices and thereby impact global food security, notably affecting import-dependent countries, potentially intensifying their vulnerability during crises; trade-opening policies, such as reducing tariffs, can promote food security by guaranteeing access to indispensable commodities but can lower incentives for domestic production;
- Disruptions to maritime trade caused by external shocks, such as the COVID-19 pandemic, the ongoing military conflict between the Russian Federation and Ukraine, the blockage or restrictions of important sea passages, leading to increased freight rates and maritime transport costs have impacted global food security;

- The COVID-19 pandemic underscored the fragility of global supply chains, with shipping disruptions and rising freight rates affecting food availability and affordability; the continuous rise in food price during the COVID-19 pandemic was a major factor influencing external supply risks, with the poorest households being particularly vulnerable to income shocks as they can spend more than a quarter of their total income on staple foods such as wheat, rice or maize, whereas non-poor households spend much less;
- The military conflict between the Russian Federation and Ukraine, in particular, has worsened food security by disrupting supply chains, agricultural production, agricultural input and fertilizer availability, further driving up prices, in particular wheat prices, notably in countries dependent on imports, and exacerbating food access issues, especially in developing countries;
- Several recent major disruptions, such as the blockage of the Suez Canal, the Red Sea crisis, and reduce transit through the Panama Canal, and underscored the vulnerability of critical maritime chokepoints, highlight their far-reaching impacts on global trade, shipping costs and supply chain security, with significant impacts on consumer prices, notably in the immediate period of six to eighteen months, and indicating significant rise in core inflation and import prices;
- Climate change induced events can lead to a range of interconnected environmental and societal challenges, also greatly affecting food security by disrupting agricultural productivity, reducing crop quality, and contributing to instability in global supply chains, further exacerbating food insecurity. Additionally, increased maritime transport costs due to climate-related disruptions and events such as port congestion and shipping delays impact food access, particularly for vulnerable populations;
- There are many determinants that affect maritime transport costs, including geographical and geopolitical factors, shipping running costs, shipped product, market-specific factors, and infrastructure, the share of which according to product, commodity and region, yet all potentially also affecting food security, noting that an increase in transport costs on import prices of commodities with a low value per ton would be relatively high, but relatively low for commodities with a high value per ton;
- The extent to which maritime transport costs increases affect consumer prices depends on a number of factors, including the duration of the increase, industry's ability to absorb them through reduced profit margins, as well as their willingness to do so; commodity import prices are more rapidly affected by transportation costs, while consumer prices are more moderately affected; there is a complex interaction between shipping costs and macro-economic conditions;
- Being peripheral in the maritime network has a higher impact on maritime transport costs than distance; SIDS, LLDCs, and LDCs are particularly vulnerable to disruptions in maritime transport, where high shipping costs, limited connectivity, and inefficient ports impede trade and economic development; these regions often bear a disproportionate share of transport costs, leading to higher food import prices and greater challenges in maintaining food security.
- Across all regions, SIDS suffer from low connectivity, and as a result of low trade volumes, maritime transport costs are generally higher, further reducing trade opportunities; the other factor influencing transport costs is port infrastructure and performance, with developing economies, LDCs and SIDS showing low port performance, with LDCs scoring lowest; a lack of data and statistics on imports and exports for some SIDS complicates the analysis of impacts;
- As agri-food products can be transported in bulk and in containers, substantial difference between the impacts of shocks to container versus dry bulk costs can be observed;

- Biofuels production and use policies can contribute to the volatility of food prices due to increased demand for feedstock and it is essential to address environmental, societal and economic factors to ensure positive impacts; biofuels produced from agricultural residues, wood waste and municipal solids that cannot be used as food would not be in competition with food and feed, while informed biofuel policies combined with energy efficiency improvements and food productivity could prove to be an effective strategy to enhance both energy and food security;
- Maritime GHG mitigation measures, including carbon pricing, can have an economic impact in four different but interrelated areas: transportation costs, transport choices, import prices, and international trade and the economy of countries; the implementation of carbon pricing in maritime shipping is expected to raise freight and import costs, with potentially higher impacts on low-value bulk commodities; the cumulative impact of increased shipping costs, climate disruptions, and geopolitical events poses significant challenges for food security, particularly in developing countries and regions with high reliance on imports.
- The implementation of IMO's technical measures aimed at reducing sulphur emissions, such as IMO 2020 and the emission control areas as well as the introduction of the EEXI, resulted in an increase of fuel costs and freight rates, but there is no clear indication of the impacts on food security although potential decline in trade value as well as imports and exports can be expected, including following the introduction of slow steaming;
- Generally, regulatory measures, as opposed to unpredictable, temporary shocks to supply chains and maritime transport, can be anticipated, planned for, and are implemented over a long period thus allowing for any negative impacts to be mitigated by international or national policies and measures; and
- Transportation shocks affect countries differently based on their level of food import dependency; and maritime transport costs being one among many different factors affecting food security.

Impact of the increase in maritime transport costs and freight rates on food security

Section 4 assesses in more detail how the relative contribution of maritime transport costs and freight rates impacts food security, as one of the contributing factors.

On the basis of the literature analyzed in this chapter, the authors identified the following key observations:

- Trade costs can be determined by many different factors; trade costs as percentage of import prices for a developed country can be broken down into transportation costs, border barriers and wholesale and retail distribution costs; agricultural trade costs are significant as many agricultural goods are low value, bulky, and perishable; and maritime transport costs have a greater impact on lower-value goods like agricultural products due to their higher cost-to-weight ratio;
- Maritime transportation shocks affect countries differently based on their level of food import dependence; it is important to distinguish between different modes of maritime transport for bulk products, processed food and perishable food as the economics generally differ between them; response to transport cost shocks between bulk and container shipping can be significantly different;
- The share of freight rates in cost and freight prices tends to display great variability over time and across commodities and trades routes; there is also much variation in the share of freight rate in the cost and freight price between commodities;

- The economics of maritime freight rates is an interplay between multiple market forces related to distance, scale, volume, type of product, port efficiency, network connectivity and market structure, the complexity of which goes beyond the scope of this literature review;
- Consumer prices are influenced by maritime transport costs via several channels. Besides the direct effects due to the increase in shipping costs, they can also increase indirectly due to increased price of intermediate products strongly embedded in global supply chains such as fertilizers and imported machinery used in agricultural production;
- The reaction of import volumes of processed food items is more pronounced than that of primary agricultural commodities;
- SIDS are particularly exposed to changes in transport cost, and particularly for container transport, due to their reliance on hub-and-spoke services and higher per-unit transport costs; which can have an impact on food security in these regions;
- The volatility of freight rates is higher than the volatility of export prices. The volatility of freight rates is driven by different forces than those influencing agricultural commodity prices, which can complicate the relationship between transport costs and food security;
- Maritime transport costs increase resulting from temporary shocks can provide an illustration of the relationship between maritime shipping costs and food security; but the impact of temporary shocks is different from permanent changes instilled by regulatory measures;
- The literature on the relationship between food security and maritime transport costs is not very well developed and a coherent picture of quantitative magnitudes is lacking; global food import price does increase from an increase in fuel prices, but the effects tend to vanish over time, i.e., there is no lasting effect on export prices from a potential increase in fuel costs due to regulatory emissions mitigation policies; and
- Estimates show that the import (or export) price responses to changes in maritime transport cost are relatively low compared to the fluctuations that are normally observed in trade statistics; over the longer term, when markets have adjusted the price effects of a potential increase in maritime fuel prices tend to diminish.

Knowledge gaps

In section 5 the authors have identified a number of knowledge gaps in the existing literature in a number of key areas that could be addressed in the future. The authors noted in particular the lack of relevant literature investigating the direct links and consequential impacts of an increase in maritime transport costs resulting from regulatory measures, such as emissions mitigation measures/policies, for international shipping on food security. The authors also noted that the existing literature and data does not have full global coverage, and that availability of detailed data, notably for SIDS and LDCs, should be improved.

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Section 1: Background and methodology

1.1 Background

Following the consideration of the findings of the report of comprehensive impact assessment of the basket of candidate mid-term GHG reduction measures at the 82nd session of the Marine Environment Protection Committee (MEPC 82), the Committee agreed to carry out between MEPC 82 (October 2024) and MEPC 83 (April 2025) further work on assessing the potential impacts on food security, in particular on essential food commodities, of the possible policy scenarios of mid-term measures assessed under the comprehensive impact assessment (see also document MEPC 82/17, paragraph 7.58).

In accordance with the terms of reference agreed by MEPC 82 for further work on food security, WMU was requested to carry out a literature review assessing the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security, notably possible cost price increases and price volatility of essential food commodities.

To adequately structure the review of relevant literature in accordance with the terms of reference, this document firstly provides an overview of relevant concepts, metrics, and key data related to food security to set the scene for the review. The review then looks into how different economic, trade, geopolitical, and climate change induced disruptions to maritime supply chains as well as how atmospheric emission mitigation policies for international shipping have impacted food security, food prices/price volatility, and for what duration, before looking in more detail into the relation between increases in maritime transport costs and food security, and providing an overview of identified gaps. As such this review aims to provide an indication of the magnitude of maritime transport costs and freight rates increases resulting from these pasts events and the consecutive impacts on food security. This would provide a context for assessing how an increase of maritime transport costs resulting from the implementation of the mid-term GHG reduction measures could affect food security, as one of the determining factors.

The literature review does not contain any new modelling or assessments, nor is based on the outcomes of the various tasks of the comprehensive impact assessment. It merely reviewed existing data, notably on food and agricultural imports and exports.

The authors further recognize that the subject of food security is a vast and complex topic, determined by many macro and micro-economic, agricultural, trade, and environmental policies, as well as geopolitical and environmental impacts. Overall, there is only very limited available literature that addresses the specifics of an increase of maritime transport costs resulting from GHG emissions mitigation measures as one of the factors determining food security.

More specifically, the review of relevant literature findings focuses in particular on the following issues:

1. The definition of food security;
2. The reaction of agricultural trade to shocks and their impact on food security;
3. Relation between maritime transport cost and food security; and

4. Data and knowledge gaps.

1.2 Methodology

A systematic literature review was conducted to assess the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security. This review was supplemented by a search using the Scopus database and Google Scholar to identify pertinent materials directly related to the research query. Additionally, MEPC 82 invited Member States and international organizations to submit relevant literature to be taken up in the assessment and these sources were also considered, as appropriate.

The findings reported in this study are mostly the result of a systematic literature review and its primary focus is to present results from peer reviewed studies that were published following comprehensive academic review. When relevant, few reports from grey literature were also considered, excluding reports from UN Agencies and international organizations that are presented in a separate activity. In addition, this review took into account references recommended by IMO Member States, with 41 references suggested by the United Kingdom, Egypt, and Togo, of which 15 sources were cited.

A preliminary list of relevant search terms or keywords was used to identify relevant studies. Figure 1 illustrates the categories of keywords employed, and Figure 2 demonstrates the combinations of these keywords and the associated statistics of the search results.

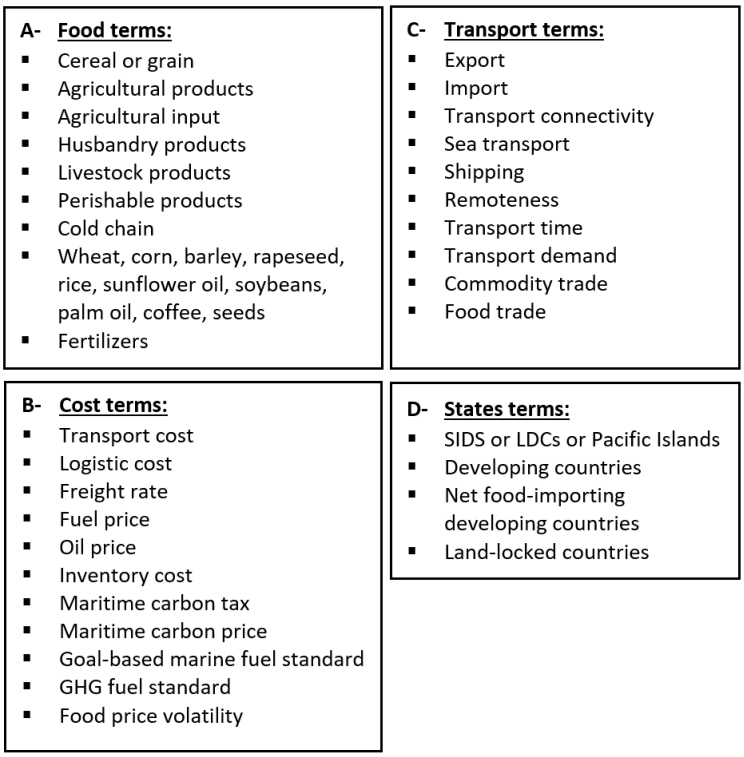


Figure 1: Four categories of search keywords

To identify the most relevant studies, a list of inclusion and exclusion criteria was defined and followed (see Table 1). In the first scan, the title and keywords of the articles were monitored, and in the second scan, the abstract and conclusion of the candidate articles were controlled.

Table 1: Inclusion and Exclusion Criteria for a literature review

Criteria	Inclusion	Exclusion
Study focus	Studies explicitly addressing food security dimensions (availability, accessibility, stability, utilization)	Studies focusing solely on unrelated topics (e.g., general health, economics, or unrelated policy areas) Articles with no direct relevance to food security or lacking actionable findings
Time frame	Articles published within the last 20 years (e.g., 2003–2023) to ensure relevance to current trends	Articles published before 2003, unless very important and foundational to the review
Data and study type	Empirical studies, systematic reviews, and meta-analyses providing quantitative or qualitative data	Opinion pieces, non-peer-reviewed articles, or reports lacking clear methodology and data
Access	Studies in English available in full text through academic databases, institutional access, or open sources	Abstract-only studies or those behind paywalls without access through the reviewer's resources

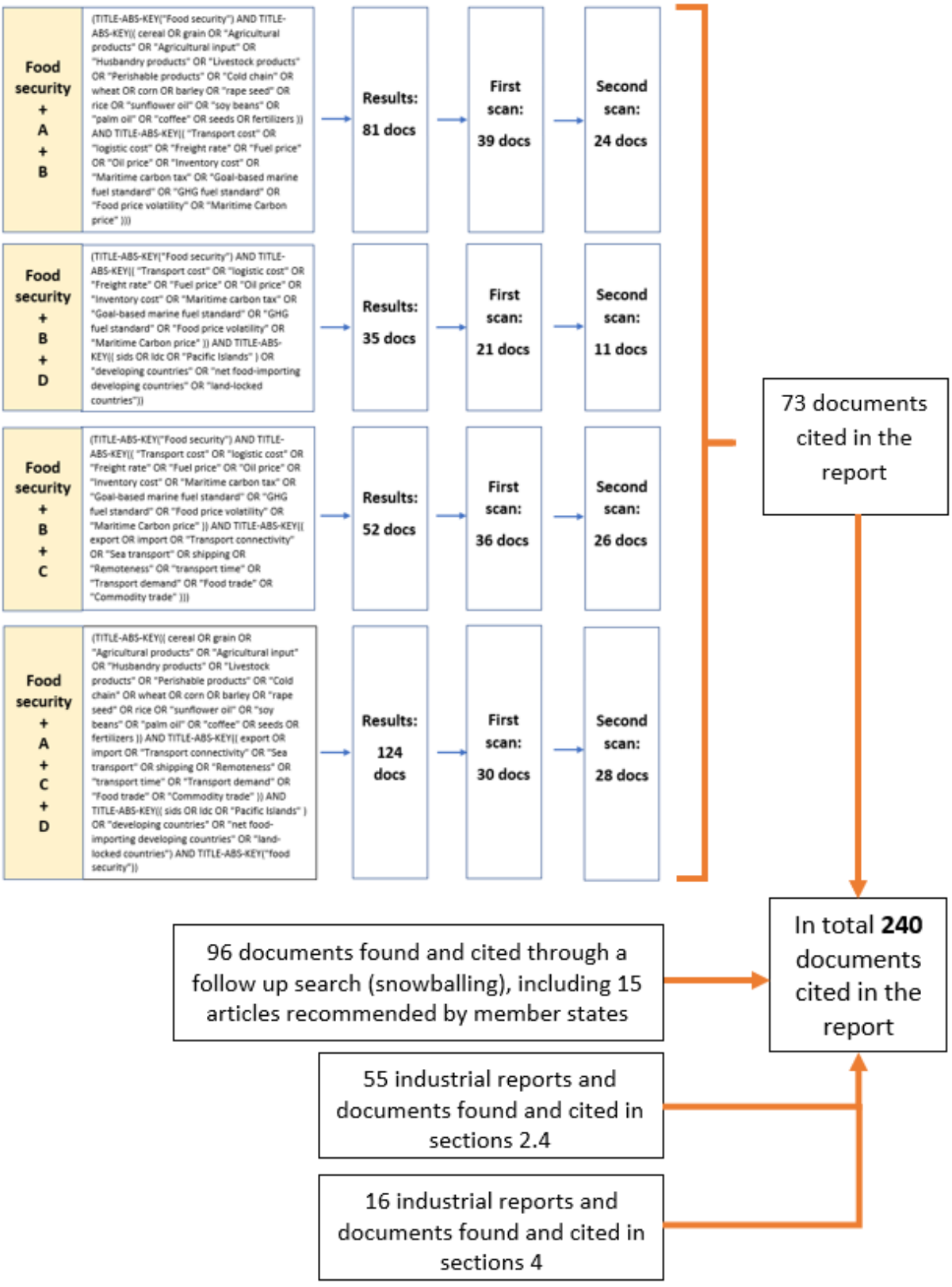


Figure 2: Various combinations of search keywords and results of search

Section 2: Concepts and definitions of food security

2.1 The four pillars of food security

The term “food security” emerged as a critical issue during the 1970s and 1980s, driven by major food crises that affected many parts of the world, particularly in developing regions. In 1974, the United Nations convened the first World Food Conference, which resulted in the Universal Declaration on the Eradication of Hunger and Malnutrition, endorsed by over 100 countries. This declaration established the “inalienable right to be free from hunger and malnutrition” and underscored the role of governments in ensuring food availability through effective agricultural policies and the provision of staple foods. At national and regional levels, food security was initially approached with a broad focus on balancing food production with energy needs (Biesalski et al., 2017).

In 1986, the World Bank expanded the food security concept (Castetbon, 2017), defining it as “access by all people at all times to enough food for an active, healthy life.” This new standpoint positioned the individual at the core, emphasizing not only the necessity for sufficient quantity and quality of food but also the significance of stable access and its link to health. Similar definitions presented by the Food and Agriculture Organization (FAO), the United Nations, and other organizations in the 1980s and 1990s emphasized a range of aspects, from economic and material access to nutritional needs, across both urban and rural settings.

In 1996, the World Food Summit, hosted by the FAO, added further dimensions, defining food security as a condition in which “all people, at all times, have physical, economic, and social access to sufficient, safe, and nutritious food to maintain a healthy and active life” (Castetbon, 2017). This highlighted not only access to adequate food but also considered the food safety and nutritional characteristic that all ensure nutritiousness of food to individuals dietary needs and food preferences for an active and healthy life. Importantly, food insecurity was also defined as “limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways”.

Surveys on food security by international NGOs, primarily focused on developing countries (although food insecurity also exists in developed countries), are conducted at both household and individual levels. These surveys frequently measure access to essential food groups, dietary diversity, and intake, offering a way to estimate the coverage of nutritional needs (Castetbon, 2017). This is severe in the developing countries where 780 million of the total world hunger prevails (Naz et al., 2023). Among the developing countries, the food insecurity is the highest in Sub-Saharan African countries and South Asian countries, noting that 281 million people were found undernourished, ranking it as the highest region with hunger occurrence (Naz et al., 2023).

Based on FAO definition, the literature reviewed identified four vital pillars of food security are **availability, access, stability and utilization** of food (Mc Carthy et al., 2018) (Naz, Amin, Khan, & Nawaz, 2023) (Manikas, Ali, & Sundarakani, 2023) (IPC Global Partners 2012)(Horn, Ferreira, & Kalantari, 2022). These pillars differ from time to time and from country to country, region to region, and locality and they affect 795 million people worldwide that are facing the non-availability of food.

Food security is not only reflected by food production, but also by the need of equitable access, proper utilization, and resilience to disruptions.

Availability refers to the sufficient production and supply of food within a region or globally. Food availability guarantees there is enough food to meet the nutritional needs of people. Nevertheless, issues like climate change, poor infrastructure, market issues, and geopolitical tensions including other global shocks can disrupt food availability (Kassy, Ndu, Okeke, & Aniwada, 2021)(Naz et al., 2023)(Horn et al., 2022)(Guo et al., 2021). Availability depends on the following factors:

- **Food production**: highlights the role of agriculture, fisheries, and livestock in ensuring an adequate food supply.
- **Distribution systems**: emphasizes the significance of competent transportation and storage systems to avoid food loss and ensure food reaches markets and consumers.
- **Imports and exports (trade)**: stresses the role of international trade in enhancing local food supplies, particularly in regions with inadequate domestic production.

Access implies individuals and households are able to obtain sufficient, safe, and nutritious food. Although food may be available, high prices, poverty, or geographic barriers can constrain access, while economic crises, inflation, and inequitable policies worsen these issues (Naz et al., 2023)(Kassy et al., 2021)(Owino et al., 2022)(Brenton, Chemutai, & Pangestu, 2022). Access depends on the following factors:

- **Economic access**: bring together household income, food prices, and economic stability as factors influencing food affordability.
- **Physical access**: underlines closeness and proximity to markets, transportation networks, and infrastructure that allow people to buy or obtain food.
- **Social access**: recognizes the role of social equity and inclusion in guaranteeing minorities and marginalized groups can access food.

Utilization is ensured when food is nutritious and can be adequately metabolized and used by the body. Therefore, even with access to food, poor dietary choices, unsafe food, or health conditions can still result in malnutrition and reduced productivity, highlighting thus the role of food quality and healthy dietary practices (Kassy et al., 2021)(Mrdalj & El Bilali, 2020)(Owino et al., 2022)(Brenton et al., 2022). Utilization depends on the following factors:

- **Dietary diversity**: emphasizes the significance of feeding on a mixture of foods to meet nutritional requisites.
- **Food safety**: emphasize the role of the quality of food, as well as its preparation, storage, and absence of contaminants. This emphasizes the role of hygiene and manufacturing practices applied in agricultural production, harvesting and storage including food processing, transportation retail, and households.
- **Health conditions**: concerns the influence of individuals' health status, for instance diseases or malnutrition, on their ability to appropriately absorb food nutrients.

Stability concerns the consistent access to food over time (permanent), without the risk of disruptions (durable). Stability indeed guarantees that food security is upheld throughout different seasons and

despite economic or environmental crises (Manikas et al., 2023)(Kassy et al., 2021)(Gregory & Ingram, 2008). It also maintains the other three pillars overtime. Stability depends on the following factors:

- **Economic stability**: considers the impact of economic shocks, inflation, and income fluctuations on food security.
- **Environmental stability**: involves climate change, natural disasters, and other environmental risks that put at risk food production and availability.
- **Political stability**: includes the influence of conflict, governance, and policy frameworks on food security.

2.2 The main determinants of food security

Many factors influence food security, negatively or positively. While there is no study that fully presented all the determinants of food security, this literature review gathers the following determinants in this section, with supporting literature listed in Table 2.

Table 2: Determinants of food security in different countries/regions

Determinant	Countries/Regions	Source
Population growth	Sub-Saharan Africa, Global	(Ouko & Odiwuor, 2023)(Darmon & Caillavet, 2017)
Market access	Ethiopia, Nigeria	(Matz et al., 2015)(Kassy et al., 2021) (Castetbon, 2017)
Income levels	Ethiopia, Nigeria, United States	(Bahiru et al., 2023)(Kassy et al., 2021)(Castetbon, 2017) (Carlson et al., 1999)
Climate change	Sub-Saharan Africa, Ethiopia, South Asia, Central and South America and Small Islands	(Ouko & Odiwuor, 2023)(Bahiru et al., 2023) (Intergovernmental Panel on Climate Change, 2022)
Sustainable management of natural resources	Global	(Larochez-Dupraz & Huchet-Bourdon, 2016) (Guo et al., 2021) (Intergovernmental Panel on Climate Change, 2022)
Transport costs	Northern Africa, India, China	(Tran, Haralambides, Notteboom, & Cullinane, 2025) (Choudhury, 2010) (Guo et al., 2021)
Political stability	South-Eastern Mediterranean Countries, Nigeria	(Capitanio et al., 2020)(Bahiru et al., 2023)(Kassy et al., 2021)
Food prices	Ethiopia, South Mediterranean Countries, Latin America	(Matz et al., 2015) (Capitanio et al., 2020) (Keles, Choumert-Nkolo, Combes Motel, & Nazindigouba Kéré, 2018)
Infrastructure	Nigeria, Global	(Kassy et al., 2021)(Guo et al., 2021)
Education	Ethiopia, Nigeria	(Bahiru et al., 2023)(Kassy et al., 2021) (Carlson et al., 1999)
Collaborative initiatives and communication	Global	(OECD, 2020) (UNCTAD, 2024) (Mc Carthy et al., 2018)(Naz et al., 2023)

The **population growth** determinant places pressure on food systems in increasing demand and draining resources (Guo et al., 2021), while agricultural output remains stagnant (Kassy et al., 2021). Therefore, high population growth, particularly in developing countries, aggravates food insecurity and generates further pressure on food systems and networks (Ouko & Odiwuor, 2023)(Cafiero et al., 2018). The global population is expected to grow from 7.3 billion to 9 billion by 2050, which primarily happens in low income countries, thus increasing the food security issues (Darmon & Caillavet, 2017).

High household **income levels** limit concerns over food security through bettering purchasing power and gaining access to different nourishments (Naz et al., 2023)(Bahiru et al., 2023)(Cafiero et al., 2018). Studies highlight that income disproportions and discrepancies considerably influence food accessibility, in that low-income households are seen more vulnerable to food insecurity than others (Bahiru et al., 2023)(Naz et al., 2023)(Kassy et al., 2021)(Matz et al., 2015).

Education advances household decision-making and help thus in gaining access to economic opportunities, supportively affecting food security (Bahiru et al., 2023)(Darmon & Caillavet, 2017)(Naz et al., 2023). Precisely, educated households are more probable to implement advanced farming practices and acquire different food sources (Bahiru et al., 2023) (Darmon & Caillavet, 2017) (Naz et al., 2023)(Lv et al., 2022)(Kassy et al., 2021). Education was found to be one of the factors that reduce the cost of postharvest losses in Ethiopia (Teferra, 2022). A study investigated the impact of education on food security in two informal urban settlements in Kenya (Mutisya et al. ,2016). The study found that each additional year of schooling among household heads was associated with a 0.019 decrease in the probability of being food insecure, with a notable reduction in severe food insecurity from 49% in 2008 to 35% in 2012. The study suggests that higher educational accomplishment further enhance food security in Kenya's households (Guo et al., 2021) (Lv et al., 2022)(Bahiru et al., 2023)(Kassy et al., 2021)(de Haen et al., 2011). In fact, the increase in incomes globally lead to rising consumption of resource demanding foods, aggravating vulnerabilities in food systems (Naz et al., 2023)(Darmon & Caillavet, 2017) (Lv et al., 2022)(Guo et al., 2021)(Naz et al., 2023)(Wilmsmeier & Sanchez, 2009).

Political instability in countries and regions increases the risk of disruptions in food production, supply chains, and market access (Ouko & Odiwuor, 2023)(Capitanio, Rivieccio, & Adinolfi, 2020) (Manikas et al., 2023). Political unrest and weak governance worsen food insecurity by undermining agricultural structures and limiting imports and exports (Capitanio et al., 2020; Kassy et al., 2021). Studies highlighted that food security is deeply interconnected with various central economic and political problems, particularly in South-Eastern Mediterranean countries (Capitanio et al., 2020), and Sub-Saharan African countries (Ouko & Odiwuor, 2023).

Climate change, including the risk of severe weather events, adversely affects agricultural output and supply chains (Fróna, 2020; Muluneh, 2021). In this sense, droughts, floods, and temperature oscillations are foremost grounds of food insecurity in areas at risk (Erdogan, Kartal, & Pata, 2024; Gregory & Ingram, 2008; Hurlimann, Moosavi, & Browne, 2021; Muluneh, 2021; Owino et al., 2022)(de Haen et al., 2011). The Working Group II (WGII) contribution to the IPCC's Sixth Assessment Report (AR6) recognizes the interdependence of climate, ecosystems and, biodiversity, and human societies (Intergovernmental Panel on Climate Change, 2022). According to the report, there is high confidence that climate change will increasingly put pressure on food production and access, especially in vulnerable regions, undermining food security and nutrition. The report highlights also that there is high confidence that increases in frequency, intensity and severity of droughts, floods and heatwaves,

and continued sea level rise will increase risks to food security. Furthermore, the report states with high confidence that, with a global warming level of 2°C or higher in the mid-term, food security risks due to climate change will be more severe, leading to malnutrition and micro-nutrient deficiencies, concentrated in Sub-Saharan Africa, South Asia, Central and South America and Small Islands.

The **sustainable management of natural resources**, such as soil and water, is essential for keeping up agricultural production (Larochez-Dupraz & Huchet-Bourdon, 2016). The over utilization of natural resources results in degraded productivity and lasting food security challenges (Larochez-Dupraz & Huchet-Bourdon, 2016) (Guo et al., 2021). The WGII contribution to the IPCC's AR6 Report (Intergovernmental Panel on Climate Change, 2022) addresses the natural resources that can be compromised due to climate change. Furthermore, the report asserts, with high confidence, that documented examples of adverse impacts of land-based measures intended as mitigation, when poorly implemented, include afforestation of grasslands, savannas and peatlands, and risks from bioenergy crops at large scale to water supply, food security and biodiversity.

The **accessibility to markets** improves food security by expanding access to inputs and assisting the sale of surplus yields (Naz et al., 2023) (Fróna, 2020). The limited market access was found to generate logistical challenges that unreasonably influence rural households (Bahiru et al., 2023)(Kassy et al., 2021)(Matz, Kalkuhl, & Abegaz, 2015). Issues related to proximity to markets, transportation networks, and maritime infrastructure, trade routes, and the maritime value chain (Bonuedi, Kornher, & Gerber, 2022).

Higher **transport costs** increase food prices, reduce market accessibility, and influence post-harvest losses (Wilmsmeier & Sanchez, 2009), (Choudhury, 2010)(Choudhury, 2010)(Fróna, 2020). Additionally, poor infrastructure in developing countries intensifies inefficiencies in supply chains, enlarging therefore food insecurity issues (Wilmsmeier & Sanchez, 2009), (Choudhury, 2010) (Guo et al., 2021). Indeed, disruptions in major maritime supply chains infrastructure, like the Suez Canal blockage, influence transport efficiency and stable food prices including availability (Tran, Haralambides, Notteboom, & Cullinane, 2025).

Efficient storage and infrastructure can bring down food deficiencies and enhance market access (Matz et al., 2015)(Naz et al., 2023)(Manikas et al., 2023). Poor infrastructure, including transportation infrastructure, in developing countries results in substantial post-harvest losses, which decrease food availability (Guo et al., 2021)(Matz et al., 2015)(Naz et al., 2023)(Kassy et al., 2021). Matz et al. (2015) explored the short-term impact of price shocks on food security in Ethiopia,highlighting how infrastructure deficiencies impair food availability challenges including how urban and rural differ in food access owing to poor storage and transportation systems. Moreover, efficient infrastructure, encompassing transportation and storage facilities, is vital for enhancing food security and ensuring better market access. For instance, Guo et al. (2021) indicated that deficient transportation infrastructure in developing countries , such as China, results in substantial food wastage, which wholly affects food availability and access. In the same vein, Naz et al. (2023) recognized the importance of incorporating enhanced infrastructure with modern logistics to reduce losses and better distribution efficiency.

Collaborative initiatives, such as regional trade agreements (RTAs), act as catalysts for accelerating trade processes, through for example tariffs reduction and standards harmonization, which boosts the

efficiency of food distribution across borders in addition to allowing maritime value chains to function properly. The OECD's policy brief on regional trade agreement (OECD, 2020) highlights that such agreements can streamline trade procedures and increase market access for agricultural products, reinforcing food supply chains. UNCTAD emphasizes the importance of investments in port and infrastructure upgrades to relieve congestion and improve supply chain efficiency, particularly in main transshipment hubs. The same is true regarding reinforcement of distribution systems through various collaborations, which all mitigate the unfavorable impacts stemming from poor infrastructure on food security (UNCTAD, 2024).

Proper **communication** among supply chain stakeholders cuts food waste, enhances logistics, and improves warehouse management (Mc Carthy et al., 2018)(Naz et al., 2023). Thus, there is a need to establish information-sharing channels that aim at improving transparency and optimizing supply chain practices, to lessens inefficiencies and directly improving food security (Mc Carthy et al., 2018)(Naz et al., 2023).

Instabilities, variations and volatility in food prices play on the affordability of commodities and undermine household food security, predominantly for low-income families (Matz et al., 2015)(Carlson et al., 1999)(Guo et al., 2021). In this sense, the urban poor households are also excessively influenced by price rise, which decrease the quality and quantity of meals (Capitanio et al., 2020)(Kassy et al., 2021)(Choudhury, 2010). Competition with alternative use of agricultural commodities such as biofuel required food crops for its production, can decrease the availability and affordability of food for local populations (Mc Carthy et al., 2018)(Matz et al., 2015)(Darmon & Caillavet, 2017). The pressure to produce biofuels from different crops, such as maize, oilseed, and sugarcane can reduce access to locally produced foods and intensify food insecurity in influenced areas (Mc Carthy et al., 2018)(B. Brown, Schoney, & Nolan, 2021). A study investigated the impact of biofuel production on deforestation (forest cover loss) in low- and middle-income countries, particularly through land-use change processes (Keles, Choumert-Nkolo, Combes Motel, & Nazindigouba Kéré, 2018) While bioethanol production generally avoids dense primary forests, it significantly encroaches on less dense forest regions, especially in Latin America. The study recommended utilization of relevant policies to mitigate the environmental costs of biofuel production and stressed the importance of monitoring land-use changes to balance renewable energy goals with forest conservation. At the same time literature found that, in particular in the recent decade, there has been an increase in regulations, globally (e.g., ICAO), regional (e.g. EU) and national (e.g. Brazil or United States), aimed at reducing possible adverse impacts of biofuel production on food security, including by mandating use of biofuels produced in accordance with specific sustainability criteria (e.g. use of second/third generation biofuels).

2.3 Metrics of food insecurity

Food security can be measured at household, at country or at global level. While the household measures aggregate data about individuals, focusing on their experience to food access, quality, coping strategies and nutritional intake among others, the country level measures gather macro level data from various national surveys, national statistics, and economic indicators assessing their food security for the larger population. A study on *A Systematic Literature Review of Indicators Measuring Food Security* exhaustively reviewed various food security indicators (measures), to evaluate their efficacy through varied settings. It categorized these indicators into household-level and global

measures, evaluated their strengths and limitations, and stressed the significance utilization of these tools to wholly comprehend this issues of food security (Manikas et al., 2023). A summary of these measures, along with their descriptions, key indicators, and studies that have utilized or addressed them, is presented in Table 3.

In the same context, a study that collected data from different global reports that measured food crises reported that 193 million people experiencing severe food insecurity across 53 countries, just in 2022 (Ouko & Odiwuor, 2023).

Table 3: Comprehensive table of food security measures

Measure	Description	Indicators	Source/Reference
Household Food Insecurity Access Scale (HFIAS)/ Household	Developed by USAID's FANTA project. It measures household experiences with food insecurity, focusing on anxiety over food supply	Questions on food-related anxiety, quality and quantity, adaptations to scarcity	(Becquey et al., 2012, 2010)(Weaver & Hadley, 2009)(Khor, 2008)
Household Dietary Diversity Score (HDDS)/ Household	Measures dietary diversity in households, assessing nutritional adequacy over a 24-hour period	Tracks 12 food groups; higher diversity scores indicate better dietary quality	(Swindale & Bilinsky, 2006)
U.S. Household Food Security Survey Module (HFSS)/ Household	Developed by USDA, HFSS which assesses food security levels across households, with questions on food quality and sufficiency	18-question survey addressing food quantity, quality, and food security levels	(Carlson, Andrews, & Bickel, 1999)
Community Childhood Hunger Identification Project (CCHIP)/ Household	Focuses on food sufficiency and coping strategies specifically for children	Uses an eight-question survey to assess childhood hunger in households	(Kleinman et al., 1998)
Food Insecurity Experience Scale (FIES)/ Global	Standardized by FAO, FIES measures food insecurity across countries, focusing on individual experiences with food access issues	Questions on food anxiety, reduction in food quality, and skipping meals	(FAO, 2024) (Cafiero, Viviani, & Nord, 2018)
Coping Strategies Index (CSI)/ Household	Measures coping mechanisms households use during food shortages, assessing resilience to food insecurity	Frequency and severity of coping behaviors (e.g., reducing portions, borrowing food)	(Maxwell & Foundation, 2008; Maxwell & Watkins, 2003)
Integrated Food Security Phase Classification (IPC)/ Global	IPC provides a comprehensive classification of food security phases, useful in crisis settings	Phase classification (minimal to famine) based on food consumption, nutrition, and livelihoods	(Cafiero et al., 2018; Ouko & Odiwuor, 2023) (IPC GlobalPartners 2012)
National Health and Nutrition Examination Survey (NHANES) Food Security Module/ Household	Part of NHANES III, this module includes food sufficiency questions focused on food quantity and access	Quantitative food adequacy and access indicators	(Darmon & Caillavet, 2017) (Biesalski et al., 2017) (Alaimo, Briefel, Frongillo, & Olson, 1998)

Prevalence of Undernourishment (PoU)/ Global	Measures the percentage of the population with caloric intake below minimum dietary energy requirements	Minimum energy requirement data, demographic information	(Cafiero et al., 2018)(de Haen, Klasen, & Qaim, 2011) (Manikas et al., 2023)
Global Hunger Index (GHI)/ Global	Combines indicators of undernourishment, child wasting, stunting, and mortality to assess and compare hunger across countries	Undernourishment, child malnutrition, and mortality rates	(Guo et al., 2021) (Manikas et al., 2023) (Kakaei, Nourmoradi, Bakhtiyari, Jalilian, & Mirzaei, 2022)
Nutritional Status Indicators (e.g., Stunting, Wasting)/ Country/Global	Used by WHO and UNICEF, these indicators assess the physical impacts of food insecurity, particularly in children	Stunting (height-for-age), wasting (weight-for-height), and underweight (weight-for-age) to measure nutritional imbalance	(de Haen et al., 2011) (Guo et al., 2021)

Several studies in the literature review have addressed food security in specific regions and countries. These are summarized in Table 4 as follows:

Table 4: Food Security Studies

Region/Country	Objective	Result	Conclusion	Source
Ethiopia	Analyze food security status and determinants among rural households	70.6% of households were food insecure. Key factors included family size, income level, and access to agricultural inputs	Improving access to education, financial services, and agricultural inputs is crucial to reducing food insecurity	(Bahiru, Senapathy, & Bojago, 2023)
Burkina Faso	Assess seasonality of dietary adequacy in urban households	The Mean Adequacy Ratio (MAR) dropped significantly during the lean season (49.61 vs. 53.57, $P < 0.0001$)	Ensuring access to micronutrient-dense foods across seasons is vital	(Becquey et al., 2012)

Nigeria	Determine food security status and influencing factors in households	61.1% of households were food insecure. Influential factors included wealth index, market access, and household size	Economic stability and market access improvements are critical to addressing food insecurity	(Kassy et al., 2021)
South Africa	Examine rural food insecurity trends from 1999 to 2021	Food insecurity decreased nationally, but rural areas remain disproportionately affected with a 37% prevalence in informal rural areas	Localized metrics are necessary to better address rural food insecurity	(Van Den Berg & Walsh, 2023)
Sub-Saharan Africa	Investigate agricultural export policies and their impact on food security	Policies emphasizing exports often reduced food availability for local communities	Balancing export policies with domestic needs is vital to maintaining food security	(Brigham, 2011)

2.4 Food commodities and key agricultural inputs

2.4.1 Essential food and agricultural inputs

First, it is important to highlight which commodities are considered essential for global food security. Table 5 presents the commodities in accordance with FAO's State of Food Security and Nutrition in the World 2024 report and FAOSTAT database. Three main categories are identified:

- Staple foods: cereals (maize, rice, wheat), roots and tubers (cassava, potatoes), pulses (peas, beans). They are major energy and protein sources.
- Fruits & vegetables: contains fruits (bananas, oranges, grapes) and vegetables (onions, tomatoes), which are rich in vitamins and minerals and often require the development of efficient cold chain logistics.
- Animal-based foods: dairy (milk), meat (bovine, poultry), fish and seafood, eggs. They're essential sources of protein, fat and micronutrients.

Table 5: Essential Food Commodities

ESSENTIAL FOOD COMMODITIES	
CATEGORY	**ITEM**
Staple Foods	**Cereals**: "Cereals - Excluding Beer", covering items like *maize, rice, wheat, barley, millet*, etc.
	Roots and Tubers: "Starchy Roots," which includes *cassava, potatoes, sweet potatoes*, and *yams*.
	Legumes/Pulses: "Pulses," encompassing *beans, peas*, and other pulses.
Fruits and Vegetables	**Fruits**: "Fruits - Excluding Wine," including *apples, bananas, citrus, dates, grapes, oranges*, and *pineapples*.
	Vegetables: "Vegetables," which covers items like *onions, tomatoes*, and other vegetables.
Animal-Based Foods	**Dairy**: "Milk - Excluding Butter," covering milk and its variants.
	Meat: "Meat," which includes *bovine, poultry, pigmeat, mutton*, and *goat meat*.
	Fish and Seafood: "Fish, Seafood," including various fish categories like *demersal, pelagic*, and *freshwater fish*.
	Eggs: "Eggs" group, covering all egg products.

Source: author's elaboration based on The State of Food Security and Nutrition in the World 2024 report (FAO, IFAD, UNICEF, WFP, WHO) and FAO data from FAOSTAT. Retrieved on 31.10.24 from http://www.fao.org/faostat/en/#definitions.

Food security is a multi-dimensional problem that depends on the relationship between domestic production, imports, exports and food stocks. While imports are a regular feature in countries' food security, at the same time there are concerns that imports may also transmit of shocks from climate change, geopolitical conflicts, and volatility in global markets.

Imports supplement local production. D'Odorico et al. (2014) point out that growing dependence on the global food system threatens to reduce social resilience, when exporting nations block exports in times of crisis to preserve domestic supply. This shows how vulnerable importers are, which can face shortages if exporters cut back on supplies. According to Erokhin (2017), food security includes not just the trade balance of imports and exports but also physical and economic access to nutritious foods, so imports must be inexpensive.

Domestic production plays an important part, too. Fraval et al. (2020) emphasize that food security concerns more than calories – it includes micronutrients and culture-rich foods, often from small family farms. Balance between production and imports will be the key to success. The more self-sufficient a country is, the more predictable its food security will be. For example, Loginov (2023) points out that food independence (80% or more of food needs are covered by domestic supply) is essential to national food security.

Other risk factors can have an impact on food insecurity, including whether the nations depend on imports of food or how much domestic production remains stable. Bren d'Amour et al. (2016) emphasize that countries most reliant on imports of cereal grains such as wheat, maize and rice are particularly susceptible to disruptions in international supply chains. Furthermore, Bren d'Amour and Anderson (2020) also mention that volatile imports (in particular from untrustworthy exporters) are also a cause of food volatility. Low biophysically able countries and less able local producers face a particular risk.

Literature outlines that food security also depends on food stocks to smoothen availability over time. Aseev et al. (2020) shows that large reserves can increase resiliency against supply shocks and fluctuations in prices, providing food security in times of emergency. This is crucial given disruptions around the world like from the COVID-19 pandemic that showed supply chain breakdowns and the need for scalable domestic manufacturing networks (Duisenbekova, 2023).

To provide some data, the World Food Program (WFP) reached more than 152 million individuals, many of them at the extreme end of emergency or disaster and famine levels of food insecurity. That included refugees, migrants and internally displaced people too.

Figure 3 illustrates the primary countries facing emergencies where WFP has been actively involved in 2023.

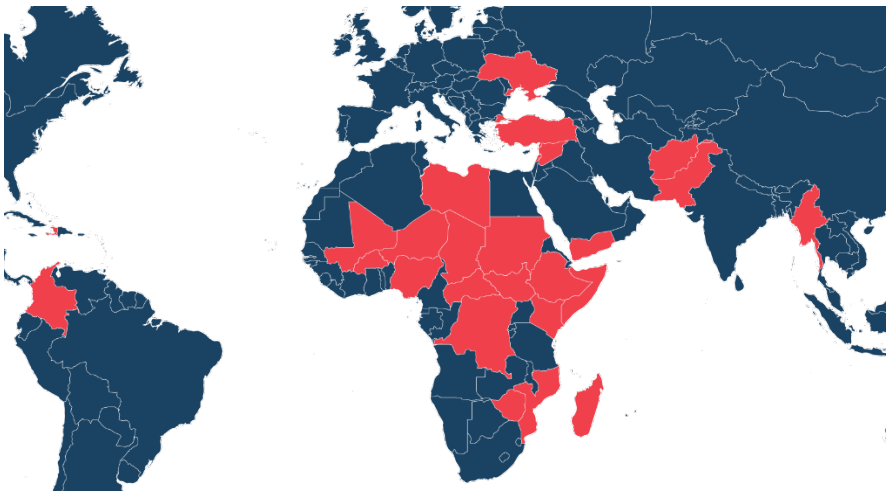


Figure 3: WFP main emergencies in 2023

Source: WFP Annual Review 2023: Keeping Pace with Soaring Humanitarian Challenges Amid Shrinking Resources

It is noteworthy to highlight that literature identified three main types of maritime supply chains for food commodities transported by sea: bulk carriers, reefers or refrigerated cargo vessels, and container ships. For bulk carriers, ships are designed specifically to carry bulk goods unpacked, such as grain, sugar and other crops. Its architecture and operation make them ideal for transporting such products in economical ways across foreign waters. For food commodities, large quantities of food

commodities is one of the bulk carriers' greatest advantages. Hermann (2024) speaks about bulk carriers as key actors in sea transportation industry and how they can efficiently carry various raw materials and products, such as grains, which are an essential ingredient of world food supply chains. Bulk carriers are built to rapidly load and unload goods, keeping the food fresh and nutritious while in transit.

Literature found that the movement of perishable products – particularly fresh produce – has changed significantly as special shipping containers, such as reefer containers, are introduced that can be made to keep goods at the ideal temperature and humidity levels. For the transport of new agricultural commodities, reefer containers have become a key element of the transportation of anything that is vulnerable to temperature changes. It has been found that these containers are vital for the preservation of fresh fruits and vegetables over extended periods of shipping, like the 17-day sea export trial from Japan to Singapore, which showed that atmospheres in regulated conditions can successfully maintain the quality of the products (Ikegaya et al., 2023; Ikegaya et al., 2019).

Container ships play a significant role in the transportation of transformed or processed food products. After declining volumes in 2022 and low growth in containerized trade in 2023, containerized trade in 2024 had a strong performance, with the Trans-Pacific Eastbound and Asia–Europe Westbound as the most important routes in terms of containerized trade volumes. However, while containerized trade volume is projected to grow by 2.7% between 2025 and 2029, disruptions at major chokepoints and strategies to enhance maritime resilience could potentially affect these projections. For instance, disruptions in East Africa have caused shortages of perishable goods and standard containers due to increased cargo delivery times impacting avocado, tea and coffee supply chains, among others (Bacrot and Faure, 2024).

Food security can be also affected by impacts on **key agricultural input** as agricultural productivity depends on access to, availability and efficient use of inputs, such as water, seeds, fertilizer, pesticides, agricultural technology and on digital agricultural technologies.

Water is the key to agricultural productivity, and agriculture uses a big portion of the fresh water on Earth. stable water supply, particularly irrigation, is an important factor for crop yields and hence for food security (Sruthy, 2023; Mansuri, 2018). Water use efficiency (WUE) needs to improve globally to reduce the impact of climate change on water availability and yields (Molotoks et al., 2020).

High quality **seeds** make a difference in terms of yield and vigor. Seed availability promotes productivity, disease and drought tolerance. Seeds that are of good quality are crucial to food security, especially in Sub-Saharan Africa and use in farming is not a novel practice (Abebe & Alemu, 2017).

Fertilizers (Nitrogen, Phosphorus, Potassium) improve soil fertility and production. They increase productivity and facilitate food security (Weikard, 2016; MacDonald et al, 2011). But overusing is environmentally harmful and should be consumed very sparingly for sustainability (Wang, 2017).

Pesticides are one of the agricultural inputs that play an important role in food security by raising yields and quality. According to the United States Environmental Protection Agency (EPA), pesticides are 'chemicals that prevent, kill, repel or control pests' and they are a crucial component of agricultural yields (Wolde & Abirdew, 2019). The Green Revolution in the 1970s led to massive increases in pesticides in order to grow food and stop world hunger (Sant'ana et al., 2019).

Agriculture technology (mechanization, commercialization) has historically contributed to raising agricultural productivity. Mechanization allows higher yield with fewer inputs (Strasser-King et al., 2023) (Dorward et al., 2014; Kilic et al., 2013).

Digital agriculture technologies can help promote food security through the increase of agricultural productivity and sustainability (Rasyid, 2024; Oruma et al., 2021; Erickson & Fausti, 2021). The application of the information technology for better crop and livestock production under the aegis of precision agriculture can increase yields, rationalize use of resources and minimize the environmental footprint of agricultural production (Erickson & Fausti, 2021; Talebpour et al., 2015).

Several studies have shown the value of precision agriculture for food security. It can for example make effective use of production inputs, size and scale agricultural operations without labor expenditure, improve site choice, better recording and traceability of products (Adepoju, 2022). Besides, the combination of precision agriculture and other digital tools like remote sensing and UAV-based monitoring can be used to further improve crop monitoring and early stress detection in order to make better decisions and allocate resources (Sagan et al., 2019).

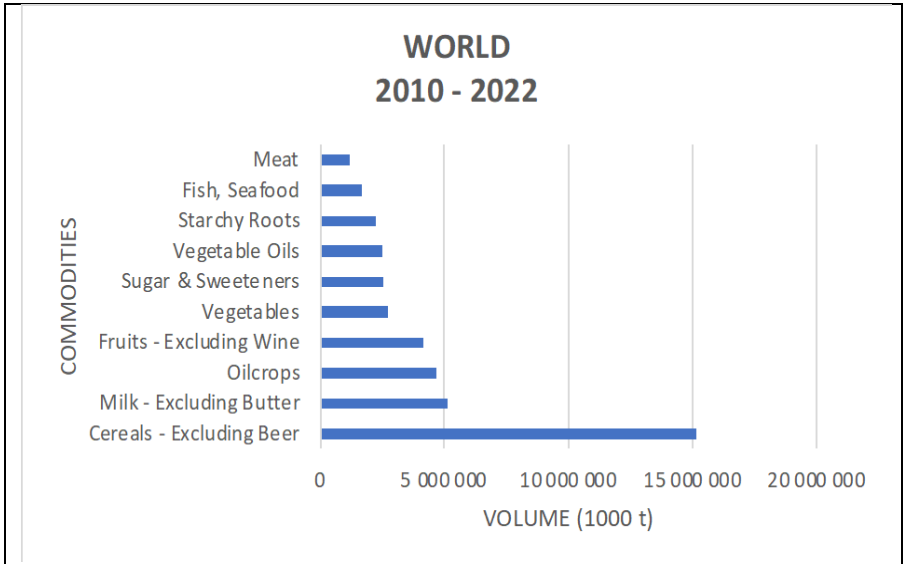
Digital agriculture technology and precision farming can greatly improve food security by enhancing production, optimization of resources, and lowering the ecological footprint of agricultural operations (Rasyid, 2024; Oruma et al., 2021; Erickson & Fausti, 2021). Literature identified that implementing these technologies will be more inclusive and requires multiple considerations ranging from technical assistance, social networks and the equitable construction of agricultural and food systems (Lee et al, 2023; Yan, 2023; Ahmed, 2019).

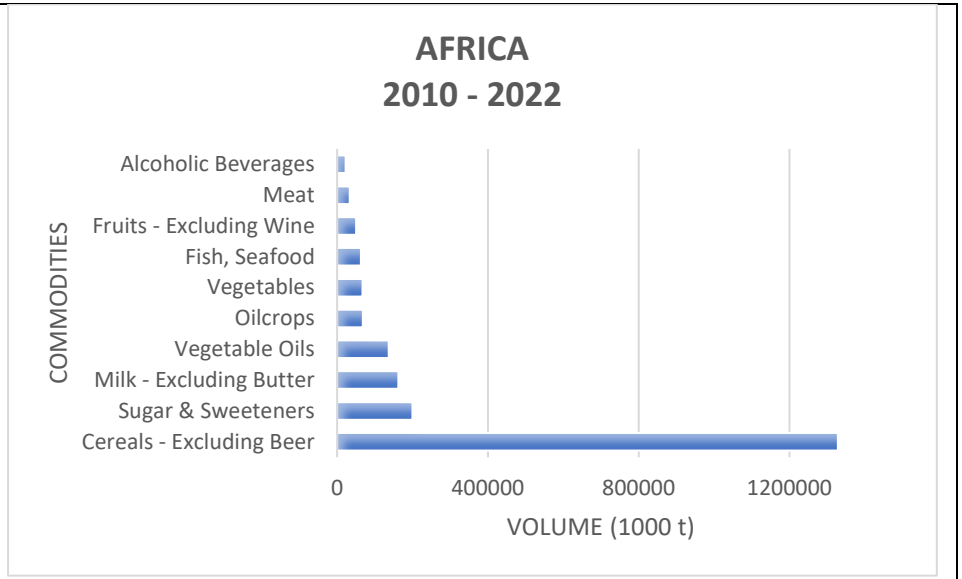
2.4.2. Essential food commodities trade, by region

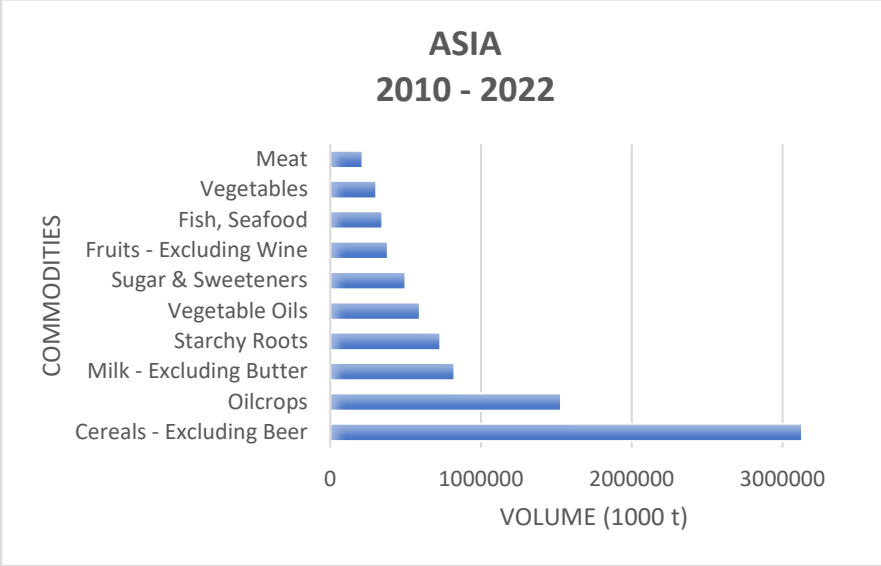
Top 10 food commodities 2010 – 2022

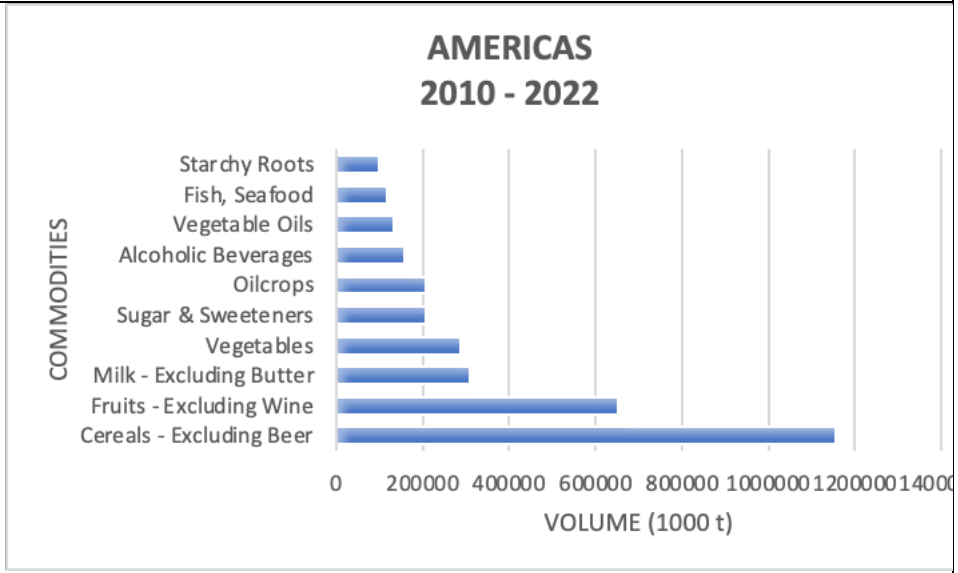
In order to present an overview of the main agricultural trade patterns, the analysis in this review relies on FAO statistics on imports from 2010 to 2022, by region (Africa, Americas, Asia, Europe, and Oceania). This is considering all imports by all modes of transport. The data is ranked by volume of imports (thousands of tons), giving a snapshot of the key food commodities influencing global trade and food security (Figure 4)**.**

When discussing the trade of essential food commodities by region, cereals and milk are ubiquitous staples, fundamental to food security, population nutrition, and agriculture worldwide. Whereas in Asia and Africa, for instance, there are many commodities of no less fundamental value than cereals (food safety), more imported commodities (and hence more varied diets) prevail in Europe and the Americas. The enormous quantities of vegetable oils exported from Asia and Africa emphasize their utility to local food systems, and the quantity of fruits and vegetables brought to the Americas and Europe signal consumers' health-consciousness.


WORLD
2010 - 2022
COMMODITIES
Meat
Fish, Seafood
Starchy Roots
Vegetable Oils
Sugar & Sweeteners
Vegetables
Fruits - Excluding Wine
Oilcrops
Milk - Excluding Butter
Cereals - Excluding Beer
0
5 000 000
10 000 000
15 000 000
20 000 000
VOLUME (1000 t)


AFRICA
2010 - 2022
COMMODITIES
Alcoholic Beverages
Meat
Fruits - Excluding Wine
Fish, Seafood
Vegetables
Oilcrops
Vegetable Oils
Milk - Excluding Butter
Sugar & Sweeteners
Cereals - Excluding Beer
0
400000
800000
1200000
VOLUME (1000 t)


ASIA
2010 - 2022
COMMODITIES
Meat
Vegetables
Fish, Seafood
Fruits - Excluding Wine
Sugar & Sweeteners
Vegetable Oils
Starchy Roots
Milk - Excluding Butter
Oilcrops
Cereals - Excluding Beer
0
1000000
2000000
3000000
VOLUME (1000 t)


AMERICAS
2010 - 2022
COMMODITIES
Starchy Roots
Fish, Seafood
Vegetable Oils
Alcoholic Beverages
Oilcrops
Sugar & Sweeteners
Vegetables
Milk - Excluding Butter
Fruits - Excluding Wine
Cereals - Excluding Beer
0
200000
400000
600000
800000
1000000
1200000
VOLUME (1000 t)

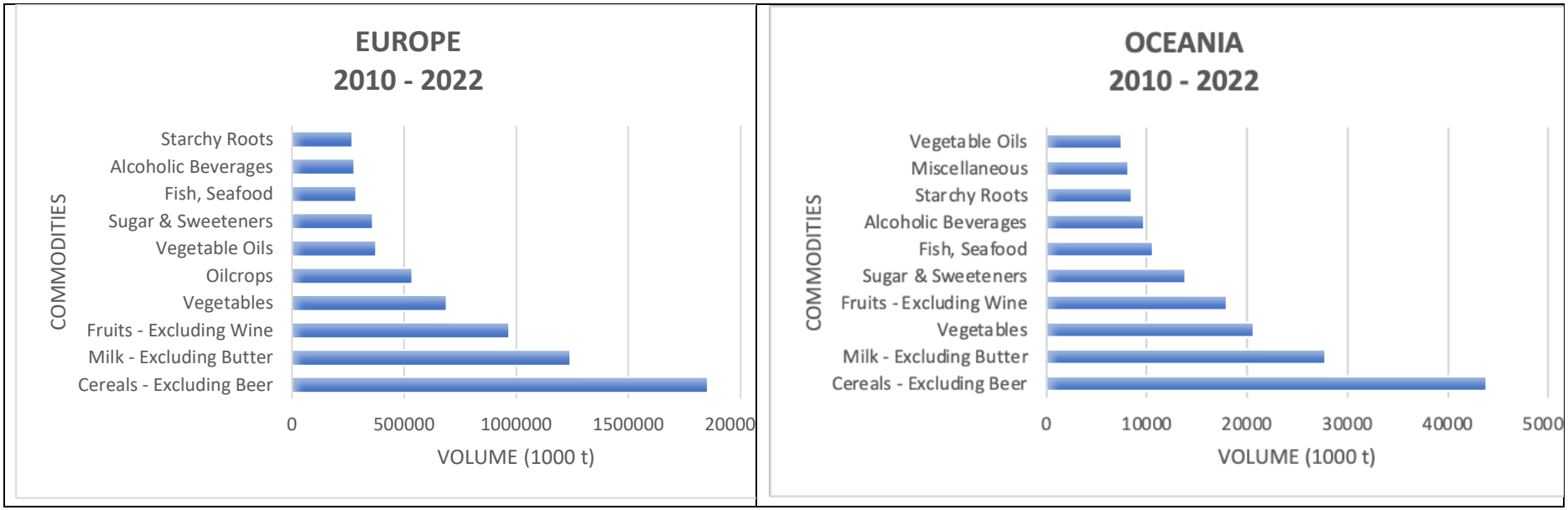


Figure 4: Top 10 Food Commodities import volume
Source: FAOSTAT; Data processing and chart by WMU

Figure 4 shows the main food commodities imported. For instance, ***in Africa*** from 2010 to 2022 cereals (excluding beer) dominate imports by a substantial margin, highlighting their role as staple foods in the region. Cereals, a source of almost a quarter of all calories in many African countries, are a key food staple, according to the FAO (2019). Growing dairy demand coincides with food diversification due to urbanization and income growth. In cities, people gravitate towards other rich foods, such as dairy, where the rise in population in Ethiopia has driven up milk consumption (Almaw et al., 2021). Imports of sugar and milk express a growing need caused by the urbanization and, in some places, the rise in purchasing power. Vegetable oil and oil crops imports prove Africa's dependence on foreign fats for cooking and food-processing. Vegetables, fish & seafood and fruits (except wine) add variety to diets, but are in lower import numbers due to their relative less priority. The smallest import volumes come from meat and liquor; therefore, they don't contribute to Africa's import requirement. As a whole, these import trends point to Africa's dependence on staple foods with more imports for a balanced diet.

The 10 most-imported food commodities in the ***Americas*** by volume between 2010 to 2022 are reported in Figure 4. Cereals (beer excluded) are by far the most dominant category, which is testament to their centrality as a staple. Fruits (not wine) and milk (not butter) come second, illustrating the importance of dietary diversity and protein. Fruits, sugar/sweeteners, and oilseeds show dependence on imports to sustain processed foods and nutritious diets. Imports of alcoholic beverages and fish meet cultural needs, and vegetable oils and starchy vegetables satisfy culinary and dietary demands. Such cycles highlight the region's diverse dietary needs, which are framed by globalization, health issues and production constraints.

The top food commodities imported into ***Asia*** in 2010 to 2022 by volume shown in Figure 4 is also cereals (barring beer), and this proves that they are staple foods in the region. Oil crops and milk (but not butter) come next with the demand for oils and dairy products in full flow. Starchy root, vegetable oil and sugar/sweeteners are all sources of imports of carbohydrate-based and processed food products. Imports of fruits and fish give dietary variety, whereas the imports of vegetables and meat are relatively small. Such trends show the dependence of Asia on staple foods and an expectation for a range of foods to ensure a healthy diet.

The top food commodities imported into ***Europe*** from 2010 to 2022, are shown in Figure 4. Cereals (except beer) are the most imported food commodity, indicating their centrality as regional staples. Milk (no butter) and fruits (no wine) are next, with a glut of dairy products and fresh fruits. There are also high imports of vegetables and oil crops as diverse food sources are required. Plant oils, sugar/sweeteners, fish/seafood point to dependence on these things for foodstuffs and processed foods. Alcoholic drinks and starchy roots come in much smaller numbers but still form part of the import pool, reflecting the diversity of Europe's food imports.

The top import food commodities in ***Oceania*** for the period 2010 to 2022 are reported in Figure 4. The most import item is cereals (no beer), which is indicative of its importance as a staple food. Milk (non-butter) and vegetables come in second, corresponding to needs for dairy and fresh foods. Other import items include fruit (not wine) and sugar & sweeteners, which means that we also require additional nutrition and processed food ingredients. Import volumes of fish & seafood and alcohol cater to certain diets and cultural needs. Starchy roots, miscellaneous items and vegetable oils make less of a contribution to Oceania's import requirements, but contribute a variety. These trends reflect the region's dependence on imports of both staple and other food products.

The next figures from FAOSTAT report statistics on essential food imports (2010-2022) by region and sub-region of the world, from which regional and sub-regional differences and trends can be deduced.

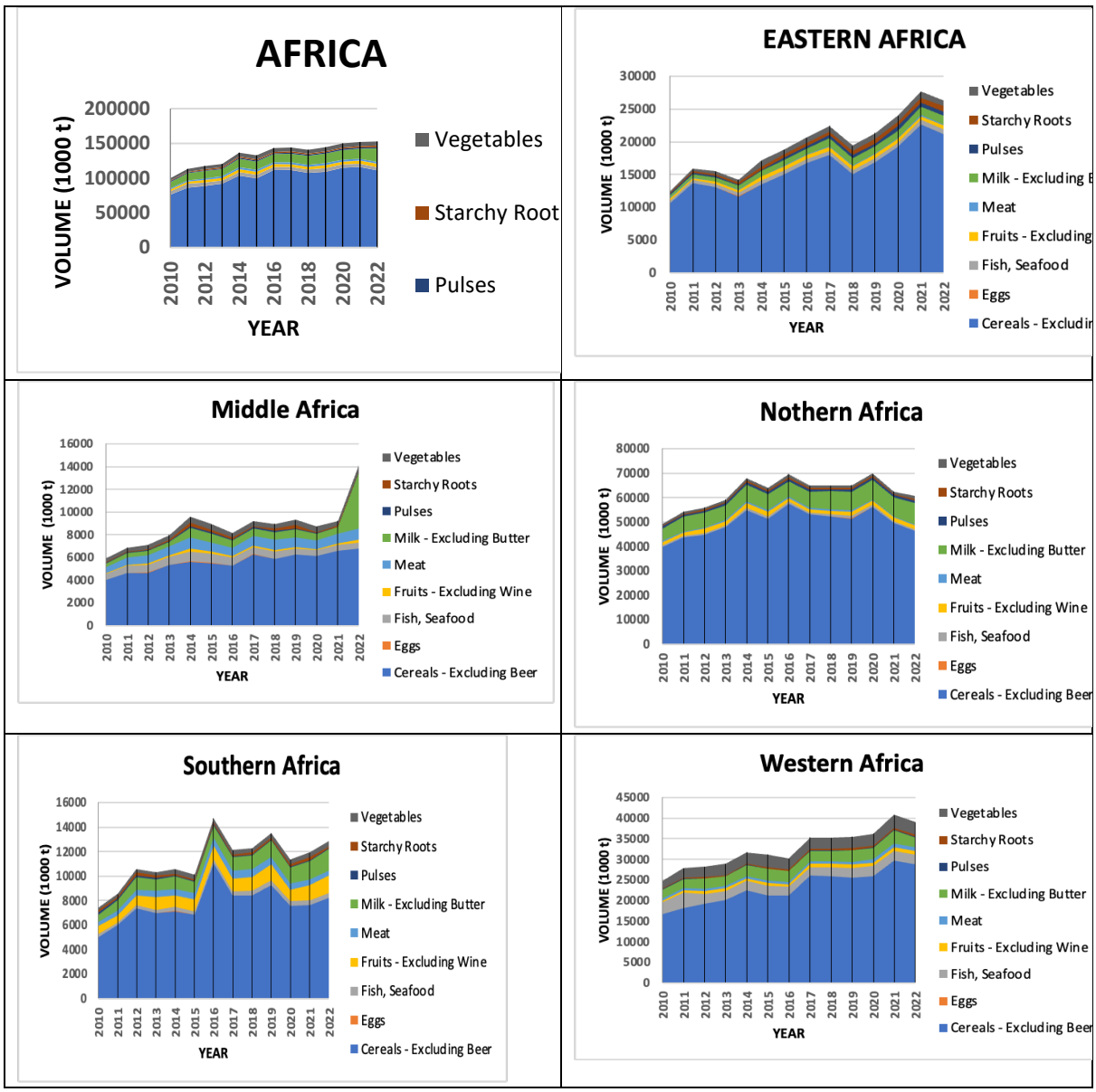


Figure 5: Import volume essential food africa (2010 -2022)
Source: FAOSTAT; Data processing and chart by WMU

Figure 5 shows the growing proportions of cereals, starchy roots and pulses in ***Africa***, likely driven by population growth, changing food needs and challenges of production. Cereals dominate imports to the continent, since they are staples, which shows an extreme dependence on the international market. This dependence is subject to volatility in price and supply chain disruptions, and it calls for resilient local agricultural systems.

- East Africa: increased cereal imports because of low domestic production. Imports of vegetables and dairy indicate gradual dietary diversity.
- Central Africa: dramatic spike in cereal imports in recent years, underscoring the region's vulnerability to production shortfalls. Milk and meat imports are low but steady.

- North Africa: stable cereal imports highlight dependence on grains. Growing exports of milk, fruits and vegetables suggest food diversification.
- Southern Africa: rising cereal imports suggest production-consumption imbalances. Milk and fruit imports indicate changing consumer preferences.
- West Africa: increasing cereal imports edging steadily upward, modest increases in vegetable and milk imports implying slow diet changes.

Rising imports of fruits, vegetables, milk and meat in ***Africa*** indicate urbanization, income growth and changes in consumption patterns. However, literature also finds that reliance on cereal imports reinforces the necessity to increase local agricultural output in order to provide long-term food security.

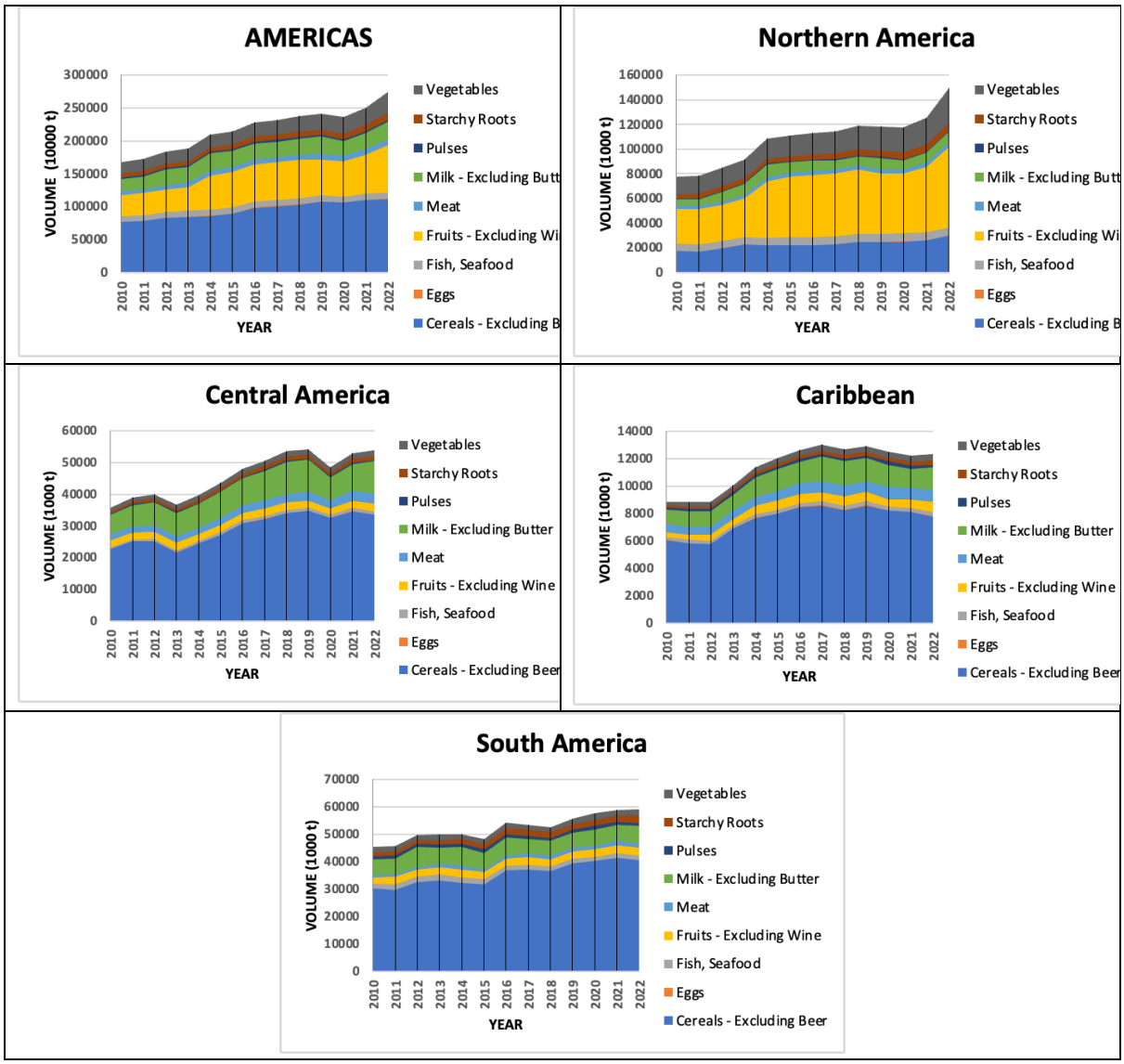


Figure 6: Import Volume Essential Food Americas (2010 -2022)
Source: FAOSTAT; Data processing and chart by WMU

Figure 6 shows a rising dependence on imports in the ***Americas*** between 2010 and 2022 due to demand for staples such as cereals, meat and fruits. Cereals are the main staple import in most parts of the world, but foods such as seafood, vegetables and dairy represent dietary diversification. Depending on the need and capacity of production in each country, the import trends are different

for each region. Import trends emphasize the need to complement imports with domestic production in order to provide more food security. Import volumes have steadily increased and, primarily for cereals, meat and fruits, the continent is reliant on global trade for basic food.

- North America: imports largely consist of fruits, cereals, vegetables, and milk, addressing dietary preferences and shortages.
- Central America: there is a significant reliance on imported cereals, milk, and meat.
- Caribbean States: minimal imports primarily focus on cereals, meat, milk, and fruits due to geographic and local limitations.
- South America: largest importer of cereals, heavily dependent on external supply for these staples, along with rising imports of fruits, vegetables, and milk.

Figure 7 shows that in ***Asia***, between 2010 and 2022, cereal imports are top and have grown steadily and make up the majority of imports. Pulses, starchy roots and milk all increase to significant extents.

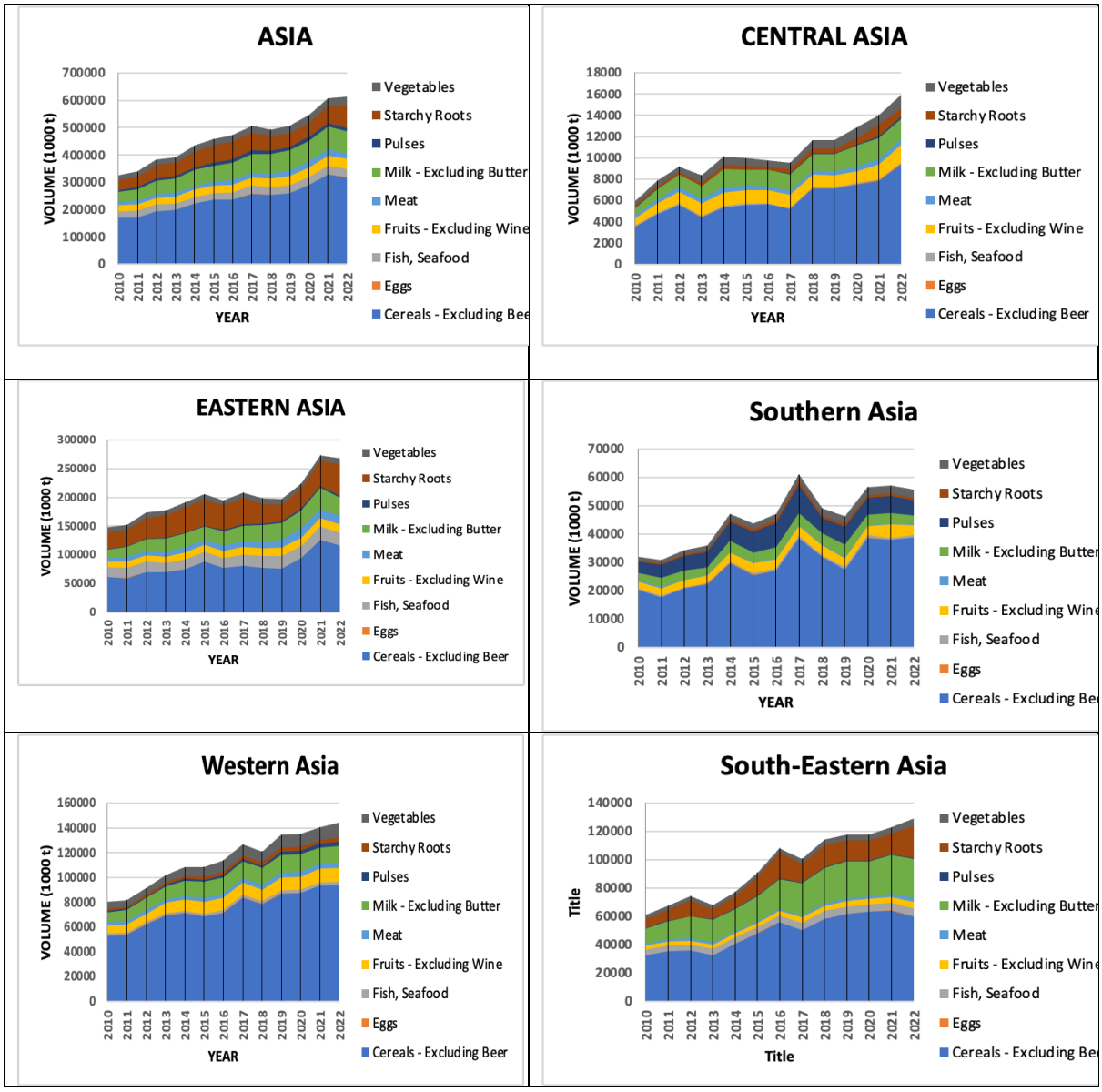
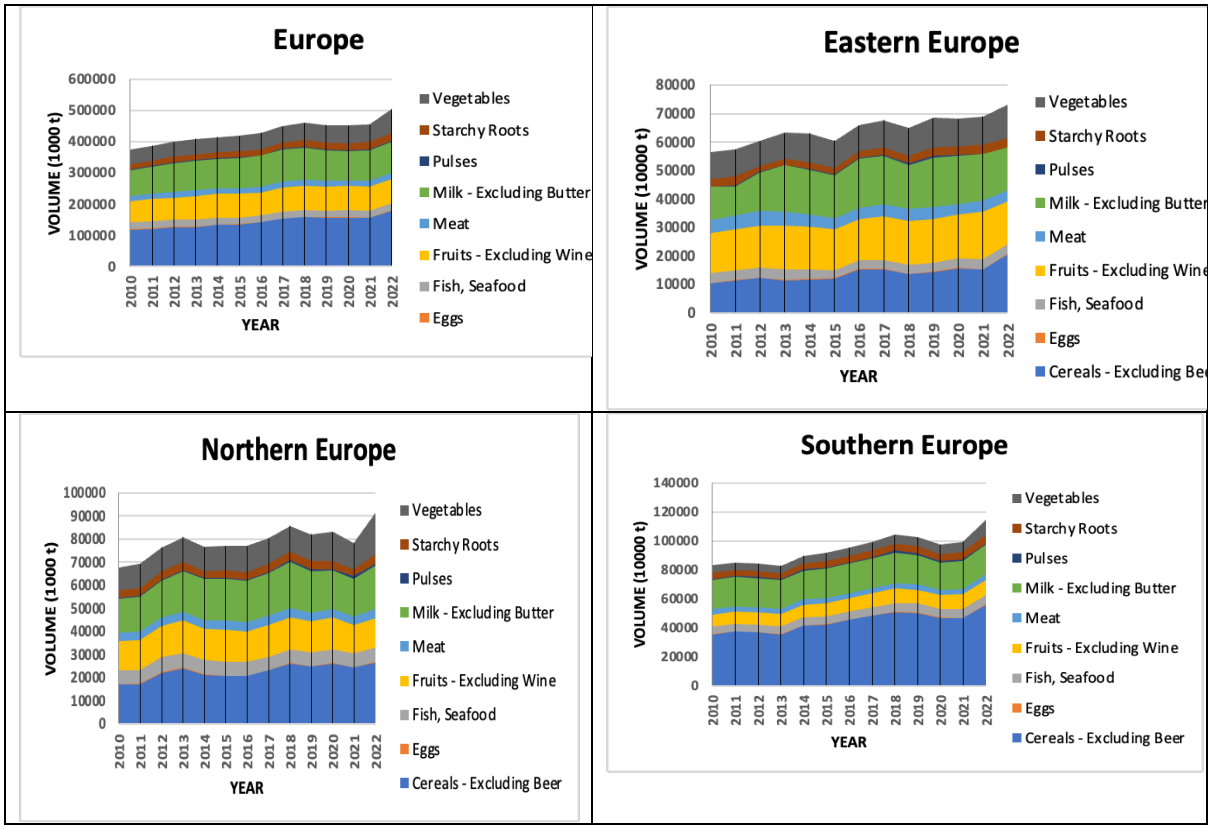


Figure 7: Import Volume Essential Food Asia Sub-Areas (2010 -2022)
Source: FAOSTAT; Data processing and chart by WMU

- Central Asia: cereal imports are predominant and are gradually increasing. While imports of pulses and milk continue to grow, they remain secondary.
- Eastern Asia: there are significant cereal imports and a rise in imports of starchy roots and fruits. However, imports of pulses and milk are stable but less critical.
- Southern Asia: cereal imports dominate the market, followed by milk and pulses. Notably, there has been substantial growth in the importation of fruits and vegetables.
- Western Asia: cereal imports are at an all-time high, with significant increases in milk and fruit imports. Imports of pulses and starchy roots are less critical but show steady growth.
- Southeastern Asia: cereal imports are substantial, matched by significant increases in starchy root crops, fruits, and milk. There is also steady growth in imports of pulses and vegetables.

Cereals make up a large proportion of imports across all Asian regions, as they are staple foods. However, the rising imports of fruits, milk, and starchy roots indicate a shift towards a more complex diet, with regional variations in dependence on specific items. This shift is driven by production challenges and changing consumer demands.

Figure 8 shows that imports in ***Europe***, between 2010 and 2022, are led by cereals, with steady growth rates. Milk, fruits and pulses contribute, as do vegetables and starchy roots, which increase gradually.



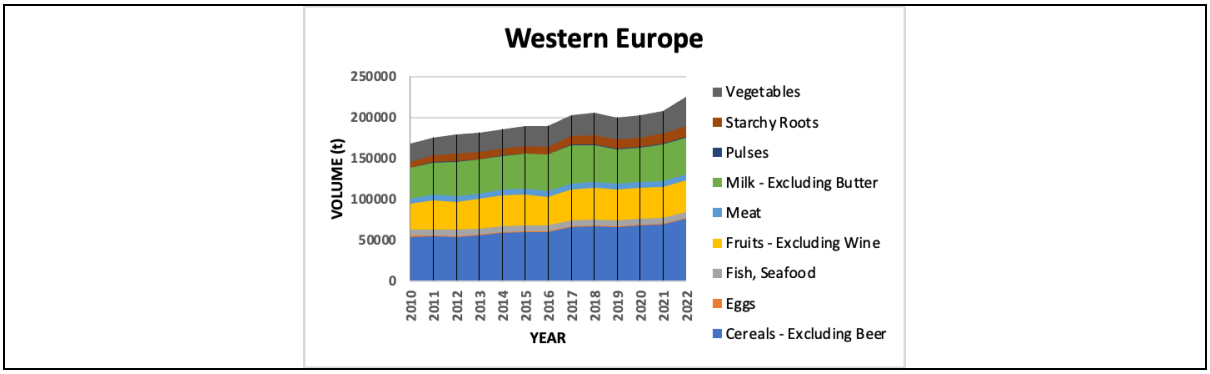
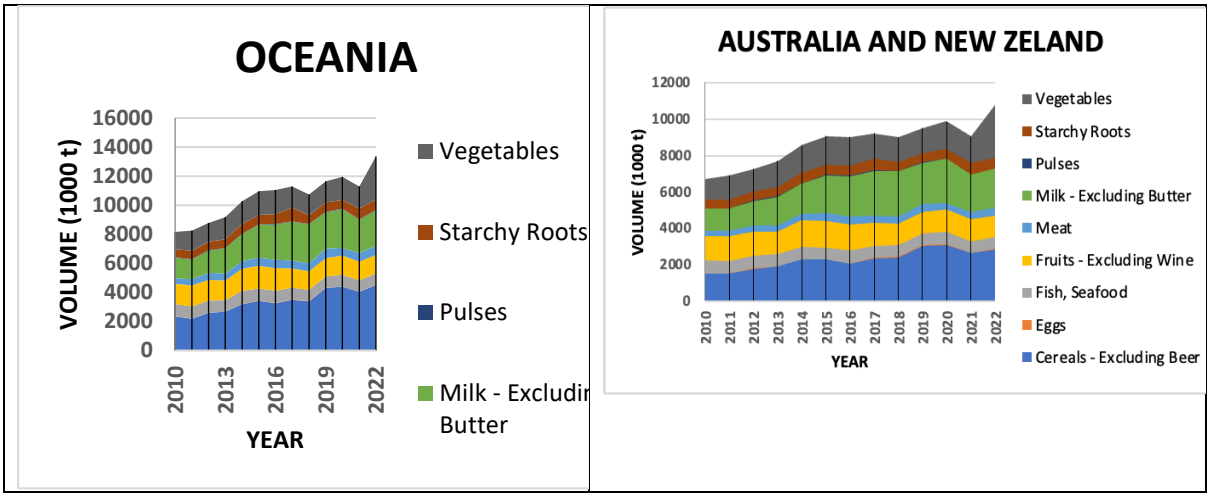


Figure 8: Import Volume Essential Food Europe Sub-Areas (2010 -2022)
Source: FAOSTAT; Data processing and chart by WMU

- Eastern Europe: primarily imports cereals, with increasing imports of milk and pulses. Vegetable imports remain relatively small.
- Northern Europe: imports consist mainly of cereals and milk, with slow growth in fruit imports. Although vegetable imports are limited, they have remained stable.
- Southern Europe: leads with cereal imports, but milk, fruits, and vegetables are also rising. Imports of starchy root crops and pulses are consistent, though they remain a lesser priority.
- Western Europe: imports the most cereals, followed by milk and fruit. Vegetable and starchy root crop imports are low but steady.

Overall, cereals dominate import volumes across all European regions as staple foods. However, the significant increase in milk, vegetables, and fruit reflects an expanding diet. The distinctions among regions also highlight differences in food consumption patterns.

Figure 9 highlights imports in ***Oceania***, between 2010 and 2022, are dominated by cereals, in stable volumes with slow growth. Dairy, roots and fruit are also important sources. We have also seen a growth in vegetable imports in recent years.



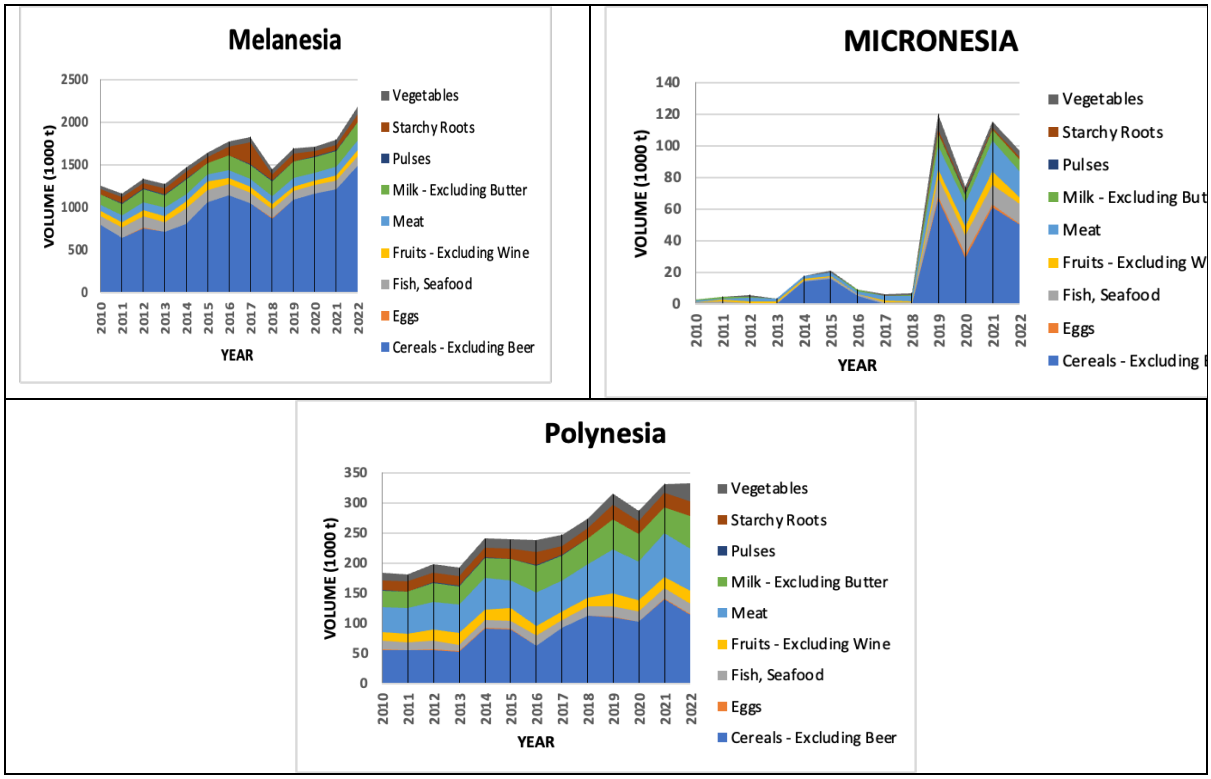


Figure 9: Import Volume Essential Food Oceania Sub-Areas (2010 -2022)
Source: FAOSTAT; Data processing and chart by WMU

- Australia and New Zealand: cereals are still the largest import, and imports of vegetables, milk, and starchy roots rise.
- Melanesia: cereals take a large share, but slowing growing milk, vegetables and fruits. Starchy roots show disproportionate spikes, suggesting regional food requirements.
- Micronesia: cereals are the largest imported product, with recent gains. But meat, milk, fruit and starchy vegetables are always coming in dwindling numbers.
- Polynesia: cereals top the list of imports followed by beef, milk, and starch vegetables. The fruit and vegetable imports have grown moderately in the past few years.

Overall, cereals are a key import throughout ***Oceania*** as staple food. But increased imports of milk, fruit, starchy roots and vegetables in every sub-region reflect a more gradual diversification of diets.

2.4.3 Key agricultural input, by region

FAOSTAT also provides data exclusively on fertilizers and pesticides, excluding data on seeds, irrigation systems, and agricultural machinery. Due to the lack of access to other databases, this analysis is based solely on FAOSTAT data, focusing on fertilizers and pesticides, while recognizing the limitations of the scope.

Fertilizer markets are subject to shocks, including climate shocks, economic recessions and trade disputes that can affect the supply, demand and prices of fertilizers (Makate & Makate, 2022; Lahmiri & Bekiros, 2018). But their sustainability is dependent on a number of factors. Firstly, farmers who can access fertilizers in the form of commercial purchases can improve the susceptibility of their crops to shocks. Farmers' access to multiple input sources and the flexibility to purchase might be able to adapt to new conditions (Makate & Makate, 2022). Second, the fertilizer markets are subject to

government subsidies and interventions. Those include measures to enhance their use as well as measures to reduce over-use in order to limit nutrient run-off. Furthermore, fertilizer market resilience could depend on the conditions of the agricultural landscape more generally, including adoption of climate-adapted crop species and farmer response to climate shocks (Acevedo et al. 2020).

Based on FAOSTAT data in 2020, the principal producers, importers and exporters of fertilizers are by nutrient type (Nitrogen (N), Phosphorus (P), and Potassium (K) (see Table 6).

Table 6: Producers, importers and exporters - Nitrogen, Phosphorus and Potassium

	Fertilizer Producers	**Exporter**	**Importers**
Nitrogen	China, India, United States, Russian Federation, Egypt	Russia (15%), China, Saudi Arabia, Qatar, Netherlands	India, Brazil, United States, France, Australia
Phosphate	China, India, United States, Russian Federation, Morocco	Morocco, China, Russia (14%), United States, Saudi Arabia	Brazil, India, United States, Canada, Argentina
Potassium	Canada, Russian Federation, Belarus, Germany, United States	Canada, Russian Federation (19%), Belarus (15%), China, Germany	United States, Brazil, China, India, Indonesia

Source: FAOSTAT (2020).

The fertilizer market is driven by multiple factors – economic, environmental and policy – which combine to dictate its trends and dynamics. Jones and Deuss (2024) provide a comprehensive summary of the key insights into the fertilizer market. Fertilizer prices have increased between 2021 and 2022, raising fears over availability and affordability. This in turn led governments to launch new policies or update their long-term strategy on fertilizer use in order to adjust to market uncertainty and better guard against future shocks. Policies that encourage mineral fertilizer are being displaced by policies that encourage the manufacture and application of organic fertilizers. This policy shift also involves subsidy to farmers to offset the higher prices of organic fertilizers and restrictions on mineral fertilizers.

According to Jones and Deuss (2024), the market is concentrated at the national and company level as mineral fertilizer is based on particular natural resources. This concentration increases market vulnerability to supply shocks arising from geopolitical or natural disasters. Export bans, quotas and taxes on mineral fertilizers are frequent measures that major mineral fertilizer exporters have taken in recent years. These were generally opaque, and liable to be modified on a regular basis, spanning the entire supply chain.

For Jones and Deuss (2024) the rising energy prices and declining output prices had made production uneconomical in some parts of the world, such as Europe. Nitrogen plants in Europe, for instance, still run at a deficit. Other countries have put in support policies for increasing fertilizer supplies and domestic production. The United States, for example, has also invested in increasing the quantity of US-developed fertilizer to keep up with prices. Organic fertilizer is now increasingly used because of environmental problems such as water pollution and climate change, but also because it has food security implications because of the cost of fertilizer.

Jones and Deuss (2024) also summarize economic perspectives in fertilizer industry with highlighting the following factors. The volatility in price is a major contributor, the price increases of 2021 and 2022 raised worries about availability and cost of fertilizers. It is the result of supply chains that have been volatile, including geopolitical issues.

Many nations depend primarily on imports for mineral fertilizers as they lack the capacity to produce them in-house (especially phosphorus and potassium) and are exposed to the markets around the world. Export controls of major exporters are very influencing international prices and make markets volatile. The concentration of the market at country and company level makes it susceptible to supply disruption.

Production of Nitrogen fertilizers relies on natural gas, so energy prices have direct implications for both the cost of production and the price of fertilizers. Subsidies or import tariffs for mineral fertilizer influence supply-demand dynamics and market dynamics.

Transport issues, particularly associated with special storage for ammonia, escalate prices and make deliveries more difficult, particularly in landlocked countries.

Fertilizers are essential to increase crop production and food security. The three major nutrients of mineral fertilizers are Nitrogen (N), Phosphate (P_2O_5 or short P) and potash (K_2O or short K). These are the major plant nutrients that are required for plant growth and are normally the limiting compounds in soils. Inorganic fertilizers such as NPK (Nitrogen, Phosphorus, Potassium) increase the growth of staple crops like maize and wheat, boosting soil nutrients required for nutrition (Liu et al., 2021; Hashim et al., 2017; Matyka, 2020). Organic fertilizers such as compost improve the quality of soil and nutrients in an ecologically sound way (Yu et al., 2020; Francioli et al., 2016). Micro-nutrient fertilizers, especially Zinc, increase yield and nutrition and correct deficiencies in critical zones (Abdu et al., 2022; Belay et al., 2021).

Phosphate and potash mineral fertilizer are mostly mined and depend on the location of deposits. In case of potash, the concentration is particularly strong with Canada, the Russian Federation and Belarus together accounting for two-thirds of global production and three-quarter of global exports. More than 80% of global potash production is traded compared to 45% for phosphate and 37% for nitrogen. Nitrogen-based mineral fertilizer (urea) is mostly produced with an intermediate stage of a chemical reaction of air nitrogen with methane to ammonia. The methane is normally coming from natural gas. This, together with high energy requirement of the production process, links fertilizer production directly to the availability of natural gas. Consequently, nitrogen fertilizer production is concentrated in countries with access to natural gas e.g., China, India, United States, and the Russian Federation.

The statistical analysis from FAOSTAT was made on fertilizers by nutrient, specifically including total values for Nitrogen (N), Phosphate (P_2O_5), and potash (K_2O).

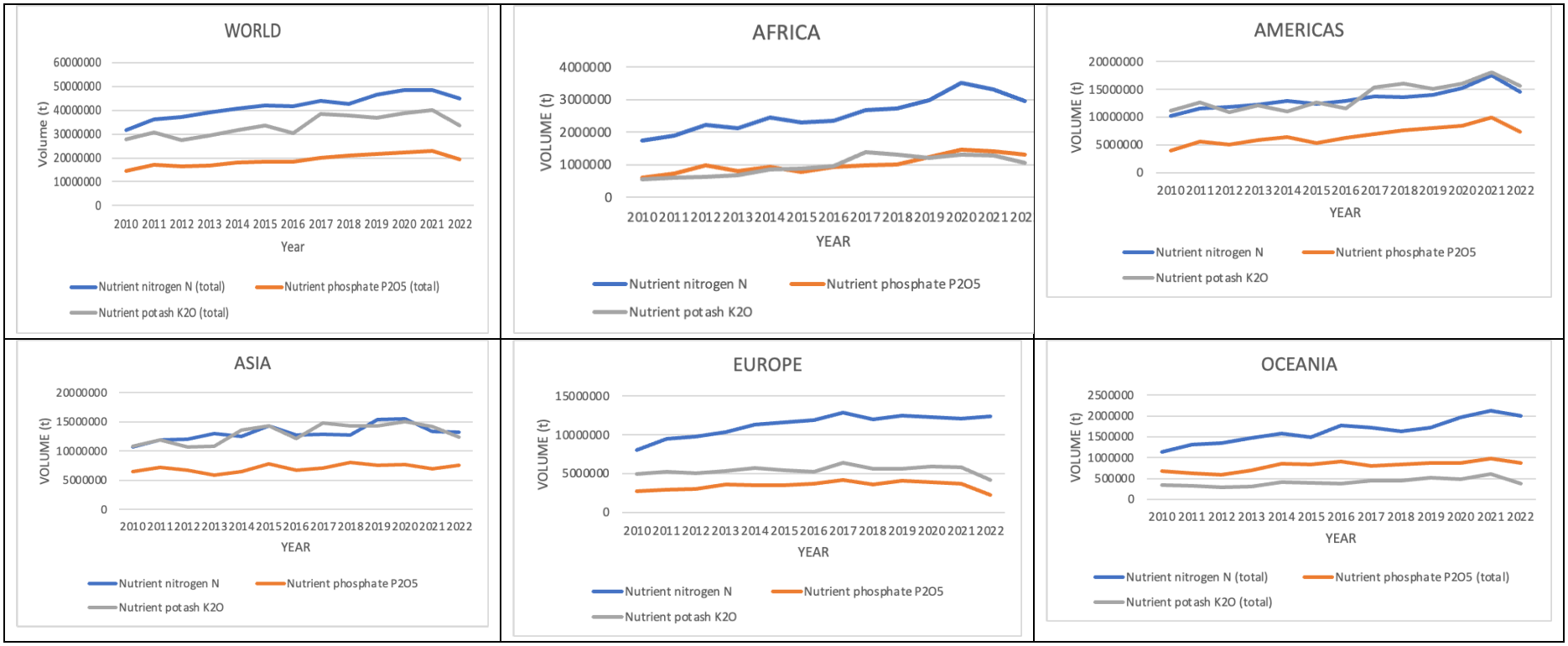


Figure 10: Import - Volume of fertilizers (2010 – 2022)
Source: FAOSTAT; Data processing and chart by WMU

As shown in Figure 10, imports of Nitrogen (N) in ***Africa*** increased over time, reaching 3.5 million metric tons in 2020 and subsequently decreasing slightly in 2021. Imports of phosphate (P2O5) and potash (K2O) also increased, each to around 1 million tons by 2021. The growth is because Africa requires fertilizers to boost food production; the decline in 2022 could be due to supply issues around the world. Potash and Nitrogen import volumes in ***Americas*** are both relatively high, gradually rising to highs around 2021 and then slowly falling. Phosphate keeps moving up, but it is still a smaller percentage than Nitrogen and potash. That means a fairly consistent demand for all three nutrients, but especially potash and Nitrogen. Nitrogen (N) imports to ***Asia*** also stood firm, fluctuating between 1.2 and 1.4 million tons between 2010 and 2022. Imports of phosphate (P2O5) remained steady at 600,000–800,000 tons, and potash (K2O) topped around 1.6 million metric tons and then fell a little in recent years. Such cyclical import trends demonstrate Asia's predictable demand for fertilizer to ensure that the land of its vast population is productive. In ***Europe***, imports of Nitrogen (N) continue to rise steadily with a 2017 peak then declining thereafter. Potash (K2O) is comparatively steady, with slight fluctuation and phosphate (P2O5) remains lower overall and falls after 2020. This suggests a relatively steady demand for Nitrogen and potash, and an increasingly lower phosphate demand. In ***Oceania*** Imports of Nitrogen are increasing continuously but imports of phosphate and potash have remained flat. It is this pattern that fuels Oceania's concern with preserving crop productivity, particularly in cereals. Even a slight decline in 2022 could be due to global supply disruption or application shifts.

The continued or rising trend of fertilizer imports in all regions highlights how essential these nutrients are for food security and crop productivity and their recent declines in 2022 could be attributed to external economic and supply chain considerations.

Modern agriculture requires **pesticides**, which also provide important food security benefits, by guarding crops against insects and enhancing yields. Synthetic pesticides such as organophosphates and carbamates have been widely used since the mid-20th century, and the global pesticide load now stands at 2 million tons a year and rising (Sharma et al., 2019; He et al., 2023). Crop loss without pesticides can be as high as 78% for fruit and 54% for vegetables (Tudi et al., 2021). Figure 11 illustrates the volumes of imports of pesticides between 2010 and 2022 by regions. Europe and the Americas continue to have the highest import levels, followed by Asia. Africa and Oceania import in much smaller quantities. Over the years, pesticide imports are generally higher, especially in Europe and Africa, reflecting increased pesticide use in these regions.

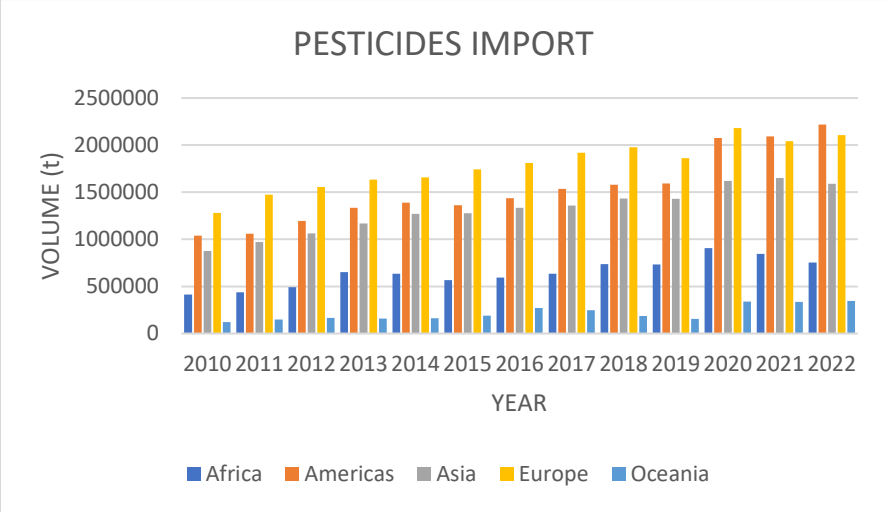
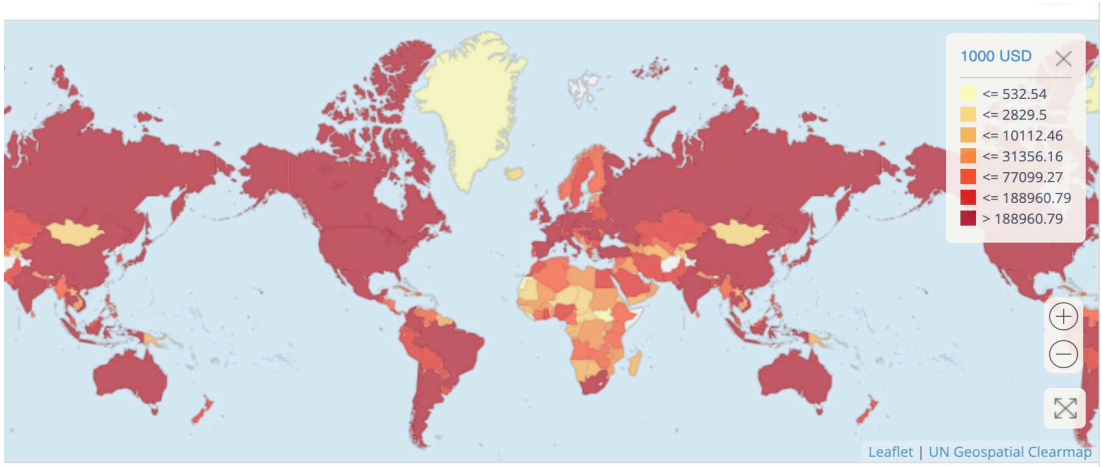


Figure 11: Pesticide's import (2010 – 2022)
Source: FAOSTAT; Data processing and chart by WMU

Figure 12 provides a picture of total import value of pesticides (1990-2022), worldwide.



The boundaries and names shown and the designations used on these map(s) do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Sudan and South Sudan has not yet been determined. Final status of the Abyei area is not yet determined.

Figure 12: Pesticides (total), import value by country (1990-2022)
Source: FAOSTAT; Data processing and chart by WMU

2.4.4 Food commodities imports by sea, by region

This section uses UN COMTRADE data to analyze the patterns of imports of food commodities by subregion in terms of sea imports. The analysis highlights the range of trends dictated by diet, trade, and regional production capacities. But it also takes into account inaccuracies in data and inconsistencies that compromise the fullness of assessments. These analyses emphasize the heterogeneity of trends dictated by diets, economic dynamics and regional manufacturing resources. But it also acknowledges the lack of data and contradictions that skew the totality of analyses.

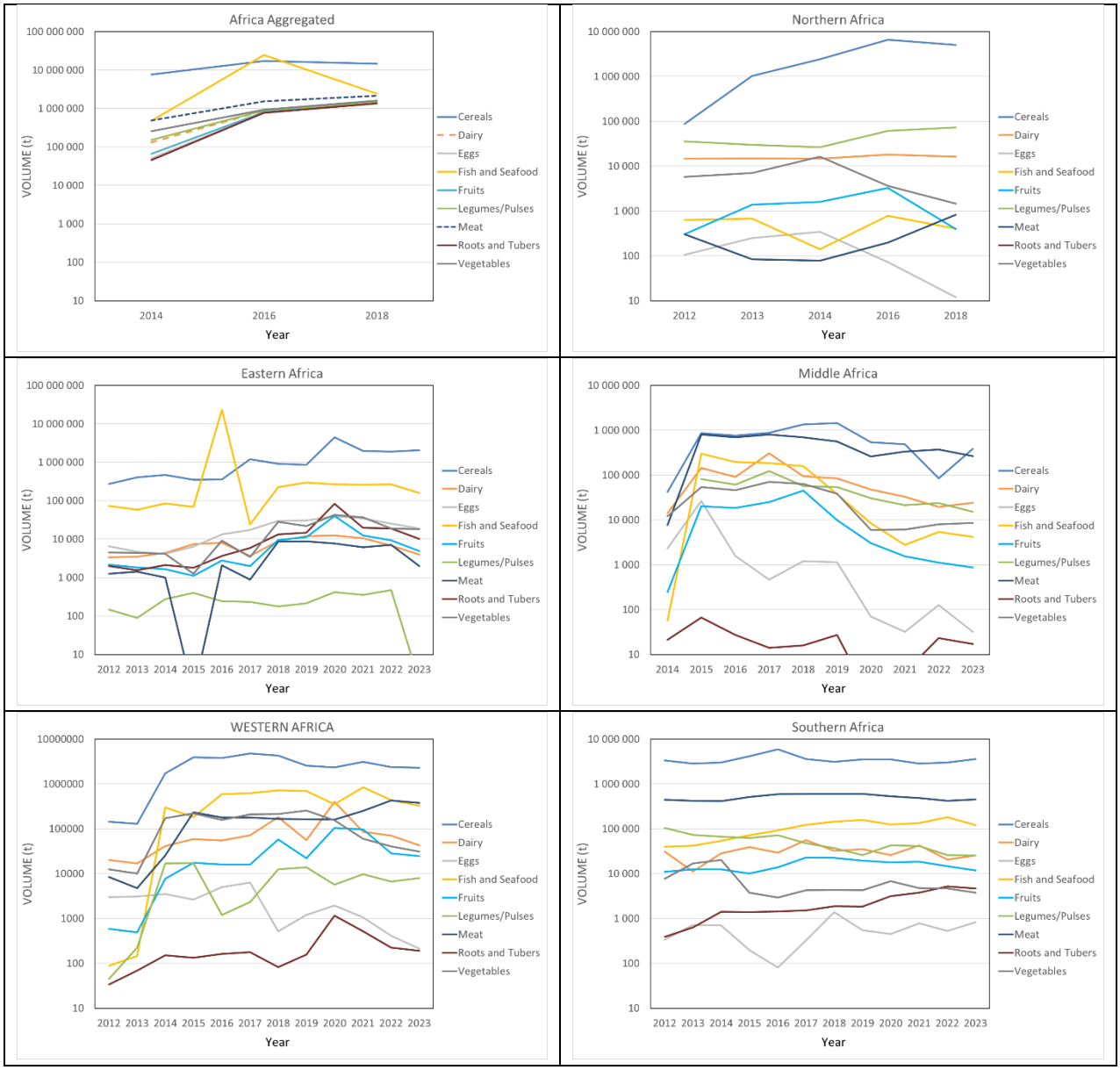


Figure 13: Food commodities imports by sea – Africa
Source: UN Comtrade; Data processing and chart by WMU

Figure 13 shows that ***Northern Africa*** depends on imports of cereals (wheat and maize) by sea because of dryness and insufficient farmland. Milk imports by sea keep growing, and fruit and vegetables don't change much. Lack of data in specific years impacts trend. Figure 13 highlights that cereal imports from the sea overwhelmingly flow into ***Eastern Africa***, topping up what was lost in local production in drought or war. Legumes and pulses imported by sea are staples of diets; fish imports stay essentially constant in the context of coastal trading. The absence of data from smaller countries can significantly distort the analysis. The imports of cereals account for the bulk of ***Middle Africa's*** food supply, rising in 2018 to more than 1.6 million tons, only to drop after 2019. This is evidence of dependence on imports to provide food security, which would be subject to volatility because of trade issues, economic pressure or better local production. Other commodities like dairy, fish, fruits and vegetables have low and stable imports, which indicate partial self-sufficiency or logistical challenges. Roots and tubers are missing due to robust local farming.

Western Africa depends a lot on sea rice and wheat imports to provide sustenance for its people. Seaborne fish and seafood imports are essential in coastal countries. Seasonal gaps are brimming with fruits and vegetables, shipped in by sea, but discrepancies between data prevent a full analysis. ***Southern Africa*** mainly imports cereals from sea also due to frequent droughts. Sea ports such as those of coastal South Africa enjoy good, well-established maritime trade in milk and fruits.

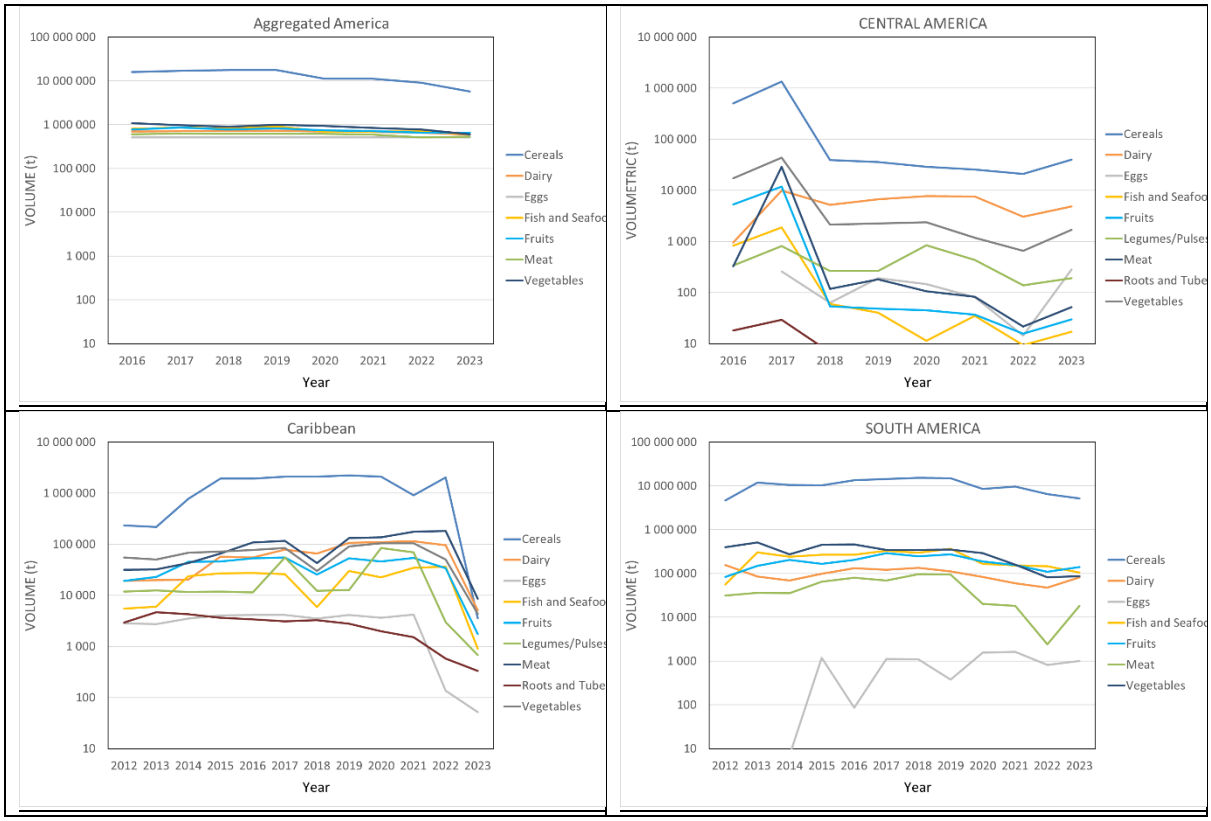


Figure 14: Food commodities imports by sea – America
Source: UN Comtrade; Data processing and chart by WMU

From Figure 14 it can be deducted that ***Central America*** needs cereals, legumes and dairy imported by sea. Fruit and vegetable imports are also shaped by seasonal trade flows. A shortage of data for some years restricts temporal trend analysis. Cereals dominate ***Caribbean*** food imports by sea, with continued high levels during the year, with only slight fluctuations. Other foodstuffs like legumes, pulses and fish stay the same because of their dietary importance. Imports of dairy and meat hardly change, but fruits, vegetables and roots remain relatively constant but at smaller volumes, and less dependent on domestic production. Cereal imports are the major import in ***South America***, and were steady at large levels throughout the year. Imports of dairy, fish and seafood, fruits and meat remain relatively constant, in line with regional dependence on domestic production augmented by imports. The vegetable crops show slight variation, and the eggs are irregular with very low abundances, probably due to local factors.

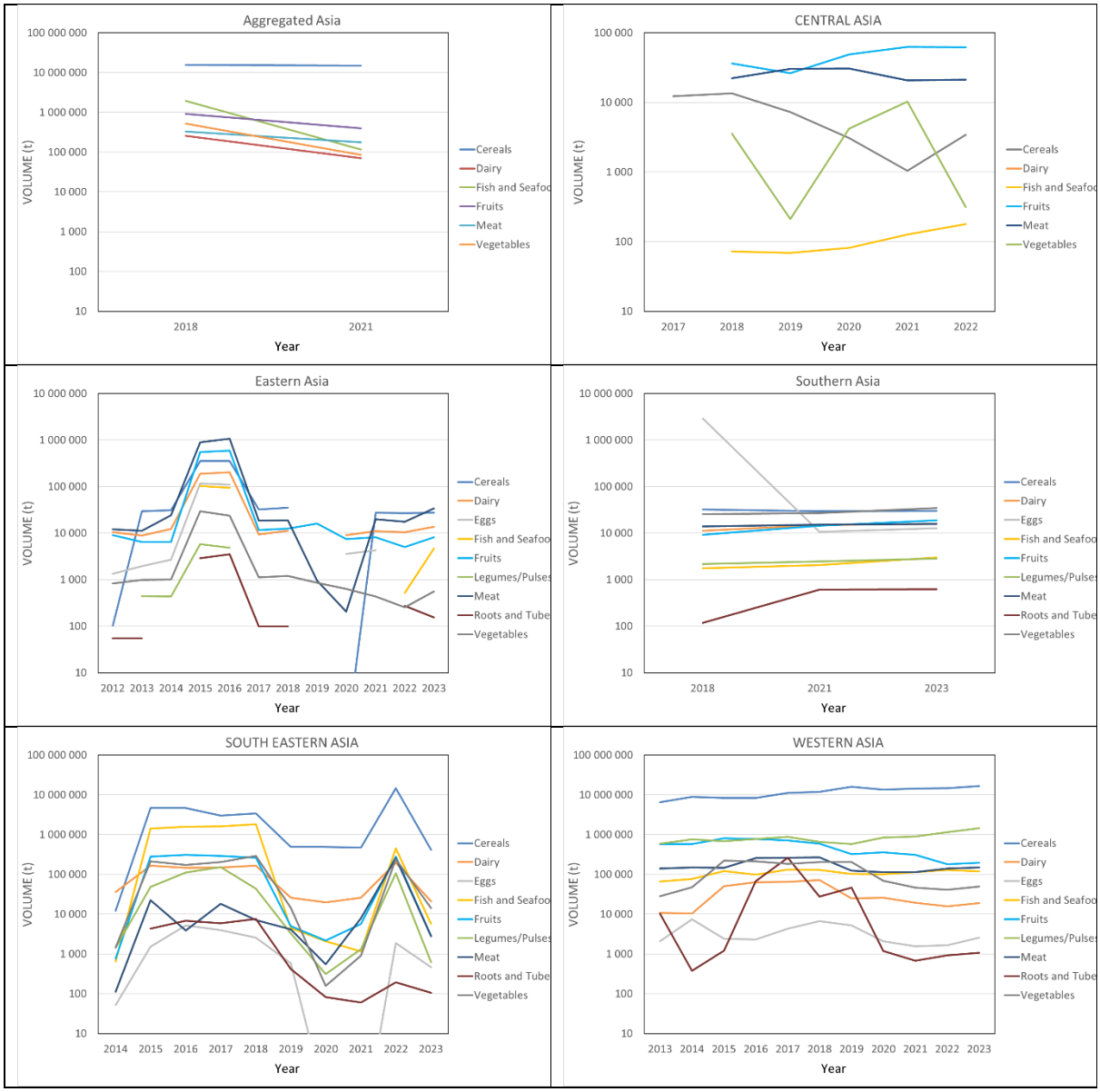


Figure 15: Food commodities imports by sea – Central Asia
Source: UN Comtrade; Data processing and chart by WMU

As shown in Figure 15, ***Central Asia*** imports of cereals are also low but relatively steady, due to their contribution to local production. Other commodities – dairy, meat, vegetables, etc. – have relatively small and stable import numbers. Fruits show some fluctuations, likely as a result of seasonal demand or regional production shortfalls. In ***Eastern Asia***, the largest import volumes are observed for cereal. Imports of cereals are at all times on a steady rise, because they are so important for the supply of food to the people. Other commodities like legumes, fruits and vegetables are imported moderately and with a relatively constant import level as a complement to local production. Dairy and meat imports also increased but at lower rates because of their secondary importance to local diets.

Concerning cereals, legumes and dairy, ***South East Asia*** relies on sea imports. Ports in India and Pakistan facilitate imports from inland countries. There is no data for certain years which prevents the comparison of trends. Cereals dominate Southeast Asia's sea imports, with steady and high volumes over the years as the region depends on staples such as rice and wheat. Imports of fish and seafood are still big, illustrating the criticality of sea food for coastal nations. Legumes, pulses, fruits, and vegetables have regular imports that augment domestic production; dairy and meat imports are

moderate and presumably served urban and food needs. Roots and tubers are little imported, which suggests regional agrarian independence. A drop in many commodities in 2020 to 2021, perhaps could be due to the COVID-19 pandemic disruptions. ***Western Asia's*** maritime imports of food are dominated by cereals, which have high levels all year round because of their centrality to regional food security. Legumes and pulses have moderate, but stable imports, and their presence in regional diets is unquestioned. Dairy imports show stable growth, meat and fish imports are moderate and satisfy a wide variety of diets. Fruits and vegetables also show regular imports supplanting local agricultural output. Roots and tubers, however, are little imported.

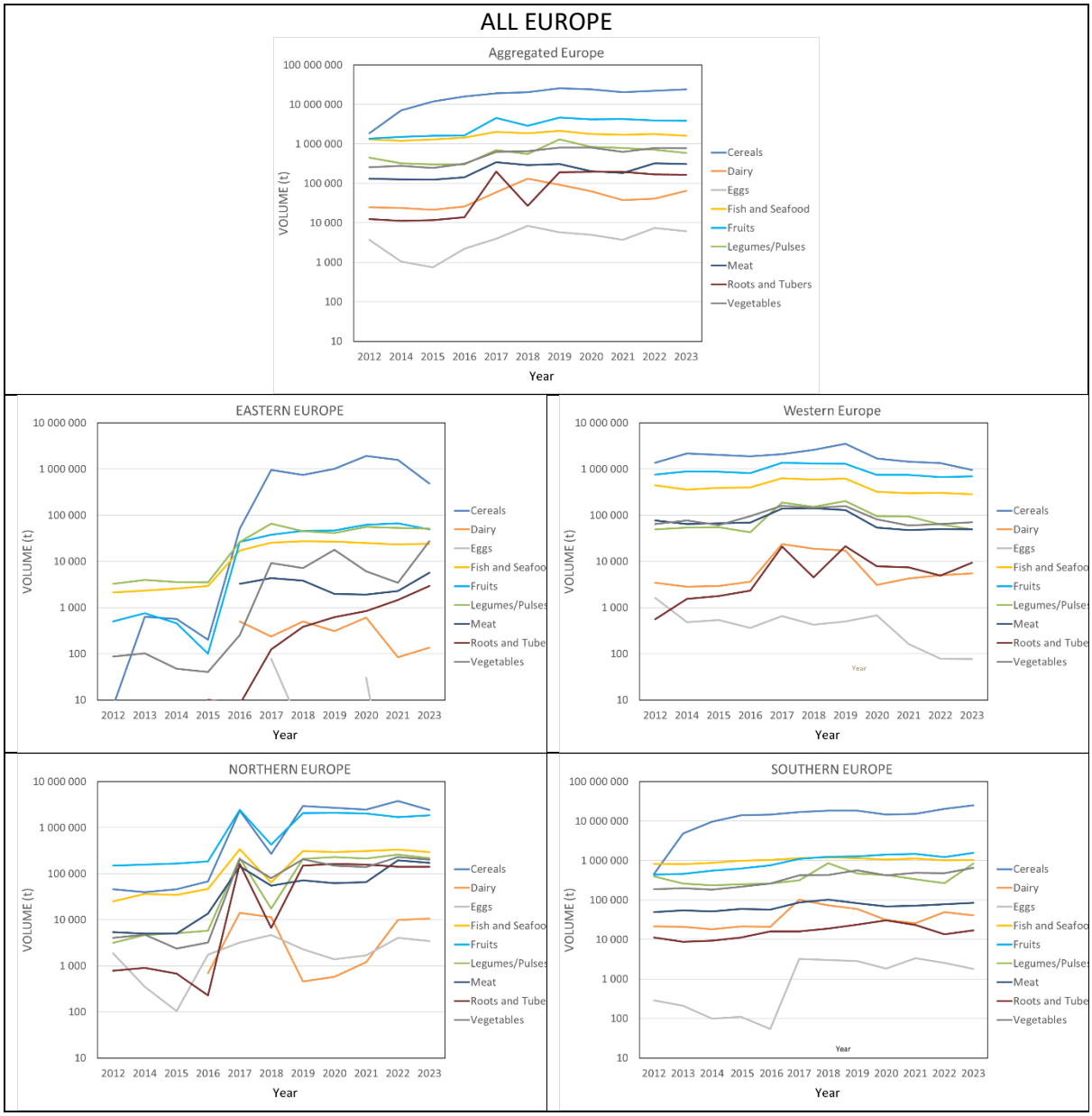


Figure 16: Food commodities imports by sea – Europe
Source: UN Comtrade; Data processing and chart by WMU

As shown in Figure 16, cereals are the most important sea imports from ***Eastern Europe***, showing a long increase through the years before dipping somewhat after 2020. This pattern is due to their central role in supporting regional food security, particularly for livestock feed and staples. Imports of fish and seafood hold steady, a fact that underpins food preferences, while legumes and pulses increase in moderate volume and show prominence in the diets of the region. Milk and meat imports

show slow increases as dietary needs shift. Fruits and vegetables also remain in stable numbers, supporting local produce. For eggs and roots and tubers, imports are few and fluctuating, most probably because of robust local production. ***Western Europe*** also has stable and large cereal imports which plays an important role in food supplies and animal feed. Imports of fish and seafood also remain significant as local tastes for marine food persist. Legumes, pulses and fruits follow a regular pattern, supplementing local food production. Imports of dairy products show slightly higher peaks in 2018, while meat imports remain stable for a wide range of diets. Low imports of roots and tubers and eggs indicate good local sufficiency in these foods. Moreover, cereals are the dominant food import by sea into ***Northern Europe***, with an increasing trend until 2018. Imports of fish and seafood still stand high, as they are also important for local diets, while legumes and pulses are moderate and stable, serving dietary requirements and supplementing domestic production. Imports of dairy have an occasional up and down, and hit a peak in 2017, probably due to demand from trade or seasonality. Fruits receive regular imports that offset local production; eggs are more variable, owing to fluctuating trade. Cereals continue to be a key import into ***Southern Europe*** in relatively large quantities for food security and feed for livestock. Imports of fish and seafood are substantial and stable, indicating the region's dependence on the sea for nutrition. Legumes and pulses, fruits and vegetables are also steady, and their complementary effects offset domestic production. Imports of dairy products and meat show a medium volume, with slight changes in years. Imports are low for root crops and tubers (high local production).

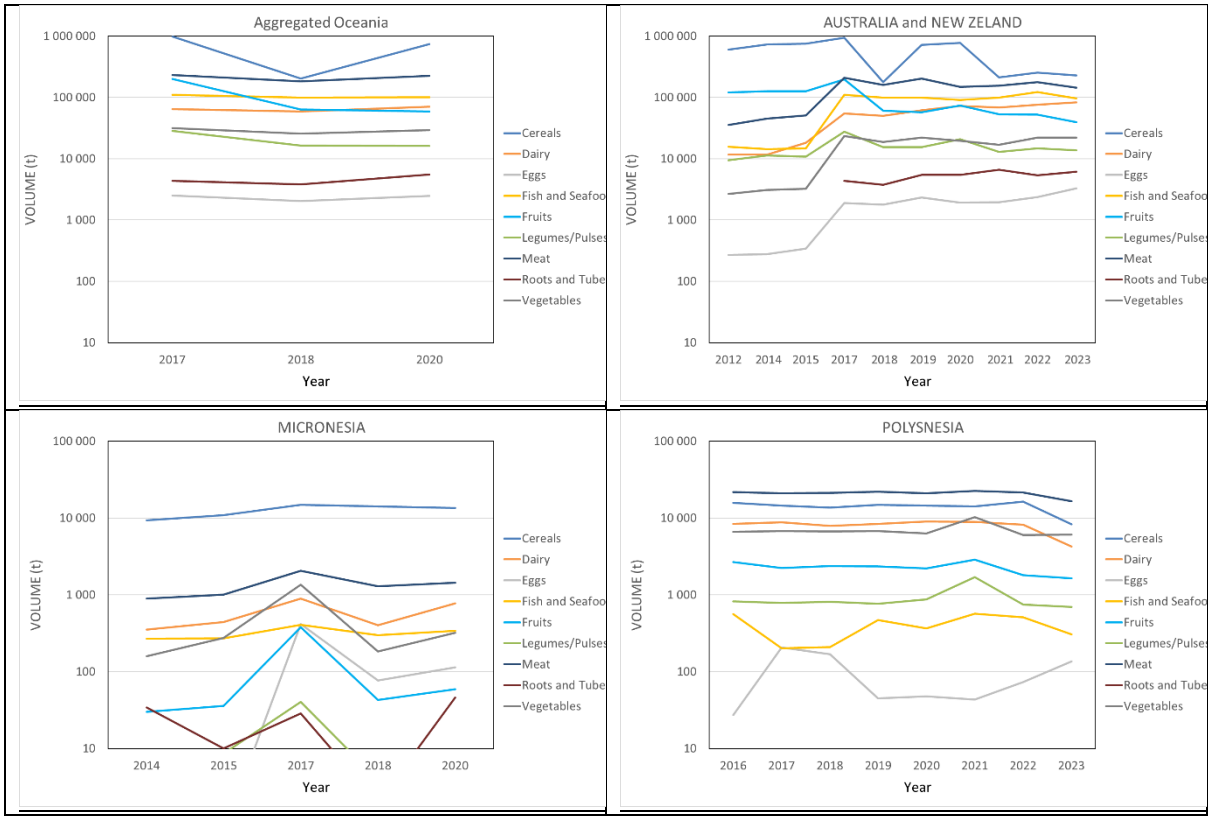


Figure 17: Food commodities imports by sea - Oceania
Source: UN Comtrade; Data processing and chart by WMU

From Figure 17 shows that ***Australian and New Zealand*** imports are dominated by cereals and experienced big surges in 2017 and 2019 before dropping sharply. These peaks are probably due to special trade events or domestic production disruptions in those years. Fish and seafood and dairy also have steady, moderate imports that meet diet requirements despite high local production. Import

of fruits, legumes and vegetables are low and stable, underscoring the dependence on domestic production for the items. Furthermore, cereals continue to be the dominant source of maritime food imports from ***Micronesia***, and their levels have not changed in decades. Milk, fish and seafood, and meat are comparatively low in imports. Legumes, fruits and vegetables all see steady but lower import levels, perhaps to suit a particular diet and season. Cereals dominate sea-borne food imports into ***Polynesia*** at ever-higher volumes, as cereals are traditional food staples. Fish and seafood, dairy and meat import volumes are moderate and stable, representing an important part of nutritional needs. The fruit, vegetable and legume/pulses have fairly steady import patterns in support of domestic agriculture. Roots and tubers are variable — 2020 to 2021 saw a decline and then rebound, most likely from trade or production interruptions during the pandemic years.

Section 3: Maritime supply chains and international shipping: impacts of economic, geopolitical, and environmental policies and disruptions on food security

This section assesses how different economic, trade, geopolitical, and climate change induced disruptions to maritime supply chains as well as atmospheric emission mitigation policies for international shipping have impacted food security, food prices/price volatility, and for what duration, as described in the relevant literature reviewed under this section. This analysis provides an indication of the possible magnitude of maritime transport costs and freight rates increases resulting from these pasts events and their consecutive impacts on food security.

3.1 Economic and policy impacts

3.1.1 Impact of food prices

Literature finds that high food prices benefit producers but harm consumers, particularly in net food-importing countries (Ungusari, 2015). The rise in food prices indeed influences poor households, considering that they approximately spend 60–80% of their income on food, as such they are highly vulnerable to price fluctuations in regions like the Middle East and Africa (Abdulkadyrova, Dikinov, Tajmashanov, Shidaev, & Shidaeva, 2016).

Domestic food prices are strongly influenced by global food price inflation, while pass-through of global food prices varies by region, with Asia showing relatively higher transmission compared to sub-Saharan Africa (Lee & Park, 2013). While developing countries commonly face more substantial pass-through effects owing to their reliance on food imports, Asian countries have higher correlations with global food price volatility than regions like Latin America and Europe, as revealed in (Lee & Park, 2013).

Another study investigated domestic food price changes in low- and middle-income countries since the world food price crisis between 2007 and 2013, including comparisons across regions, countries, focusing on rice, wheat, and maize (Dawe, Morales-Opazo, Balie, & Pierre, 2015). The study indicates that domestic prices increased by 19% for rice and wheat and 29% for maize during this period. Similarly, the study indicated that there is regional variability.

Countries' vulnerability was also examined e.g., in the case of China's grain trade, focusing on its reliance on imports from a limited number of partners. The study revealed that China's grain imports are highly concentrated, with 67.32% coming from four countries in 2018: Australia, the United States, Canada, and Ukraine (Duan, Yong, & Jiang, 2021). From 2014 to 2018, China's dependence on grains exporters expanded, with North America, Northeast Asia, and the Russian Federation becoming critical suppliers (Duan et al., 2021).

Examining Morocco's reliance on global cereal markets, a study revealed significant dependency on international prices, particularly for durum wheat (Capitanio et al., 2020). The study utilized a GARCH model, suggesting that global price shocks influence Morocco's cereal markets within one week. With cereals comprising 30% of rural employment (farmers), the study highlights how price volatility in global markets directly affects local economies, emphasizing the strong co-movement between Moroccan and global cereal prices (Capitanio et al., 2020).

Examining the sub-Saharan region and the food security, the structural barriers to food security in the region were investigated in (Bjornlund, Bjornlund, & van Rooyen, 2022), underlining dependence on rain-fed agriculture. The study revealed that only 6% of agricultural land is irrigated, compared to 37% in Asia, and food production per capita has stagnated for 50 years, furthering persistently the high malnutrition rates. The Sub-Saharan region is particularly exposed to food insecurity and price shocks. Analyzing the impact of soaring food prices during the 2007–2008 global food crisis on poverty levels in the sub-Saharan region Wodon & Zaman (2009) show that rice and wheat prices went up by 47% and 43%. Additionally, literature found that for each 10% increase in food prices poverty goes up between 2 to 3%. The impact of inflation on food security across 25 countries in Sub-Saharan Africa was examined (Abdoulaye, LanHui, & Beckline, 2015). Key findings of the study include that a 1% increase in the Consumer Price Index (CPI) leads to a 0.5% decline in food security scores, and countries that have higher domestic agricultural output are less affected.

The drivers of phosphorus fertilizer price spikes were explored in (Brownlie et al., 2023). They report a more than five-fold price increase since 2020 due to fuel costs, trade disruptions, and the ongoing military conflict between the Russian Federation and Ukraine. These price increases have made fertilizers less accessible, threatening crop yields and food security, particularly in low-income countries (Brownlie et al., 2023).

Ferrari et al. (2023) utilized a general equilibrium model to assess the broader effects of transport cost surges, showing that higher shipping costs raise consumer prices, especially for countries heavily reliant on global supply chains. This modelling approach underscores the complexity of estimating transport cost increases and the need for comprehensive data. However, it also highlights a key gap in current analysis: small island developing states (SIDS) and peripheral economies remain underrepresented in global data, limiting the ability to fully assess their vulnerability to shocks.

3.1.2 Impact of oil and fuel prices

Oil prices affect agricultural prices in through at least four channels. First, oil products are used as inputs into agricultural production, for example as tractor fuels. Second, nitrogen fertilizers are produced with natural gas, whose price is related to that of oil. Third, oil prices enter into the transport

cost by road, rail and sea. Fourth, the oil price impacts the decision to use crops for biofuel production. Oil market fluctuations hence influence food price movements as well (Wilmsmeier & Sanchez, 2009). High oil prices and the positive relation between oil prices and biofuel production are found to be significant contributors to food price volatility (Ungusari, 2015) (Dawe et al., 2015). A study explored the relationship between global oil market shocks and food price instability in Sub-Saharan Africa, focusing on corn as a key commodity (Dalheimer, Herwartz, & Lange, 2021). Specifically, the study highlights how global oil market shocks threaten food price particularly through rising transportation costs. Oil-supply shocks during the 2011 Libyan crisis doubled corn prices in Kenya, and drove an increase by 70% in Ethiopia and 40% in Ghana. The study also underlines the heterogeneity of market responses, for instance, countries like Tanzania and Zambia remained comparatively insulated due to differences in market integration and policy interventions.

In the same vein, the relationship between global oil prices, exchange rates, and agricultural commodity prices in China were examined in another study (Ma, Xu, & Dong, 2015), focusing on five key commodities (soybean, maize, wheat, colza oil, and japonica rice) over the period between 2002 and 2013. The study highlighted that oil prices significantly influence soybean prices due to its role in biofuel production, while other commodities like maize, wheat, and rice show no long-term relationship. This study as described how exchange rates also have minimal impact on agricultural prices, attributed to China's controlled exchange rate policies and limited market integration. High oil prices indirectly raise agricultural costs through increased transportation and production expenses, with soybean particularly affected as 80% of the soybeans used in China came from foreign suppliers.

The relationship between global oil prices and wheat prices in Kazakhstan, an oil-producing country, was examined by (Yugay & Yemelina, 2013). Their analysis concluded that no direct correlation exists between the two due to the low production of biofuels, noting that various other policies limit the price response. However, wheat prices in Kazakhstan are closely linked to those in the Russian Federation and global wheat prices, including Canadian wheat. Overall, the study indicated that fuel take the part of wheat production costs, accounting for 17–19%, alongside seeds (15–17%), wages (12.5–13.5%), and repair parts (10.3%).

Notably, the impacts of rising global fuel and food prices on Mozambique between 2006 and 2008 were investigated in Arndt et al. (2008). The study exhibited considerable increases in maize, rice, and wheat prices, along with adverse effects on household welfare, macroeconomic stability, and poverty. According to the study, urban households, principally net food importers, faced substantial losses, while rural households, as net food sellers, benefited from higher prices. Overall, the fuel price shocks had larger macroeconomic impacts than food price increases, worsening terms of trade, reducing absorption, and deepening poverty, particularly in Mozambique urban areas.

In the same context, a study explored the relationship between global crude oil prices and Chinese corn prices from 2008 to 2018 (Ma & Hou, 2019). The study revealed that changes in oil prices have a long-term positive impact on corn prices. This study attributes this link largely to China's growing ethanol gasoline market, which has increased demand for corn and heightened concerns about food security as corn prices rise. The results of the study are summarized in Table 7.

Table 7: Crude oil and Chinese corn prices (2008–2018)

Category	Details
Highest WTI Crude Oil Price	142.52 USD/bbl.
Lowest WTI Crude Oil Price	29.19 USD/bbl.
Average WTI Crude Oil Price	76.25 USD/bbl.
Highest Chinese Corn Price	508.27 USD/ton
Lowest Chinese Corn Price	206.19 USD/ton
Average Chinese Corn Price	366.56 USD/ton

* WTI: West Texas Intermediate
Source: (Ma & Hou, 2019)

Given these results, rising fuel prices are found to considerably impact food security by increasing production and transportation costs, which are major contributors to food price surges (Han, Yuan, Wang, Zhao, & Gong, 2023). For example, literature found that shipping costs now account for 20% of the total cost of corn imports, and during the COVID-19 pandemic, these costs tripled (Han et al., 2023). Furthermore, higher oil prices drive demand for biofuels like ethanol, for example diverting 30% of the United States' corn production when oil prices exceed $60 per barrel, further tightening food supply and exacerbating food price volatility (Han et al., 2023).

3.1.3 Impact of trade policy

Literature found that trade policy interventions influence global agricultural commodity prices. Trade restrictions, including import tariffs and import quota, export taxes and export bans, as well as efforts to stabilize currency may have been used to mitigate the domestic impacts of global price shocks, but lead to more variability of world market prices (Dawe et al., 2015). Exporting countries often impose export restrictions during world market price rises to stabilize domestic markets while importing countries may respond by lowering tariffs. After a period of price spikes, export restrictions are often revoked and import tariffs raised again, which exacerbates international food price volatility (Gouel, 2016).

Bouët & Laborde Debucquet (2016) analyzed how export taxes imposed during food crises, such as those in 2007–2008, worsened global food insecurity. They found that responses which increased prices and excessively restricted supply affected import-dependent countries, intensifying their vulnerability during crises. Employing a computable general equilibrium (CGE) model, (Beckman, Estrades, & Aguiar, 2019) assessed the influences of export restraints and controls on staple commodities like wheat and rice. The study underlined how such measures affect global poverty and food security, in addition to implying a correlation between restrictive policies and rising food prices in vulnerable regions. The critical relationship between tariffs, trade policies, and food security were also examined in (Zolin, Cavapozzi, & Mazzarolo, 2021). The study exhibited that trade-opening policies, such as reducing tariffs, can promote food security by guaranteeing access to indispensable commodities, like milk in China. The study suggested that minimizing trade barriers, countries with inadequate natural resources could meet growing domestic demand across imports, alleviating food supply and prices. On the contrary, protectionist measures, such as high tariffs, can limit access to affordable food imports, exacerbating food insecurity, particularly in nations dependent on international trade to meet local demand.

According to (Dawe et al., 2015) domestic prices have typically increased much less than world prices in 2007 and 2013, and domestic prices are less volatile than world prices. They show that domestic price indices broadly mirror the large world price spikes, but domestic price changes have varied widely across countries, and domestic price increases are not necessarily due to increases in global market prices. For example, in Bangladesh, domestic rice prices in 2013 were 8% lower than in 2007 due to an open rice trade policy that allowed private sector imports to stabilize prices, whereas in China and the Philippines, domestic rice prices increased despite a decline in world rice prices, driven by higher production costs and protective government policies.

One study investigating the food price surge during 2007 and 2008 highlights global market and welfare distributions (Edward Yu, Tokgoz, Wailes, & Chavez, 2011). Their findings indicate that rice prices rose by 24%, wheat by 14%, and barley by 9%, which were principally driven by export bans and reduced import tariffs in major trading nations. On the other hand, developing countries (net importers) without trade interventions faced severe welfare losses resulting from interventions implemented by other major trading countries. Policy-implementing nations, such as India and Nigeria, saw mixed outcomes. India experienced a net welfare gain of $236.8 million for wheat, despite losses in producer welfare, while Nigeria, despite consumer surplus gains of $1,120.93 million due to reduced rice tariffs, faced a net welfare loss of $72.8 million. In brief, this study underlines that short-term trade policies often aggravate global price volatility, which influences food-deficit countries. (Edward Yu et al., 2011). Table 8 below shows the policy used, commodity, and price changes.

Table 8: Examples of commodities along with policies and price changes

Region/Country	Commodity	Policy	Price Change (%)	Net Welfare Change
India	Wheat	Export restrictions	+14% (wheat)	+$236,819
Nigeria	Rice	Tariff reductions	+24% (rice)	-$72,765
Argentina	Soybeans, corn	Export taxes	+3.8% (soybeans)	+$1,934,500

Source: (Edward Yu et al., 2011)

Similarly, another study analyzed Bolivia's policy response to the 2007 to 2008 food price spike (Schüttel, Kleinwechter, Ihle, & Grethe, 2011), (see Table 9 that presents the targeted commodities, government measures, and the results of such measures). The policy responses targeted wheat flour imports, export bans, and tariff exemptions. The study indicated that these policies were generally ineffective in protecting domestic markets from international price shocks. Wheat flour prices echoed international prices, leaving rural populations unprotected. Measure on poultry trade, like export bans and tariff exemptions, were also symbolic and failed to alter long-term price dynamics. For sunflower oil, export bans mitigated short-term price spikes but caused financial losses to producers.

Table 9: Effectiveness of Bolivia's policy measures during the 2007–2008 food price crisis

Commodity	Government Measures	Results
Wheat Flour	Large-scale wheat flour imports from Argentina, subsidized distribution, and export bans	Perfect price transmission with international markets; government interventions ineffective in shielding domestic prices from shocks, affecting rural populations and food security in general
Poultry	Temporary export bans and tariff exemptions	Price shocks from Peruvian markets fully transmitted to Bolivia; measures were symbolic and

		failed to alter long-term price dynamics, limiting the benefits to consumers
Sunflower oil	Temporary export bans, export quotas, and tariff exemptions for imports	Price shocks fully transmitted to Bolivia; export ban mitigated short-term price spike but caused long-term financial losses to producers

Source: (Schüttel et al., 2011)

Another study that analyzed the impacts of wheat import tariff changes in Sudan using a Computable General Equilibrium (CGE) economic model (Elsheikh, Elbushra, & Salih, 2015). The study indicated that reducing wheat tariffs by 50 to 100% increases imports, lowers domestic wheat prices, and improves GDP and trade balance, but at the same time reduces incentives for domestic production and private consumption (Elsheikh et al., 2015). In contrary, simulating essentially autarky by lifting tariffs by up to 1200% degrades imports and fosters domestic production but adversely affects GDP. Overall, the study indicate that tariff reductions enhance short-term food availability but lower incentives for domestic production.

Price hedging through futures is another aspect that was also investigated. A study looked at strategies to manage maize price volatility in Malawi and Zambia, laying emphasis on hedging through the South African Futures Exchange (SAFEX) (Dana, Gilbert, & Shim, 2006). Retail maize prices in both countries are more volatile than South African wholesale and global markets, therefore, the study suggested that hedging using SAFEX futures or options can reduce price volatility by spreading import costs over time, though high transport costs and inefficiencies remain significant barriers to realizing full benefits.

A study revealed that global economic policy uncertainty (EPU) considerably disrupts China's agricultural imports, making trade less stable and unpredictable (Zhang, Brizmohun, Li, & Wang, 2022). This instability creates risks to food security and negatively influences consistent supply of imported agricultural goods that threaten China's imports to meet domestic demand. The study also highlighted that high domestic food price volatility and low agricultural productivity further worsen the impact of EPU on food security (Zhang et al., 2022).

Finally, a study by (Gilbert, 2012) posits that international agreements should be utilized to manage food price volatility, particularly those addressing issues such as export controls during crises, biofuel policies linking energy and food markets, and trade frameworks. Furthermore, the study recommends flexible biofuel mandates and stronger global trade rules on export restrictions as measures to reduce price spikes and enhance global food security.

3.2 Impact of external shocks on global trade and food security, with a focus on maritime disruptions

A number of recent events, including the global COVID-19 pandemic, the ongoing military conflict between the Russian Federation and Ukraine, and the blockage of the Suez Canal or restricted passage through the Panama Canal, have underscored the critical role that maritime transport plays in global trade. These disruptions, along with the effects of climate change, have caused significant supply chain shocks, resulting in increases in maritime transport costs from the end of 2020 to the end of 2022, often setting new records. This section draws on evidence from the reviewed literature to explore

how these external shocks – economic, geopolitical and environmental – have influenced global trade, shipping costs, and commodity prices, and food security.

3.2.1 COVID-19 pandemic

The COVID-19 pandemic significantly disrupted maritime trade flows, port calls, and liner shipping connectivity, revealing the vulnerability of the maritime supply chain (Liu et al., 2023; Alamoush et al., 2022; Ghaforian M. et al., 2022). This disruption was marked by factors such as port congestion, shipment delays, container shortages, labor shortages, and difficulties navigating the Suez Canal, all of which contributed to soaring freight rates. For instance, during the pandemic's peak, container freight rates between Asia and the United States reached record levels, with the China Containerized Freight Index (CCFI) hitting a historic high of 3,444 points in Q1 2022, approximately four times higher than pre-COVID levels (Rožić et al., 2022; Ding & Choi, 2023).

Labor shortages and port congestion, exacerbated by COVID-19-induced public health restrictions, drove a dramatic increase in shipping costs. The price of a 40-foot container soared from an average of $1,331 in February 2020 to a peak of $11,109 in September 2021 (Fernando & Dunn, 2022). According to Fernando and Dunn (2022), international shipping costs increased by 72.3% points from a trough of -22.0% below trend in the first quarter of 2020 to a peak of 50.3% above trend in the third quarter of 2021. As a result, the authors conclude that slightly more than half of the 72.3 percentage point increase in international shipping costs following the COVID-19 recession can be attributed to normal supply and demand factors, whereas the remaining is related to disruptions in international shipping.

As Yaya et al. (2020) argue, globalization faced significant challenges as governments-imposed restrictions on international trade to limit vulnerability to the pandemic. In regions like Africa, where economies depend on single export-oriented industries like oil and gas, the economic consequences were particularly severe, aggravating food insecurity. Lockdowns also disrupted the agricultural sector, further threatening livelihoods and food security (Laborde et al., 2020a).

The pandemic's impact on food security was multi-dimensional, affecting all four pillars: availability, access, utilization, and stability. The crisis led to disruptions in food availability, shifts in consumer demand toward cheaper, less nutritious foods, and fluctuations in food prices, thereby worsening food access (Laborde et al., 2020a).

An overview of the potential impacts of the COVID-19 pandemic on food security as identified in the reviewed literature is provided below, through the four dimensions of food security:

- **Food availability**: in their study, Beckman et al. (2021) deployed the International Food Security Assessment (IFSA) model to analyze three indicators of food insecurity: the number of food-insecure people, the share of the population that is food insecure, and the food gap. With a focus on food availability, Beckman et al. (2021) argue that COVID-19 has significantly affected the agricultural sector, causing disruptions in the food supply chain to the extent that the World Bank and FAO have raised the alarm regarding the potential impacts on food security. According to Zhang et al. (2021), over 120 countries and regions prohibited or

restricted ship entry in order to prevent the spread of COVID-19. This resulted in one of the most serious transportation crises in decades. Due to the inefficiency of the port transportation system and the decline in economic affordability, the global external supply of food was interrupted.

- **Food access**: Beckman et al. (2021) predicted that across the seventy-six countries covered by the IFSA model, COVID-19 could increase the number of food-insecure people in 2020 by 211.2 million (or almost 27.8 per cent), for a total of 972 million people in food insecurity. Taking into account the lower and upper bounds, the authors conclude that by implementing measures to slow the spread of COVID-19, the economic shocks will result in an increase between 136 million and 271 million people who are food insecure in seventy-six low- and middle-income countries in 2020.

The continuous rise in food prices during the COVID-19 pandemic was a major factor influencing external supply risks. As shown in Figure 18, the cereal price index reached 124.2 points in January 2021, an increase of 22% since its highest point in 2019, reflecting an increasingly tight global supply (Zhang et al., 2021).

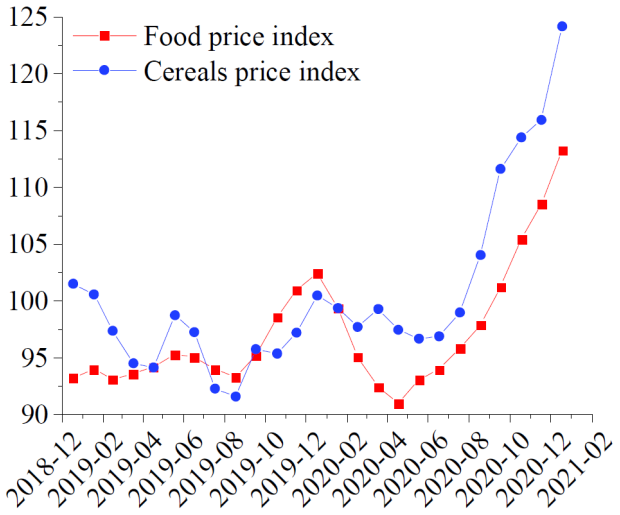


Figure 18: The global food price index from January 2019 to January 2021
Source: Zhang et al., 2021

Laborde et al. (2020a) argue that access to food was threatened by COVID-19 primarily due to lost income and assets that adversely affected the ability to purchase food. Food security was particularly vulnerable to income shocks in the poorest households, which spent approximately 70% of their income on food. The IMF predicted a 5% decline in the world economy in 2020, a much deeper recession than that experienced during the global financial crisis of 2008-2009. Using model-based simulations, it was estimated in the literature that between 90 million and 150 million people lived in extreme poverty, the majority coming from Sub-Saharan Africa and South Asia. It was income declines (less food access) that posed the greatest challenge to vulnerable households during the pandemic rather than food shortages (lack of availability) (Laborde et al., 2020a).

- **Food utilization**: a study by Laborde et al. (2020a) suggests that during pandemics, people living in extreme poverty were unable to purchase the food they needed in order to avoid hunger and malnutrition and were forced to consume food that was cheaper and less nutritious. Beckman et al. (2021) estimated the food gap, which measures the gap between observed consumption and the 2,100 kcal/day target, to increase 8% to almost 373 kcal/per capita across the seventy-six IFSA countries as a result of COVID-19. The Laborde et al. (2020b) study of 300,000 households in low- and middle-income countries found that poor households spend more than a quarter of their total income on staple foods such as wheat, rice, or maize, whereas non-poor households spend only 14%. Furthermore, their analysis of the global economic model scenario indicated substantial shifts away from nutrient-rich non-staples toward starchy staples.

- **Food stability**: it was a common reaction by policymakers during pandemic to restrict the export of a main food product in order to protect domestic consumers from an imminent shortage or sharp price increase. Even though such restrictions served a national interest in the short term, they reduced supplies to world markets, resulting in an increase in world prices. In addition to destabilizing prices, such quantitative restrictions on food exports reduced the ability of markets to adjust to production shocks through changes in exports. As a result of expectations regarding the introduction and subsequent removal of these restrictions, there was instability in food availability, with exports increasing prior to their enactment and stocks accumulating prior to their abolition (Laborde et al., 2020a).

3.2.2 Military conflict between the Russian Federation and Ukraine

As the world was recovering from the COVID-19 pandemic, the ongoing military conflict between the Russian Federation and Ukraine exacerbated global food security concerns. Literature found that the combined impacts of these crises have worsened food insecurity, especially in Sub-Saharan Africa, where it has been a persistent issue since 2015 (Wudil et al., 2022). In their study, Martin and Minot (2022) assert that there is a stable relationship between the world wheat price and the prices of wheat on the domestic market. However, during the pandemic and Ukraine crises, local wheat price insulation nearly doubled global wheat prices and caused their volatility to be aggravated. The military conflict has caused significant disruptions in agri-food trade, with major consequences on wheat prices and food security, particularly in countries dependent on imports (Behnassi & El Haiba, 2022; Lin et al., 2023). These crises have led to price volatility and aggravated food insecurity globally, particularly through rising oil prices, fertilizer shortages, and changes in agricultural production (Ayaz et al., 2023; Abbas & Alnafrah, 2024).

Sun et al. (2024) argue that the military conflict has had the greatest food security impact in Europe and Sub-Saharan Africa, primarily due to disruptions in agricultural production and the destruction of arable land. In contrast, Zhang et al. (2023) show that countries heavily dependent on Ukraine and the Russian Federation for food and fertilizer imports, such as Georgia and Mongolia, have been most vulnerable. Alexander et al. (2023) add that the rise in food prices, compounded by energy price hikes, is a significant driver of increased food insecurity. They suggest that input costs and reduced exports from these countries could lead to up to a 100% increase in food prices, exacerbating global undernourishment.

The impact of such shocks on food security varies across countries depending on their economic structures and trade patterns. For example, the rise in oil prices and shifting maritime trade routes as a result of the Ukraine conflict indirectly affect global shipping costs, influencing food prices and access.

The world wheat price rose to USD 202.01/ton in 2020 and USD 258.68/ton 1 year later. However, given the conflict in Ukraine, the price rose to USD351.98/ton (January–September 2022) (Gebeltová et al., 2023). In addition, the disruption of global wheat exports, particularly from the Russian Federation and Ukraine, which together supply a large portion of the world's wheat and other agricultural commodities, has compounded the challenges of securing affordable food supplies, especially in countries like Egypt, which relies heavily on imports for its wheat supply (Gebeltová et al., 2023). In light of the rise in the world wheat price and noting Egypt's dependence on 50% wheat imports, Gebeltová et al. (2023) argue that Egypt has to accept world prices precisely because of food insecurity, and wheat prices do not play a significant role in determining the extent of imports.

The military conflict has also disrupted fertilizer supplies, leading to increases in agricultural input costs and, consequently, food prices (El Bilali & Ben Hassen, 2024; Berndt et al., 2022).

Since the Russian Federation and Ukraine are major exporters of fertilizers, minerals, agricultural products, and energy (FAO, 2022; OECD, 2022) the conflict between them has disrupted food production and trade, and has led to concerns about global food security (El Bilali & Ben Hassen, 2024). There is a strong export market for fertilizers including Nitrogen, Potassic, and Phosphorous for these two countries (FAO, 2022). Combined, Russian Federation and Ukraine produce 12% of the world's calories and are among the top five suppliers of barley, wheat, corn, and sunflower seeds (Urak et al., 2024). As shown in Table 10, these two countries have a significant share of the global agriculture and food export markets, including wheat, corn/maize, barley, rye, oats, and sunflower seeds (El Bilali & Ben Hassen, 2024).

Table 10: Rank and share of Russian Federation and Ukraine in selected agricultural commodities production and export

		Production quantity		Export quantity	
Commodity	Country	Share (%)	Rank	Share (%)	Rank
Wheat	Russia	10	4	17	2
	Ukraine	4	7	12	5
Corn/maize	Russia	1	10	2	6
	Ukraine	4	6	17	4
Barley	Russia	12	2	13	4
	Ukraine	7	4	18	3
Rye	Russia	14	2	12	4
	Ukraine	5	4	40	1
Oats	Russia	17	2	6	4
	Ukraine	2	11	1	7
Sunflower	Russia	25	2	25	2
	Ukraine	30	1	50	1

Source: El Bilali and Ben Hassen (2024)

According to Abu Hatab (2022), the military conflict has adversely affected food supply chains through a number of channels, including energy markets and shipping routes, supply and cost of agricultural inputs (e.g., fertilizers), the rise in domestic food prices, and the imposition of trade restrictions. According to Berndt et al. (2022), as shown in Table11, in the short term, a reduction in agricultural exports from Ukraine (scenario GTAP_UKR_st) and additionally from Russian Federation (scenario GTAP_UKR_RUS_st) leads to expenditure-weighted increases in consumer prices (excluding Ukraine and Russian Federation) by 3.0% and 6.4%, respectively.

Table 11: GTAP percentage change deviation of average global consumer prices in the scenarios compared to base year, excluding Russian Federation and Ukraine

Product groups			
Scenario	"Cereals"	"Agri"	"Agri-food"
GTAP_UKR_ short-term	3.0%	0.5%	0.5%
GTAP_UKR_RUS_ short-term	6.4%	0.9%	1.0%
GTAP_UKR_RUS_ long-term	1.8%	0.7%	0.6%

Source: Berndt et al. (2022)

Note: "Cereals" = rice, wheat, maize, barley, other grains; "Agri" = "cereals" + vegetables and fruit, oil seeds, sugar cane and beet, spices and other crops, live cattle, other animal products, raw milk; "Agri-food" = "agri" + cattle meat, pork and poultry, vegetable oils and fats, dairy products, processed rice, sugar, other food products. Aggregated consumer prices are weighted by private expenditure of the respective commodities.

The section below examines the identified impacts in the reviewed literature of the ongoing military conflict between the Russian Federation and Ukraine on food security through the four dimensions of food security as outlined in Section 2 of this literature review:

- **Food availability**: As a result of the ongoing military conflict between the Russian Federation and Ukraine, significant disruptions in agri-food trade have occurred and food security in several countries has been affected (Behnassi & El Haiba, 2022). Lin et al. (2023) found that the military conflict would lead to a 60 percent decline in wheat trade, a 50 percent increase in wheat prices, and a 30 percent increase in severe food insecurity in the most severe scenarios. As Alexander et al. (2023) point out, trade restrictions on the Russian Federation and Ukraine have resulted in higher food prices, which have been further exacerbated by energy costs increases. A similar increase has been observed in the cost of agricultural inputs, such as fertilizers. With Russian Federation being a leading supplier of critical fertilizer components, including natural gas and potash, rising energy prices and transport costs have caused fertilizer prices to double or even triple (Lin et al., 2023). In response to the increase in production costs, the expansion of croplands (due to lower fertilizer usage) may result in a decrease in production rates or the cessation of agriculture.

- **Food access**: increasing food prices and inflation are the primary reasons for the adverse effects of the military conflict on food financial accessibility and affordability. El Bilali and Ben Hassen (2024) attribute this increase to the rise in production costs and disruptions in supply chains. According to Alexander et al. (2023) in their food cost projections in 2022, food costs may increase by 60-100% in 2023 compared to 2021 levels. A combination of rising agricultural input costs and export restrictions may have contributed to this increase. Disruptions in global supply chains, particularly those involving staple foods such as grains and cereals, have adversely affected food availability due to sanctions imposed on Russian Federation and damage to the infrastructure for transport and logistics from Ukraine (El Bilali & Ben Hassen, 2024).

- **Food utilization**: due to the conflict, diet quality and dietary diversity have been negatively affected, resulting in poorer diet patterns and nutrition, particularly in countries heavily reliant on food imports from Ukraine and the Russian Federation. According to Mottaleb et al., (2022), reducing wheat exports by 50% could result in a 15% increase in the price of wheat for producers. Increasing the price of wheat could result in a reduction in wheat consumption and dietary energy intake by as much as 8%, which would adversely affect the food and nutrition security status of millions of people (Mottaleb et al., 2022).

- **Stability**: the military conflict has introduced volatility in food prices and uncertainty about future food supplies. Fang and Shao (2022) argue that the conflict increases the volatility risks of commodities markets, including agricultural products. According to them, the conflict affects commodity markets through both financial and economic channels. Stabilizing the food supply requires action on agricultural production to ensure availability, and agri-food trade to ensure accessibility. For instance, referring to the case of wheat, Júnior et al. (2022) argue that maintaining stable wheat supplies and controlling stock levels wisely are necessary to guarantee food and national security in many countries around the world.

The ongoing military conflict has the potential to impact agricultural practices in ways that could further affect global food security. High fertilizer costs and agricultural input shortages might lead to a decrease in land use intensity, pushing for expanded cropland (Alexander et al., 2023; Carriquiry et al., 2022). Overall, the military conflict has exacerbated food insecurity, malnutrition, and poverty, especially in developing countries, and has highlighted the need for more resilient, sustainable food systems to prevent further setbacks.

3.2.3 Challenges in the Red Sea, Suez and Panama canals

Maritime transport and ports are vulnerable to various disruptions, including natural causes (e.g., droughts, hurricanes/typhoons, floods, earthquakes, volcanic eruptions) and human activity (e.g., vessel groundings, explosions, economic and geopolitical crises, wars, terrorist attacks, pandemics, cyberattacks, labor disputes and strikes). In recent years, several major disruptions have significantly impacted global trade, such as the blockage of the Suez Canal, the Red Sea crisis, the collapse of the Francis Scott Key Bridge in Baltimore, and Panama Canal's reduced transit capacity due to drought (Tran et al., 2024).

In late 2023 and early 2024, the Red Sea and the Strait of Bab al-Mandab saw heightened risks with over 40 attacks on international shipping, including drones, anti-vessel missiles, and gunmen on speedboats. These attacks forced around 80% of container vessels that would typically transit the Suez Canal to reroute around the Cape of Good Hope, resulting in longer transit times, higher freight rates, and increased air emissions (Notteboom et al., 2024). Spot freight rates for North Europe surged, with the Shanghai Containerized Freight Index (SCFI) rising by 339% from mid-November 2023 to January 2024, and vessel insurance premiums increased due to the heightened risks in the region (Notteboom et al., 2024).

Meanwhile, the Panama Canal, which handled about 290 million tons of cargo in 2023, was severely impacted by a drought in 2023 and 2024, reducing its transit capacity. Daily transits dropped from an average of 36 to 22 vessels by December 2023, and the authorized draft was lowered, leading to delays of 1.7 to 6 days (Tran et al., 2024).

The Suez Canal, accounting for 30% of global container traffic, also plays a pivotal role in global trade. Even brief disruptions can have significant consequences. The six-day blockage of the Ever Given in March 2021 delayed $51.1 billion worth of goods, contributing to a 0.2%-0.4% reduction in global trade annually (Allianz Research; Tran et al., 2024).

The combined risks and disruptions in the Red Sea, Suez, and Panama Canals underscore the vulnerability of critical maritime chokepoints, highlighting their far-reaching impacts on global trade, shipping costs, and supply chain stability.

It is estimated that the Suez Canal accommodates 61.2% of the world's tanker fleet, 92.7% of the bulk carrier fleet, and 100% of the container vessels operating between Asia and Europe (Tran et al., 2024). In accordance with Carrière-Swallow et al. (2023), approximately thirty percent of global container traffic transits through the Suez Canal, and alternative shipping routes add weeks to the crossing time. Trade disruptions caused by even brief closures can have a significant impact on the global economy. The authors' analysis indicates a significant impact on consumer prices over the estimation period, with a large impact over the period of six to eighteen months. Furthermore, their findings indicate a significant rise in core inflation and import prices.

3.2.4 Climate change

Literature found that climate change, driven by GHG emissions, leads to a range of interconnected environmental and societal challenges, also greatly affecting food security. First, rising global temperatures result in more frequent and severe heatwaves, negatively affecting human health, energy demand, and agricultural productivity, with studies showing reduced global wheat yields under various climate scenarios (Asseng et al., 2015). Second, altered precipitation patterns bring droughts to some regions while causing increased flooding in others, disrupting water supplies, agriculture, and infrastructure (Almazroui et al., 2021). Third, melting polar ice and the thermal expansion of seawater lead to sea-level rise, threatening coastal communities with erosion, flooding, and saltwater intrusion into freshwater reserves (Hurlimann et al., 2021). Fourth, the frequency and intensity of extreme weather events, such as storms, hurricanes, and cyclones, have escalated, causing extensive damage to infrastructure, agriculture, ecosystems, and cities (Coumou & Rahmstorf, 2012). Fifth, oceanic changes, including rising temperatures and shifting current patterns, impact marine ecosystems, fisheries, and weather systems, disrupting food chains and biodiversity (Hurlimann et al., 2021).

Therefore, literature finds that climate change can significantly impact food security. The section below provides a detailed overview of the possible impacts identified in the reviewed literature from climate change across the four dimensions of food security:

- **Food availability:** the literature indicates that events generated by the impact of climate change such as droughts, floods, and extreme temperatures disrupt agricultural productivity, initiating decreased crop yields and livestock losses, among others (Gregory & Ingram, 2008). Climate change threatens global food production, which causes food price inflation that shock hardly low-income and developing countries (WEF, 2023). Devastating typhoons overwhelmed the Indian subcontinent and South-East Asia whereas the Sahel and Greater Horn regions of Africa experienced severe droughts and devastation from locust swarms linked to climate change (Brenton et al., 2022). Taking wheat as an example, which is a primary source for food in developing countries, climate variability affects crop yields. This impact is severe in vulnerable countries that depend on consistent precipitation patterns (L. R. Brown & Halweil, 1998). China’s dependency on the Yellow River for irrigation (for around 70% of grain production) showed this vulnerability, as recurrent dry spells affected crop yields (L. R. Brown & Halweil, 1998). Rising sea levels and extreme weather events indeed threaten agricultural output, which result in reduced food availability (Brenton et al., 2022).

- **Food access:** climate-induced extreme weather events disrupt economies, leading to increased food prices (Erdogan et al., 2024). By 2022, the number of people suffering acute food insecurity had risen from 135 million in 2019 to 345 million across 82 countries, with climate change being a major factor (Brenton et al., 2022), which disrupt farming, processing, and distribution, leading to this food price instability. Studies draw attention to "heatflation" where rising temperatures is a factor of food price inflation, raising a significant concern in countries like Nigeria, where food insecurity is widespread (Erdogan et al., 2024).

  In SIDS, extreme weather has caused infrastructural damages which hinders food distribution networks, reducing access to food (Brenton et al., 2022). Climate change also presents significant threats to maritime infrastructure, considering that the costs born will soon become evident. A study on ports and shipping estimated that without aggressive GHG mitigation efforts, climate change impacts could cost the shipping industry up to $25 billion annually by the end of the century, including damages to port infrastructure and disruptions to global trade (EDF, 2023). Additionally, another study on ports forecasts that by 2050, between 55% and 59% of global ports could face extreme sea levels exceeding 2 meters above baseline, with this figure increasing to 71%-83% by 2100, thus threatening operational integrity and exacerbating economic losses.

- **Food utilization:** the increase in CO_2 emission levels decrease the protein and micronutrient content in staple crops like wheat and rice, affecting ***dietary quality*** (Owino et al., 2022). This trend predominantly pertain to developing countries reliant on these staples (Owino et al., 2022). Research highlight that countries' limited irrigation resources, which is impacted by growing urban demand reduce crop quality, ultimately impacting dietary quality and food security (L. R. Brown & Halweil, 1998). Climate change worsens ***health issues*** in SIDS, including increased prevalence of waterborne diseases, which can impair nutrient absorption and utilization (Brenton et al., 2022). In other words, health issues that impair food nutrients absorption increase malnutrition, which influence their diet and thus increase food in security

- **Food stability**: climate instability (extreme weather) create market volatility that ***disrupt food prices and supply stability***, affecting food security in developing countries, particularly those dependent on import (Brenton et al., 2022). In 2023, nearly 282 million people, or 21.5% of the population in 59 analyzed countries, faced high levels of acute food insecurity requiring urgent assistance (Brenton et al., 2022). This marks an increase of 24 million people since 2022, linking this issue to climate change as a major contributor (Brenton et al., 2022). Overall, the number of people at risk of acute food insecurity climbed from 135 million in 2019 to 282 million in 2023 across the same 59 countries (Brenton et al., 2022).

3.3 Relation of maritime transport costs to inflation and commodity prices

Rojon et al. (2021) argue that there are five different groups of determinants that affect the maritime transport costs, including: geographical and geopolitical factors, ship running costs, shipped product, market-specific factors, and infrastructure. The share of transport costs in imports varies according to product and region; however, the average country's share of transport costs amounted to approximately 9% from 2005 to 2014 (Rojon et al., 2021). According to Rojon et al. (2021), "the impact of increasing transport costs on import prices of commodities with a low value per ton would be relatively high, but relatively low for commodities with a high value per ton", and in the study "5.1% of the value of imported manufactured goods can be ascribed to shipping and insurance, compared

with 10.9% for agricultural goods and 24.1% for industrial raw materials, which they explain with the higher value-to-weight ratio of manufactured compared to agricultural goods and industrial raw materials" (Rojon et al., 2021).

Michail et al. (2022) by analyzing monthly data from January 2009 to August 2021 attempted to examine the relationship between shipping costs and inflation. They show a mild impact of freight rates on inflation with a maximum impact of 0.35% after a 10% freight cost shock. They argue that during the first eight months of 2021, the contribution of Non-Energy Industrial Goods (NEIG) inflation to total inflation almost quadrupled to 0.27%, compared with an average contribution of 0.07% since 2014. A large part of this increase can be attributed to inflation in the furniture and household sectors, which have been severely impacted by supply chain disruptions during the pandemic, since most of these industries are located outside the Eurozone. Furthermore, using the threshold regression method, they demonstrated that inflation becomes more sensitive to changes in shipping prices as shipping prices rise above USD 1200 to USD 1500 per day (Michail et al., 2022).

Herriford et al. (2016) underline that "U.S. import price indices omit information about shipping costs, so shipping cost pressures act as an additional, but often overlooked, channel through which imports affect aggregate price growth". According to their findings, a 15% increase in shipping costs results in a 0.10% increase in core inflation after a year.

In Europe, Koester et al. (2021) demonstrate that the pass-through to consumer prices usually takes more than one year. According to them, a surge in commodity price inflation, substantial increases in shipping costs, and an insufficient supply of some raw materials and intermediate products increased input costs for the euro area during the pandemic. To answer a question regarding the extent to which these pressures ultimately affect the prices of goods at the consumer level, Koester et al. (2021) argue that it depends on a number of factors, including their duration, firms' ability to absorb them through reducing profit margins, as well as their willingness to do so.

Ferrari et al. (2023) assert that an increase in trade costs and import prices will also affect consumer prices, albeit to a lesser extent. Final goods are directly impacted by the increase in shipping costs, but they can also be indirectly affected by the increase in prices of intermediate products in global supply chains, such as selected raw materials or parts and components used in manufacturing.

Michail and Melas (2022) argue that the small size of shipping cost effect on inflation could be explained by the fact that international shipping costs make up only a relatively small share of the final cost of manufacturing output. Attinasi et al. (2021) by referring to the World Input-Output Tables, argue that "transport costs make up less than 3% of the final cost of manufacturing output, implying that international shipping costs make up less than 1%". It is stated by Ferrari et al. (2023) that although international shipping costs are excluded from import price indices, importers may pass on changes in shipping costs to consumers, thereby affecting aggregate price increases.

Literature reviewed containing an analysis of the effects of container shipping price increases on consumer prices, it was predicted that, on average, across 198 economies, the consumer price increase between 2020 and 2023 was 1.5%. This impact was pronounced in small economies. For example, consumer prices were predicted to be increased in Estonia by 3.7%, in Lithuania by 3.9%, while in the United States it was only 1.2%, and in China it was 1.4%. According to these findings, container shipping price increases have had varying degrees of impact on global consumer prices (Ding & Choi, 2023).

Based on a study on the impact of rising shipping costs on inflation, it was found that transportation costs are closely related to commodity import prices. In this report, the effect of transportation costs on inflation is demonstrated by assessing how import price inflation is transmitted to consumer price inflation. According to their findings, commodity import prices are rapidly affected by transportation costs, while consumer prices are more moderately affected. The findings of this study emphasize the complex interaction between shipping costs and macroeconomic conditions (Ding & Choi, 2023).

There is an interesting attempt by Macera and Divino (2015) to differentiate between the macroeconomic effects of maritime transport costs and import tariffs, both of which fall under the category of trade costs. According to them, an increase in import tariffs leads to an increase in import prices. Increasing import costs lead to an increase in demand for domestic products, which in turn leads to an increase in domestic prices. In addition, they explain that import tariffs affect only imports, while maritime transport costs affect both imports and exports, and an increase in maritime transport costs can also decrease exports. Therefore, they believe that to examine the impact of trade costs, it is necessary to clearly identify the types and characteristics of the trade costs being investigated. In relation to this discussion, Rojon et al. (2021) argue that "transport costs can be as large a barrier to trade as tariffs, if not larger", and specifically for Africa, transport costs are a greater trade barrier than tariffs and other trade restrictions.

Through an analysis of the fluctuations of the Baltic Dry Index (BDI), Carrière-Swallow et al. (2023) attempted to analyze the relationship between global maritime transport costs and inflation in 46 countries and regions over the period 1992 to 2021. They found that as a result of sharp fluctuations in the BDI, import prices, the Producer Price Index (PPI), the Consumer Price Index (CPI), core inflation, and inflation expectations increased significantly. In addition, they observed that this impact is more noticeable in countries where imports account for a greater proportion of domestic consumption. It should also be noted that, compared with global oil and food price shocks, the impact of global maritime transport costs is similar in magnitude but more sustained. Furthermore, they investigated the response of inflation to changes in maritime transport costs, finding that an increase of one-standard-deviation in maritime transport costs typically results in an increase of 0.15 percentage points in domestic inflation within a year of the change (Carrière-Swallow et al., 2023).

3.4 Impact of changes in transport cost for SIDS, LDCs, LLDCs, and NFIDCs

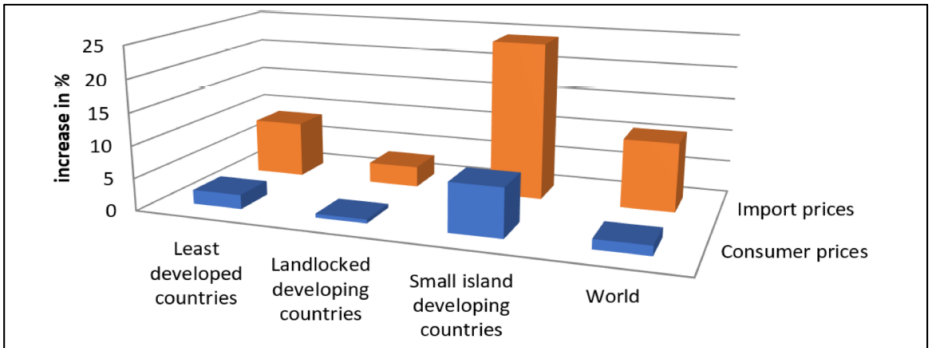
Brewer et al. (2023) by providing a descriptive overview of international food trade in the context of food security and nutrition in Pacific Island Countries and Territories (PICTs), argue that "PICTs are increasingly dependent on imports to ensure food security, which is creating potential vulnerabilities through the erosion of food sovereignty". Their analysis shows "the growing dependence on imports of rice from South-East Asia and wheat from Australia, and recent growth in imports of meat from Australia, New Zealand and USA, and highly processed foods from South-East Asia".

A literature review by Rojon et al. (2021) reveals that "effect of distance on maritime transport costs lies between 14% and 30% for every doubling in distance". Rojon et al. (2021) also argue that "being peripheral in the maritime network has a higher impact on maritime transport costs than distance", and "if a country can 'double' its centrality in the maritime network and thus significantly increase its direct liner services to more countries, its transport costs can decrease by up to 15.4%". In addition, "remote countries trading by utilizing at least one maritime hub incur 26% less transport costs compared to those trading directly with their partners" (Rojon et al., 2021). Across all regions, SIDS

suffer from low connectivity. As a result of their low trade volumes, many SIDS become dependent on hub-and-spoke services that increase maritime transport costs as they are served by smaller vessels that have higher costs per unit of cargo. As a result of low trade volumes, maritime transport costs are generally higher, further reducing trade opportunities.

Number of carriers operating and competing on a route lowers the shipping prices and reduces the carriers' ability to discriminate prices across products. For example, "prices for shipping Latin American imports are, on average, 30% higher than those for United States' imports and one-third of this difference is due to the limited number of carriers serving Latin American importers" (Rojon et al., 2021).

The other factor influencing transport costs is port infrastructure and performance. Developing economies, LDCs, and SIDS have shown low port performance, with LDCs scoring lowest. The average port turnaround time in LDCs is more than twice that of developed countries (Rojon et al., 2021). Estimations by Rožić et al. (2022) regarding percentage changes in prices for individual countries' categories are presented in Figure 19. They expected an increase of 8.7% in the price of imported goods in underdeveloped countries. Moreover, they estimated that small island countries would experience the greatest increase, both in terms of consumer prices and import prices. Compared to the estimated 10.6% increase on the global level, small island countries could face increases of up to 24.2%.



	Least developed countries	Landlocked developing countries	Small island developing countries	World
Consumer prices	2.2	0.6	7.5	1.5
Import prices	8.7	3.2	24.2	10.6

Figure 19: Simulation of the effects of current freight rates on the maritime container market on import and consumer prices.
Source: Rožić et al., 2022

Likewise, according to Ferrari et al., (2023) "the impact of the high freight charges would be greater for Small Island Developing States (SIDS), which could see import prices increase by 24% and consumer prices by 7.5%. In LDCs, consumer price could increase by 2.2%".

Rojon et al. (2021) estimate that global average transport costs represented about 15% of the value of imports. They also highlight the marked differences in ad valorem transport costs depending on countries' development status: Developed countries spent on average about 11% of the value of imports on international transport and insurance, while LLDCs paid 19%, LDCs 21% and SIDS almost 22% of the value of imports (see Figure 20).

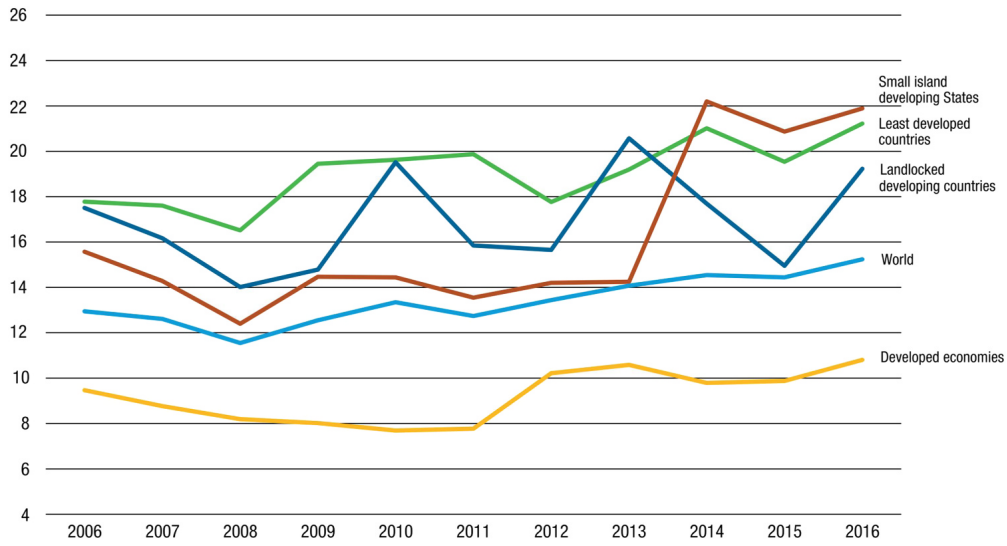


Figure 20: Transport and insurance costs of international trade, 2006–2016 (percentage share of value of imports).
Source: Rojon et al. (2021)

According to Rojon et al. (2021), for islands that are most reliant on food imports by sea, food import costs may increase by 0.03% at a carbon price of \$10/ton CO_2 and by as much as 1% at a carbon price of \$50/ton CO_2. Furthermore, Rojon et al. (2021) argue that "the cost increase in maritime transport at an allowance price of \$15–30/ton CO_2 (\$10–50/ton CO_2) would vary from 0.02% to 0.04% (0.01–0.06%) of GDP for developed countries to 0.07–0.15% (0.05–0.25%) of GDP for most groups of developing countries. For SIDS, however, the impact would be considerably higher at 0.45–0.89% (0.3–1.49%) of GDP".

In a study focusing on SIDS, Moon (2014) revealed that, between 2004 and 2013, the average expenditure on transport costs for importing goods in SIDS was 2% higher than the world average of 8.1%, with the Comoros, Seychelles, Solomon Islands and Grenada experiencing the highest expenditures of 17–20.2%. Due to this, some developing countries, SIDS, and LDCs would likely require assistance to mitigate the negative effects of increased maritime costs on their real incomes and trade flows (IMO, 2021).

For LLDCs, the need for maritime freight poses a challenge to policy-makers. It is due to their landlockedness that the LLDCs tend to have much higher trade costs, lower trade volumes, and, consequently, lower levels of socioeconomic development (Pham & Sim, 2020). By investigating of 31 LLDCs from 2001 to 2012, Pham and Sim (2020) demonstrate that shipping cost has large and negative effects on development on the LLDCs. They found that "on average, the doubling of container shipping cost is associated with a 20% and 40% decrease in GDP and lights per capita, as well as a 40 and 80 (per 100,000 live births) increase in infant and under-5 mortality, respectively. Thus, the negative effects of an increase in shipping cost on the LLDCs are potentially nontrivial". Furthermore, they asserted that "a 1% increase in trade per capita increases GDP per capita by 0.69% on average" in LLDCs.

Magrini and Amrouk (2024) by using an econometric technique called panel local projections estimated the dynamic effect of shipping costs (due to shocks) on the food import bill (FIB) with a specific focus on Net Food Importing Developing Countries (NFIDCs). They argue that "more than half of the changes in the FIB occur within the first six months from the shocks, emphasizing the need for

policymakers to focus on short-term effects due to the fast propagation of trade disruptions across maritime transportation routes". They argue that "the import demand for food and agricultural goods does not, at least in the short run, react enough to the price shocks that are induced by changes in the shipping costs. The increase in the overall expenditures triggered by higher import prices is not compensated by the reduction in traded volumes, highlighting the relative inelastic nature of food demand". They warn that the consequences of a shock for maritime transportation costs may quickly affect importing economies by increasing the value of the FIB and potentially influencing domestic prices and inflation that may put pressure on the domestic economy, particularly in NFIDCs.

As agri-food products can be transported in bulk and in containers, Magrini and Amrouk (2024) reported in Figure 21, a substantial difference between the impacts of shocks to container (0.34) versus dry bulk (0.12) costs, due to: First, the share of containerized agri-food products grew significantly in recent years. While bulk transportation still dominates by volume, the value traded using container shipping is higher. Second, there are market-specific factors. Bulk shipments typically serve single point-to-point voyages and usually return almost empty to the origin, while container deliveries are handled by liner shipping companies traveling on predetermined routes that visit several ports. If trade imbalances are significant, meaning ships travel fully loaded towards importing countries but return with empty containers, companies charge higher prices to compensate for losses incurred on the return journey. The impact on the food import bill of the initial shock to container freight rates may be amplified by the round-trip effect due to backhaul problems. Third, transportation shocks affect countries differently based on their level of food import dependency (e.g., NFIDCs) (Magrini & Amrouk, 2024). Figure 21 shows this differentiation more clearly.

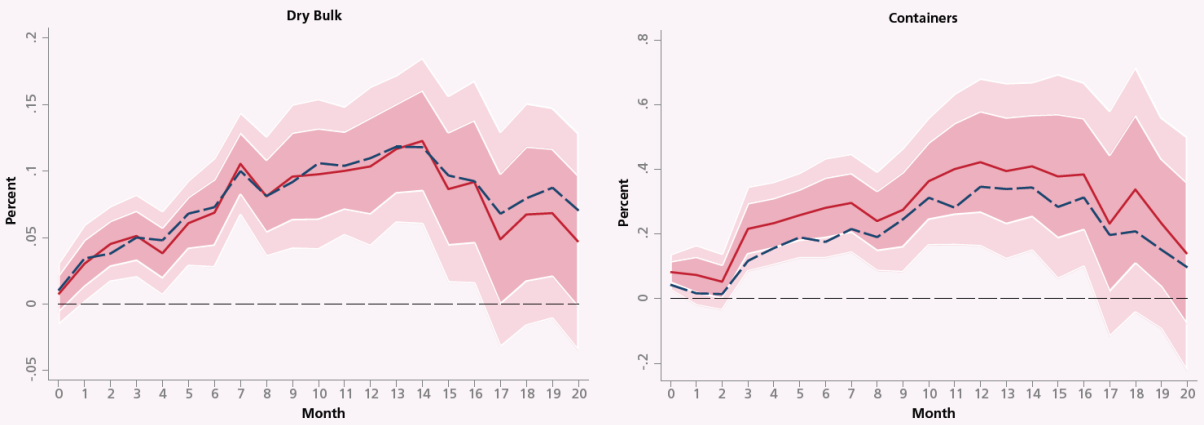


Figure 21: the cumulative impact of a 1.0 percent increase in shipping costs on the value of the FIB of the NFIDCs
Source: Magrini & Amrouk, 2024

For dry bulk costs, there are no substantial differences between the NFIDCs' cumulative response (solid red line) and the baseline estimate using the full dataset (dashed blue line). Conversely, a 1% shock to container shipping costs increases the NFIDCs' food import bill by 0.43% after 12 months, with over half of the total cumulative effect occurring in just three months. Magrini and Amrouk (2024) explain these results by three factors. First, in the short run, the effects of import price shocks on food and agricultural products in NFIDCs are more inelastic than in the full sample of countries due to the fact that these products are necessities with a limited number of substitutes. Second, NFIDCs have large trade imbalances and need to compensate for backhaul issues with liner shipping companies, which exacerbates the effects of a shock on container costs.

3.5 Impact of biofuel production on food security

The use of biofuels, which are fuels derived from organic materials (biomass), is on the rise. The literature reviewed identified that while biofuel production is considered by some as a potential source of revenue for developing countries, others have raised concerns that it could undermine food access for vulnerable groups. This subsection examines the findings from the reviewed literature on the impact of biofuel production on food security.

A study by Subramaniam et al. (2019) investigates the implications of biofuels on food security in 51 developing countries from 2011 to 2016. They provide evidence that biofuels adversely affect food security in developing countries. Similarly, Brinkman et al. (2020), in a study to quantify impacts of biofuel production on the four pillars of food security for urban and rural households in Ghana as a developing country, argue that the largest food security effects of the biofuel mandate are negative impacts on food prices and import dependency. Biofuel technologies offer marginal improvements in terms of energy security. Since biomass has a much lower energy density than oil, large quantities of food are required to displace relatively small quantities of gasoline or diesel. To replace less than 10% of gasoline consumption, the United States, the world's largest corn producer, diverted about 40% of its harvest to ethanol production in 2010. While biofuels contribute about 3% of transport energy worldwide, they consume a lot of food production to reach this share. This includes 11% of coarse grains and vegetable oil and 21% of sugarcane use (OECD-FAO, 2011).

In addition to the cost of feedstock, the economics of production are also influenced by the price of oil. Biofuels are more competitive when oil prices are high and they are less competitive when feedstock prices are high. The policy of biofuels also contributes to the volatility of food prices. Agricultural commodities become substitutable with petroleum products as a result of biofuel policies, which facilitate price transmission from energy markets to food markets; high oil prices encourage consumers to switch to biofuels as an alternative, which increases demand for feedstock and increases food prices (OECD-FAO, 2011).

Biofuels produced from agricultural products are considered as first-generation biofuels in the literature. Second-generation biofuels are produced from agricultural residues, wood waste and municipal solids that cannot be used as food and are therefore not in competition with food and feed. In addition, third-generation biofuels are produced from microscopic organisms which can avoid the disadvantages associated with food-fuel competition associated with first-generation biofuels (Naik et al., 2010; Subramaniam et al., 2019; Arias et al., 2024). A second-generation biofuel is considered cleaner than a first-generation biofuel due to its lower environmental impact, higher energy efficiency, and lower cost of feedstock (Naik et al., 2010). The use of algae for third-generation biofuels is considered to be the most promising in the future. In addition to lower production costs than other biofuels, algae-based feedstocks are also readily available and highly productive, as compared to first- and second-generation biofuels, algae-based feedstocks can produce 15–3000 times more oil for biodiesel production (Scott et al., 2010; Maliha & Abu-Hijleh, 2022; Arias et al., 2024).

Literature found that land-use change is another concern associated with the expansion of biofuel production. In the process of bringing new land into production, vegetation is cleared and soil is turned over. When this land has a high carbon stock, such as rainforests or peatlands, then the emissions can be significant (Bailey, 2013).

In response to critiques against biofuel industry, in the case of India, Gunatilake et al. (2014) suggest "combining the biodiesel expansion policy with energy efficiency improvements and food productivity increases proved to be a more effective strategy to enhance both energy and food security, help mitigate climate change, and cushion the economy against oil price shocks". In case of Ghana, Brinkman et al. (2020) argue that "the projected increase in food production and consumption as a result of expected economic progress in the country far outweigh the projected impacts of a biofuel mandate on the availability of and access to food". Even they state that increased energy access due to bioenergy expansion can benefit food utilization by improving food quality through improved storage and preparation (Brinkman et al., 2020).

In the same direction, according to Arias et al. (2024), the main approaches to focusing on biofuel production alternatives include the valorizing of agricultural, livestock, and forest residues, the use of algae, non-food raw materials, as well as other non-useable waste streams, such as cooking oil waste. In addition, a careful analysis of the use of marginal areas is necessary in order to ensure sustainability. First, the type of crop used in biofuel production must have a high energy yield, low chemical and fertilizer requirements, and minimal negative effects on the environment (Sallustio et al., 2022; Khanna et al., 2021; Arias et al., 2024). The production of biofuels using marginal areas can, in general, contribute to promoting more sustainable action and ensuring food security on a higher level. However, it is imperative to address environmental, social, and economic factors in order to ensure that biofuel projects have a positive impact on these regions. Subramaniam et al. (2019) argue that although no significant progress has been made with second and third generation of biofuels, it is still important to take these generations to potential conflicts with environmentally sustainable agriculture and food security.

3.6 Impact of GHG emissions mitigation policies on Food security

3.6.1 Economic instruments

As identified by Halim et al. (2019), maritime GHG mitigation measures, including carbon pricing, can have an economic impact in four different but interrelated areas: transportation costs, transport choices, import prices, and international trade and the economy of countries. They conclude that "introducing greenhouse gas mitigation measures, such as carbon prices applied to bunker fuels in the range of 10 to 50 USD/ton of carbon dioxide, might increase maritime transport costs by 0.4 percent to 16 percent. However, this would only marginally increase the import prices of goods (by less than 1 percent). For transport choices, the increased cost of maritime transport induced by greenhouse gas mitigation measures might only slightly reduce the share of maritime transport, by 0.16 percent globally. Furthermore, a global carbon tax applied to all transport modes might stimulate a shift toward maritime transport from all other modes. The impacts of a carbon price in the range of 10 to 90 USD/ton of carbon dioxide on national economies are expected to in the range of −0.002 percent to −1 percent of GDP. Generally, regulatory measures, as opposed to unpredictable, temporary shocks to supply chains and maritime transport, can be anticipated, planned for, and are implemented over a long period thus allowing for any negative impacts to be mitigated by international or national policies and measures.

Rojon et al. (2021) by reviewing studies focusing on the impacts of a maritime carbon price on maritime transport costs and the price of imported goods, have presented Table 12.

Table 12: Impacts of a maritime carbon price on maritime transport costs and the price of imported goods.

	Inputs/assumptions			Findings	
	Specific focus, if any	Fuel price assumption	Carbon price or bunker contribution	Increase in Maritime transport costs	Increase in import prices of goods
Anger et al., 2009	Carbon price		US$2.4–14.2/tCO$_2$ (2020); US$6.6–38.8 (2050)	Not specified	0.00% (food & drink, agricultural products)
	ETS		US$56/tCO$_2$ (2020); US$1022/tCO$_2$ (2050)	Not specified	0.00–0.08% (food & drink) 0.00% agricultural products
Faber & Rensma, 2008		US$700/tonne	US$30/tCO$_2$	4–8%	< 1%
		US$450/tonne		6–12%	
Kronbak et al., 2009	Container shipping; select commodities	US$550/tonne	US$45/tonne fuel (US$14/tCO$_2$)	1–5%	0.15–1.86%
Faber et al., 2010	Handy- and Capesize bulker, Handysize product tanker, VLCC, container and ro-ro	US$360.5/tonne	US$30/tCO$_2$	7–16%	0.4–3%
			US$15/tCO$_2$	4–8%	0.2–1.4%
IMO, 2010			10% increase of bunker fuel price	Not specified	< 0.2% (similar for exports)
	Iron ore			5–14%	
	Crude oil			1.2–6%	0.2–0.4%
	Grains			2.5%	0.2–0.7%
	Furniture & clothing				< 0.2%
Chowdhury & Dinwoodie, 2011	Coking and steam coal		10% increase in spot bunker price	10–11%	
Purvis & Grausz, 2012	all, but impacts only determined for US	US$2.40/gallon (~US$741/tonne)	US$15–30/tCO$_2$	Not specified	0.1–0.28%
	Agriculture (only US)				0.14–0.29%
	Raw material (only US)				0.18–0.36%
	Crude oil (only US)				0.06–0.13%
	Manufacturing (only US)				0.1–0.2%
Anger et al., 2013	all	US$738/tonne	US$10–50/tCO$_2$	0.4–3.4%	
Miao & Fortanier, 2017	all	US$25/barrel (~US$184/tonne)	Fuel price increase to US$75/barrel (~US$551/tonne)	1.49%	
Sheng et al., 2018			US$18/tCO$_2$	Not specified	0.2%
ben Brahim et al., 2019	Danish maritime cargo sector		US$387–443/tCO$_{2e}$	100%	6–8%

Source: elaborated by Rojon et al. (2021) based on a review of available studies

In summarizing the results shown in Table 12, Rojon et al. (2021) conclude that "the introduction of a carbon price on maritime transport could increase freight costs by between 0.4% and 16%, with most studies concluding that the increase would be below or around 10%". They also add "the impact on import prices is estimated to be small in most studies; mostly below 1%, with higher impacts generally estimated for commodities with a low value per unit of mass or volume".

According to Rojon et al. (2021), the impacts of a 10% increase in bunker fuel prices on four types of cargo and ship types could be as following:

- Freight costs of Iron ore (Capesize) would increase between 8.9% and 10.5% according to UNCTAD (2010), and 5–14% according to Vivid Economics (2010).
- Freight costs of Crude oil (VLCC) would increase by about 2.8% according to UNCTAD (2010), and by 3.2–3.7%, according to Vivid Economics (2010).
- In case of grains (Panamax), impacts vary by grain type and by market. Vivid Economics (2010) calculates that freight costs would rise by 2.5%, wheat prices in South Africa by 0.2%, wheat prices in Kenya by 0.4%, and maize prices in Saudi Arabia by 0.7%.
- In case of furniture and clothing (container), Vivid Economics (2010) estimates that prices for apparel and furniture would increase by 0.2% or less.

The impact of maritime carbon taxes applicable to international container shipping on real GDP percentage change was studied by Lee et al. (2013). Based on six simulation scenarios, they have reached the following conclusions:

- "The impacts depend heavily on the carbon tax amounts and the taxing regions. The imposition of a maritime carbon tax on international container shipping will result in significant economic impacts only if the tax level is high. Medium and low carbon tax scenarios show no measurable changes".
- "Among all countries, China faces the largest loss in real GDP (around -0.02% under the scenario of a global carbon tax of $90/tCO2). This result arises from the fact that: (i) China is a major exporter of containerizable commodities in the world economy and (ii) China's container exports have relatively longer shipping distances. In other words, the container shipping volumes and shipping distances are the two major reasons determining the CO2 emissions and hence the economic impacts caused by the maritime carbon tax".
- "If a maritime carbon tax on international container shipping is imposed only on the European exporting/importing routes, the European countries will suffer more economic damage compared to the scenario of a global maritime carbon tax. However, even under the EU tax scenarios, China still has the largest GDP loss among all countries. This result arises from the above-mentioned fact that a large portion of China's exports are to the EU".
- "Imposing a maritime carbon tax of $90/tCO2 on international container shipping will decrease the loaded container trade volume worldwide by 915 thousand TEUs. In terms of individual countries' container exports, the decrease in containers mostly comes from China (177 thousand TEUs), South America (156 thousand TEUs), the Rest of Asia (132 thousand TEUs), and the USA (112 thousand TEUs)".

At the end, they conclude that "imposing a maritime carbon tax on international container shipping will discourage distant trade but will promote trade with neighborhood countries" (Lee et al., 2013).

A study conducted by Transport & Environment (T&E, 2024) examines the impact of the EU's ETS on global shipping. It is shown that the ETS has only a limited negative impact on SIDS and LDCs, and if the EU extends its carbon pricing mechanism to all ships calling at European ports, the additional revenues can actually benefit those countries as climate finance. According to this study, "the EU ETS will have a very limited impact on SIDS and LDCs (on average, just above 7% of seaborne trade to SIDS and LDCs will be regulated under the EU's carbon market). The largest impact will be in a handful of West African countries, for whom between 15% and 19% of their total shipping traffic will be regulated by the ETS; while the impact will be zero or close to zero on shipping trade to the Asian and Pacific SIDS and LDCs" (T&E, 2024).

Mundaca et al. (2021) by using a comprehensive panel dataset for products at the 6-digit Harmonized System (HS) level of aggregation covering the years 2004–2017 conclude that imposing a global and uniform carbon tax of $40/ ton CO_2 for an annual trade activity (ton-nautical miles) similar to that between 2009 and 2017 and carbon intensities for the maritime vessels for the same period would reduce carbon emissions by about 7.65% for heaviest products. According to them, the products with the highest relative reduction in carbon emissions resulting from a $40/ton CO_2 carbon tax are fossil fuels (11.5%), ores (10.5%), cereals (8.4%), iron and steel (8.3%), and fertilizers (8.1%). The value-to-weight ratio for these products is among the lowest in maritime trade. Among the products with the highest value-to-weight ratios in their dataset, furniture (1%) and motor vehicles (1.8%) had the lowest relative reductions in carbon emissions. The study also proposes a plan which involves a carbon tax that increases by $20 per 5-year period starting in 2025 and ending in 2050, when the carbon tax reaches $120 by 2050. This scheme could fulfill two objectives, first, continue disincentivizing the use

of fossil fuels, and second, to finance the replacement of 20% of all old (bunker-operated) ships with ZEVs between 2040 and 2050 (Mundaca et al., 2021).

Cariou et al. (2023) by using data from 2016, have attempted to estimate the impact of a change in transit time and transit cost on grain and soybean trade flows and on vessel speed. In contrary to most theoretical models that predict an increase in fuel costs will always lead to a reduction in speed and carbon emissions, they argue that a bunker levy of $50 per ton of fuel, or less, will not trigger a change in the optimal speed of the vessel. Further, they clarify that bunker levies exceeding $100 per ton may be necessary to reduce carbon emissions when trade flows are affected by trade costs and transport times, as is the case with many agricultural commodities.

3.6.2 Technical instruments

- **IMO 2020 sulphur limit**

As of January 1, 2020, IMO prohibited all vessels on the high seas from burning fuel oil with a sulphur content higher than 0.5%. According to Sigalas (2022), the IMO 2020 regulation disrupted the established business paradigm, because around its enforcement in January of 2020, the compliance cost had been borne by suppliers of transportation tonnage instead of customers of the transportation service. To support this statement, Raza (2020) also emphasize the considerable financial burden for maritime shipping companies as a result of implementation of IMO 2020. While fuel surcharge schemes are designed to absorb the additional cost of fuel, and keep the Time Charter Equivalent (TCE) intact, the absence of a fuel protection mechanism by policymakers in dry bulk shipping led to the introduction of IMO 2020 with a heavier financial burden on bulk compared to others (Sigalas, 2022). As a result of IMO 2020 enforcement, the price spread between the high cost-low sulfur fuel oil (LSFO) and the low cost-high sulfur fuel oil (HSFO) had been passed on to the ship-owners, and the additional fuel cost has not been incorporated nor reflected in the total freight paid by customers. Since freight rates had not increased enough to absorb the additional fuel costs, the net effect, i.e., the gross profit margin for shipowners, as measured by the TCE rate, was zero (Sigalas, 2022). As IMO 2020 came into force, the strong positive correlation between freight rates and their TCE rates began to weaken (for Panamax) and even turn negative (for Capesize and Supramax). In dry bulk shipping, this phenomenon provides empirical support for the decoupling between freight rates and their TCEs (Sigalas, 2022).

According to Uría-Martínez et al. (2021), “prior to 2020, IMO 2020 analyses anticipated significant fuel mix shift toward marine gasoil, with some challenges to fuel availability, and potentially substantial increases, at least in the short run, for the cost of marine fuels (40% or more). Some studies also anticipated observable spillover effects on the prices of diesel and gasoline fuel”. However, “contrary to some initial concerns, compliance with low-sulfur, petroleum-based fuels neither has turned out to be, nor is expected to be (based on Annual Energy Outlook (AEO) 2021 price forecasts), very expensive”.

- **Emergence of emission control areas**

Emission control areas (ECA), under MARPOL Annex VI, are regions where mandatory measures control ship emissions of NOX, SOX, and particulate matter (PM) to reduce their impact on health and the environment. Their constraints primarily address non-GHG emissions and do not serve as a GHG mitigation measure or policy. Nevertheless, the effects on fuel prices and operational aspects provide sufficient rationale for examining the impacts of ECA constraints on shipping operations and the

economy. Whilst the literature reviewed does not explicitly address the impacts of emission control areas on food security, the associated increase in fuel costs and maritime transport costs, could indirectly affect food security.

The study by Raza et al. (2019) examined the feasibility of slow steaming as a method of mitigating the anticipated SECA compliance costs from the perspective of RoRo and RoPax shipping firms. According to their findings, the 0.1% SECA regulation requiring the use of higher-priced MGO has not resulted in significant slow steaming in the RoRo and RoPax segments. By increasing the Bunker Adjustment Factor (BAF), bunker prices are partly transferred to customers and partially borne by shipowners. It has been concluded that the impact of bunker prices on RoPax and RoRo segments has not caused slow steaming due to rigorous competition and different service quality requirements.

Accordingly, Adland et al. (2017), by analyzing a dataset of observed vessel speeds derived from the Automated Information System (AIS) over a three-year period for nearly 7000 boundary crossings within the North Sea ECA, argue that introducing stricter sulfur regulations from 1st January 2015 had no effect on vessel speeds, even considering macroeconomic conditions. Fuel prices and freight rates are not generally determinants of vessel speed, according to them. Instead, vessel speed is determined by a number of factors, including route characteristics, vessel types, weather, market segments, and market conditions, as well as the nature of the commercial contract between the shipper and the operator.

Unsimilar to the last two sources mentioned above, Cariou et al. (2024) have anticipated the negative impacts of future Mediterranean SECA in 2025 on trade. Their analysis indicates a potential decline in trade value by -1.0%, with imports decreasing by -1.1% and exports by -0.8%. The sectors anticipated to be most significantly impacted, in percentage terms, are foodstuffs, animal products, and vegetable products. Furthermore, their estimations suggest that the countries likely to experience the most substantial effects include Syria (-1.5%), Lebanon (-1.4%), and Spain (-1.0%).

- **EEXI enforcement**

The Energy Efficiency Existing Ship Index (EEXI) is an IMO mandatory measure designed to reduce the carbon intensity of all ships by 40% by 2030, compared to a 2008 baseline, with the goal of improving the technical performance of existing ships. Although some articles have discussed EEXI compliance and its implications (e.g., Vasilev et al., 2025; Polemis et al., 2023), no study has investigated the effect of EEXI implementation on global fleet speeds and operational profile after its enforcement since 1st January 2023.

Even though the main objective by enforcement of EEXI has been to motivate existing vessels to retrofit technical energy efficiency measures, however, studies show that engine power limit (EPL) has been the most utilized method to comply with the required EEXI limits (Ghaforian M. et al., 2024). In this line, however, Ghaforian M. (2023) by referring to Clarksons database demonstrates that EPL implementation have not been led to a significant slowdown of ships' speed.

According to the Clarksons research database at the end of 2023, one year after EEXI enforcement and EPL implementation, speed reductions have been very marginal for the main shipping segments (Clarksons Research, 2023). As shown in Figure 22, in 2023, the container and bulk segments experienced minor speed reductions of 2.8% and 1.7%, respectively, compared to 2022. However, tankers' average speed has increased by 2.2% and 1.8% compared to 2021 and 2022, respectively (Ghaforian M., 2023).

Figure 22: Yearly average speed for main shipping segments
Source: Ghaforian M., 2023

- **Fuel standard**

MEPC is currently discussing the adoption of a global marine fuel standard (GFS) regulating the phased reduction of a marine fuel's GHG intensity. It is a relatively new measure and published academic literature on this issue is limited. Apart from IMO submissions, there is very limited literature on the impacts of the proposals under discussion, notably with respect to its impact on ship speeds, freight rates, or similar factors.

Section 4: Impact of the increase in maritime transport costs and freight rates on Food security

This section assesses in more detail how the relative contribution of maritime transport costs and freight rates impacts food security as one of the contributing factors.

4.1 Relative contribution of maritime transport costs to Food security and critical agricultural input

Trade in food and agricultural products increases the availability of food by enabling products to flow from surplus to deficit areas. Open trade can also improve utilization and nutrition by increasing the diversity of national diets. Open markets improve the stability of availability and access, for the simple reason that international markets pool production risks across individual markets. About 20% of calories consumed globally have crossed international borders (OECD, 2023).

Higher trade costs, broadly defined to include transport cost, policy cost and distribution cost, tend to reduce the benefits of open markets by raising the import prices of traded goods and services and hence reducing demand. In an earlier study Anderson and van Wincoop (2004) concluded that while trade costs are determined by many different factors, trade costs as percentage of import prices for a representative developed country can be broken down into 21% transportation costs, 44% border barriers, and 55% wholesale and retail distribution costs. This estimate shows that international transport costs are a key component of landed prices, even if more recent data and estimation methods may refine the original findings of the study.

Beghin and Schweitzer (2020) point out that agricultural trade costs are significant as many agricultural goods are low value, bulky, and perishable. Maritime transport costs, in particular, have a greater impact on lower-value goods like agricultural products due to their higher cost-to-weight ratio. Transportation cost is difficult to capture in a realistic way because it is heterogeneous across goods, transportation modes and time. Lower-value goods like agricultural products are more sensitive to transport cost changes, with about 10.9% of their value tied to shipping, compared to only 5.1% for manufactured goods. As food products have different transport requirements, Wilmsmeier and Sanchez (2009) categorize sea transport modes of food products as in Table 13 below. The distinction between different modes of maritime transport is important as the economics will generally differ between them. Consequently, the impact of changes in cost components on specific importers will depend on their product and transport mode profile.

Table 13: sea transport modes of food products

Type of product	Type of movement	Transport requirements
Bulk products	Bulk	Bulk carrier, carriages and trucks
Processed food and special food stuff	Container	Cellular ships, truck and rail chassis
Perishable food	Reefer container	Idem, plus energy

Source: Wilmsmeier and Sanchez, 2009

How important are maritime transport costs, as part of overall trade costs cost, for trade in key food commodities?

Within food trade, grains and oilseeds are specifically important (see section 2) and more than 80% of global trade in grains and oilseeds relies on maritime transport (IGC, 2022). Trade costs not only affect the prices of these goods in importing countries, but can also influence the domestic prices of bread, meat and other food products since imported grains and oilseeds are used as a feedstock or input in the food and feed sectors.

Using detailed weekly and daily data on freight costs for different grains and oilseeds for up to 200 bilateral trade links between 2007 and 2021 from the International Grains Council, Deuss et al. (2022) conclude that freight rates accounted on average for 11% of the 'cost and freight price'[1], but this share ranges between 2% and 43%, demonstrating the potentially large impact of freight rates on consumer prices.

Approximate estimates of changes in landed price for grains and oilseeds can be obtained. Taking the Deuss et al. average of 11% and taking the range of maritime transport cost increases of 1 % to 16% reported in Rojon et al. (2021) across all commodities, the average first order impact on cost and freight prices would lie in the range of 0.1% (=0.01 * 0.11)*100 and 1.8% (= 0.16 * 0.11)*100. For trade links, where the trade cost share represents a significant 43%, the price increase range would fall between 0.43% and 6.9%. These preliminary calculations assume that all other factors remain constant, but of course various adjustments will take place.

The share of freight rates in cost and freight prices tends to display great variability over time and across commodities and trades routes. Freight rate shares peaked between mid-2007 and end-2008 and subsequently came down in the wake of the global financial crisis. Between the end of 2010 and mid-2021, the share remained between 5% and 15% for all the grains and oilseeds commodities.

There is also much variation in the share of freight rate in the cost and freight price between commodities. This share is lower for soybeans than for sorghum and wheat, for instance, as these commodities have the same freight rate per volume (i.e., the freight rate for HSS cargoes) but soybean has a higher fob export price than sorghum and wheat. This confirms a general pattern: freight rates are more important for products with a low value-to-weight ratio. See also Mundaca (2024) who finds in an econometric analysis of 21 products that cover about 75% of globally shipped weight that the smaller the average unit sales value per kg, the larger the impact of changes in bunker fuel price (i.e., a possible carbon tax) on export prices. The volatility of freight rates is higher than the volatility of export prices. For instance, Deuss et al. (2022) report the coefficient of variation, a common measure for volatility, to be 13% in 2020 and 2021 across all exporters and commodities, against 8% in 2020 and 6% in 2021 for fob prices.

Maritime transportation shocks affect countries differently based on their level of food import dependency. Magrini and Amrouk (2024) isolate the response of NFIDCs to transport cost shocks. The authors are able to distinguish bulk from container shipping. For dry bulk costs, they find no substantial differences between the NFIDCs' cumulative response and the average across all countries. This contrasts with container shipping: a 1% shock to container shipping costs is found to increase the food import bill of NFIDCs by 0.43% after 12 months, with over half of the total cumulative effect occurring in just three months. The authors point out that food and agricultural products in NFIDCs are necessities with a few substitutes, making the reactions to import price shocks more inelastic in the short run compared to the full sample of countries. Importing agrifood products by sea is relatively more costly for NFIDCs than for other countries, as the transport costs represent a higher share of the food import bill for these countries (Deuss et al., 2022). SIDS are particularly exposed to maritime transport cost increases due to their reliance on hub-and-spoke services and higher per-unit transport costs. They are physically more distant from major exporters, served by fewer shipping routes, and

[1] The 'cost and freight' (C&F) price is defined as the sum of the freight rate and the free on board (fob) price. The freight rate shares are obtained by dividing the freight rate by the C&F price.

marginalized by the global shipping network (Rojon et al., 2021; Fugazza & Hoffmann, 2017; Korinek and Sourdin, 2010; Willmsmeier et al., 2009).

Michail et al. (2022) and Herriford et al. (2016) found that freight rate shocks have modest inflationary effects, with a maximum inflation increase of 0.35%. Similarly, Koester et al. (2021) noted that the pass-through of shipping costs to consumer prices can take over a year. However, shipping costs still indirectly raise food prices through increased input costs for intermediate products in supply chains, as shown by Ferrari et al. (2023).

4.2 Main determinants of agricultural freight rates for agricultural commodities

The economics of maritime freight rates is an interplay between multiple market forces and goes beyond the scope of this review. Hence, this sub-section focusses on findings from the literature on maritime trade in agricultural commodities, and specifically on the most widely traded category of grains and oilseeds.

Trade literature has predominantly treated transport costs as exogenous, without aiming to understand the various forces that influence them. Some empirical studies try to gauge the relative importance of distance, scale and volume, type of product, port efficiency (e.g., Clark, Dollar & Micco, 2004), network connectivity and market structure (e.g., Wilmsmeier & Martínez-Zarzoso, 2010). In relation to the agricultural sector specifically, Korinek and Sourdin (2010) show that distance alone does not explain maritime transport costs.

Narrowing down on bulk trade of grains and oilseeds, the most comprehensive freight cost data are produced by the International Grains Council. The IGC dry bulk freight model uses a uniform methodology to calculate voyage rates on a daily basis, and the results are made public through their website (IGC, 2025).

The calculations incorporate several parameters such as fixed route parameters (including distances, sizes, loading and discharge), daily market variables (including hire rates and bunker (fuel) prices), and comprehensive vessel specifications (including speed and fuel consumption). Figure 23 illustrates with an example the multi-step process used to calculate the voyage rate for shipping ‘HSS’ (heavy grains (wheat, durum), sorghum and soybeans) from Santos in Brazil to Dalian in China. The increase in maritime transport cost is mostly leading to an increase in fuel cost that account for 28% of total maritime cost.

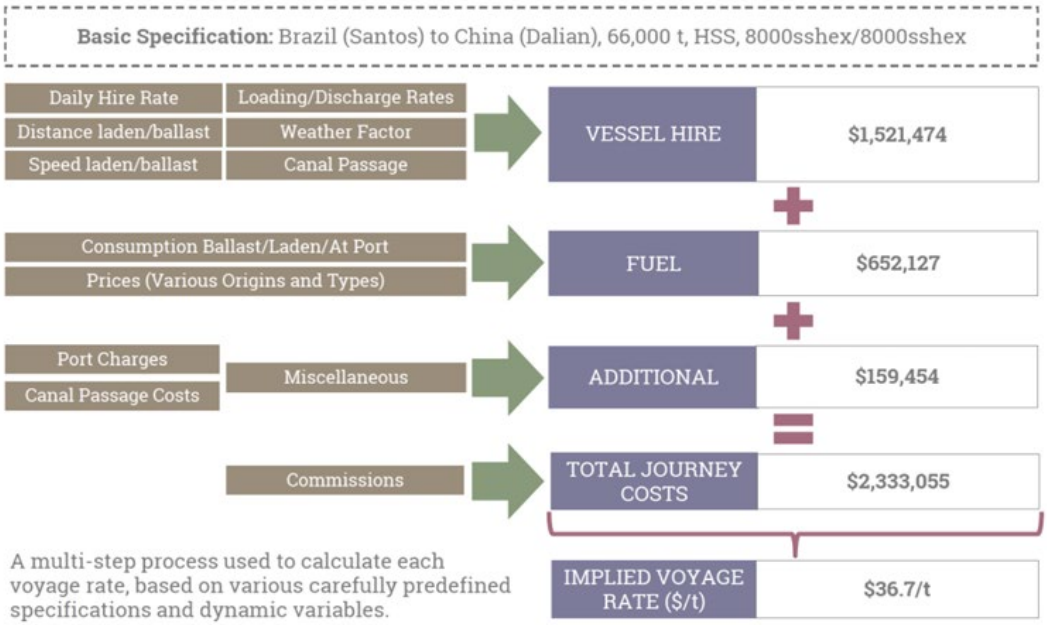


Figure 23: Example of calculation methodology used in the IGC dry bulk freight model
Source: International Grains Council, 2019

Freight rates are influenced by distance between ports and, surprisingly, less so by the scale of the shipped quantity. Using the IGC dry bulk freight data, Deuss et al. (2022) show that a 10% increase in the distance between two ports leads to a 2.2% increase in freight rates in the long run, and 2.6% in the short term.[2]

In the long run the results suggests that freight costs increase as grains and oilseeds are shipped over longer distances. The results also show that freight rates are not affected by the volume of shipped grains and oilseeds. This absence of a statistically significant scale effect can potentially be explained by higher port and canal charges and longer load and discharge times for larger vessel, even though using larger carriers may provide some economies in terms of per ton vessel hire costs or fuel consumption per ton of cargo.

In the short term, contrary to the long-term analysis, the fob price has a negative and significant impact on freight rates. More specifically, a 10% increase in the current or one-month lagged fob price leads to a 0.8% decrease in freight rates. This result suggests that exporters facing increasing commodity prices tend to try to negotiate lower freight rates in efforts to stay competitive. Deuss et al. (2022) report that in 2021, this was for example observed in Argentina, where an increase in maize prices led to the country lowering its freight rates for shipments to Southeast Asia and Viet Nam.

4.3 Impacts of economic and geopolitical shocks to maritime transport costs on Food security

The literature documents that recent shocks to the global economy have resulted in significant spikes in maritime transport cost, and hence it can be expected that some insights into the relationships between maritime shipping costs and food security can be gained from those events. At the same time the literature acknowledges that a temporary shock, such as the COVID-19 pandemic and the military

[2] They econometrically estimate a so-called gravity model to assess the impact of fob prices and distance on trade flows. This method does unfortunately not permit to isolate the effect of fuel prices since there are no data on fuel prices by trade route and commodity.

conflict between the Russian Federation of Ukraine, is different from the permanent changes instilled by GHG mitigation measures impacting the maritime shipping industry which can be anticipated, planned for and are implemented over a long period of time. The food security impacts of a systemic shock (COVID) and an idiosyncratic shock are certainly illustrative and reveal important transmission channels, but findings cannot simply be extrapolated to the situation when maritime transport costs are structurally raised by policy measures.

During the COVID episode agricultural supply shocks combined with maritime transport bottlenecks due to surges in demand for consumer products to impact availability and access to food globally. The military conflict between the Russian Federation and Ukraine impacts a major exporter of grains and oilseeds. It has raised prices of key agricultural commodities in the short term and has been impacting most heavily importers who predominantly rely on that country for their supplies.

Disentangling the contributions of different factors impacting on prices and volumes of food stuffs traded to importing countries involves amongst others to isolate: direct the effect of destruction of export capacity in Ukraine; direct cost factors impacting on freight rates, in particular oil prices and insurance; indirect effects on freight rates through re-routing and shifting demands for grains and oilseed to other suppliers; impacts on production outside Ukraine due to higher fertilizer prices (negative incentive) as well as higher commodity prices (positive incentive to increase output).

Prior to the military conflict between the Russian Federation and Ukraine, global food markets, and indeed the global economy were subject to the systemic shock stemming from the COVID-19 pandemic that stated in 2020. High international transport costs confounded with local logistic problems, shortfall of farm labor and dropping incomes to led to heightened concerns about food security in developing countries.

Ferrari et al. (2023) capture much of the heterogeneity of impacts of a surge in transport cost through an economic simulation model that captures bilateral trade relations and maritime trade costs between countries as well as input-output relationships in production in a general equilibrium framework. This modelling enables discerning effects on trade volumes, but also on final demand and consumer prices, which is ultimately of interest for food access and availability. Consumer prices are influenced by maritime transport costs via several channels. Besides the direct effects due to the increase in shipping costs, they can also increase indirectly due to increased price of intermediate products strongly embedded in global supply chains such as fertilizers and imported machinery used in agricultural production.

Estimating in detail the transport cost increases during the COVID-19 episode by use appropriate weighting of transport modes and commodity composition, their results show a generalized increase of import prices, a reduction of the volume of world trade by 0.42 % and of value by 0.23 %, compared to 2020 base values, but with significant discrepancies among countries. The non-uniform increase in transport costs leads to a shift towards the markets with the lowest resulting import price. For commodities with very elastic demand and for which the transport costs represent a high share of the import price, such as perishable agricultural products, an increase in transport costs is found to lead to lower export prices as well as globally lower trade volumes.

Importantly, by taking into account supply chain relationships and market adjustments in the face of a shock the analysis captures indirect effects beyond the direct effects of the transport cost rise. The indirect effects, increase in production price, change in income and demand across all commodity groups are also considerable.

This type of modelling is able to capture direct and indirect effects of the transport cost shocks within and between countries. The commodity detail and country disaggregation is relatively rich, but still insufficient to study the impacts on small peripheral economies due to lack of data. The model uses the GTAP database, the latest version of which now contains 160 countries or regional aggregates and great progress has been made to include more African countries and South-East Asian countries, see Aguiar et al. (2022). However, small island states are still beyond the reach of this global data – and modelling effort.

4.4 Transport cost, import prices and import volumes

The literature on the relationship between food security and maritime transport costs is not well developed and a coherent picture of quantitative magnitudes is lacking. Nonetheless some insights can be gained by combining findings from various quantitative studies reviewed here.

Table 14 below combines estimates reported in three of the studies to calculate upper- and lower-bound estimates of impacts of maritime transport cost changes on global import prices and import volumes. Those numbers are obviously surrounded by much uncertainty due to different methods, different time frames and different data sets used, but give nonetheless some idea of the magnitudes involved.

The calculations in Table 14 reveal that: First, the reaction of the import price with respect to maritime transport cost is naturally larger when the share of transport cost in the import price is higher. Second, the first order, or direct, impacts on import cost are magnitudes bigger than the impacts obtained from modelling that includes indirect effects. The lower part of the table shows that when market adjustments are taken into account the ultimate impacts of a 10% rise in transport cost on import prices lies around 0.5%, compared to 1.1% and 4.3% for the average and high range of direct effects.

Similarly, Stochniol (2011) calculates global food import price increases from a 10% increase in fuel prices (not total transport cost) to lie between 0.1% (beverages and spirit) and about 0.5% to 0.6% (cereals and vegetables).

These results are comparable to those from a detailed econometric study on the pass through of a maritime fuel tax on export prices by Mundaca (2024). This study reports short- and long-run export price effects of increases in bunker fuel prices, see Table 15. The orders of magnitude of the estimates from the different studies cited here are broadly in line. The Mundaca (2024) study also highlights that the effects tend to vanish over time, i.e., there is no lasting effect on export prices from a potential increase in fuel costs due to a carbon tax.

Even if the results are not directly comparable due to differences in methods and time frame, taken together the estimates show that the import (or export) price responses to changes in maritime transport cost are relatively low compared to the fluctuations that are normally observed in trade statistics. Over the longer term, when markets have adjusted the price effects of a potential increase in maritime fuel prices tend to diminish.

Table 14: Approximate changes in import prices when maritime transport costs increase

	Change transport cost	Share of maritime cost in import price grains and oilseeds (C&F)	Change import price (c&f)	Implied elasticity of import price	Change import price for 10% increase transport cost
	1	**2**	**3**	**4**	**5**
	Rojon et al.	Deuss et al.	(col 1 x col 2)	(col 3/ col1)	(col 4 x 10%)
Low	1.0%	2%	0.2%	0.02	0.2%
Average	10.0%	11%	1.1%	0.11	1.1%
High	16.0%	43%	6.9%	0.43	4.3%
	Ferrari et al., Figure 5				
Low	20.0%	n.a.	1.0%	0.05	0.5%
High	50.0%	n.a.	1.8%	0.04	0.4%

Source : Rojon et al. (2021) ; Deuss et al. (2022); Ferrari et al. (2023)

Note: Column 1 uses numbers from Rojon et al. (2021) in their meta-analysis on carbon pricing. Column 2 reports relatively the lowest, average and maximum share of maritime transport cost in C&F prices for grains and oilseeds reported in Deuss et al. (2022). The lower part of the table shows numbers as reported in Figure 5 of Ferrari et al. (2023) in their study of covid pandemic. Column 4 is an estimate of the point elasticity of import price to transport cost. This is a dimensionless number that summarizes the change in import price for a change in transport cost.

Table 15: Estimated response of unit export values to an increase in bunker price

	Contemporary effect on unit export value to 1% increase of bunker price (%)		Long term effect at t+2 on unit export value to 1% increase of bunker price (%)	
	Larger distance destination	**Shorter distance destination**	**Larger distance destination**	**Shorter distance destination**
Cereals	0.36	0.21	0.04	0.02
Grains (soya)	0.29	0.13	0.09	0.04
Animal and vegetable oil	0.56	0.56	n.a.	n.a.
Animal fodder	0.35	0.35	0.05	0.05
Fertilizer	0.4	0.4	0.02	0.02

Source: Mundaca, 2024

Table 16 reports similar approximations for global import volumes based on the modelling study by Ferrari et al. (2023). First, the reaction of import volumes of processed food items is more pronounced than that of primary agricultural commodities. This is due to the generally higher sensitivity of processed foods to price changes. Second, even with the substantial change in maritime transport costs reported by Ferrari et al. (2023) the equilibrium reaction of import volumes is found to be modest, though a factor 2 to 3 bigger than the import price changes in Table 14. This reveals the parameterization of the model with import price elasticities between 2 and 3.

Table 16: Changes in import volumes for selected commodities

	Change imports	Change transport cost	Implied elasticity of imports	Change import volume for a 10% change in transport cost
	1	**2**	**3**	**4**
			(col 1 / col 2)	
Processed rice	-2.0%	15%	-0.13	-1.3%
Wheat	-1.5%	20%	-0.08	-0.8%
Processed oils	-2.5%	15%	-0.17	-1.7%
Fertilizer	-0.75%	10%	-0.08	-0.8%

Source: Ferrari et al. (2023): Columns 1 numbers from Figure 8, column 2 numbers from Figure 5.

Note: Column 4 is an estimate of the point elasticity of import volumes to transport cost. This is a dimensionless number that summarizes the change in import volumes for a change in transport cost.

Section 5: Knowledge gaps

As mentioned at several instances in this literature review, there is very limited academic literature addressing the potential impacts of an increase of maritime transport costs, in particular from GHG emissions mitigation measures, on food security. In addition, the review has identified in a number of cases data gaps for specific regions and some individual countries, in particular SIDS. More specifically, while conducting this literature review, the following knowledge and data gaps were identified:

- **Transport costs and food security**: there is a need for further research into the global impact of transport inefficiencies, particularly in low-income, landlocked, or maritime-dependent nations, and how this impact food security. In the absence of such broader sectoral background research, it will be difficult to precisely assess any direct impacts of increases in maritime transport costs on food prices, let alone on the four dimensions of food security.
- **Transmission of transport cost changes to domestic markets**: this matter is open to empirical questions:
    - who absorbs which share of the cost increase–exporters, importers, or shippers?
    - what is the relative importance of cost increases for commodities relative to agricultural inputs, with the latter supporting domestic food production and the former substituting for it?
    - how do cost increases in non-agricultural items impact indirectly on food security through lowering real incomes available for food expenditures?
    - data on small island economies remain particularly scarce.
- **Regional coverage**: existing studies examining links between maritime transport costs/freight rates and food security focus primarily on China and Africa, leaving in particular gaps in the interpretation of the interaction between oil prices, agricultural production costs, and food security in regions like Latin America, Oceania or Europe.
- **Transport decarbonization impacts**: few studies have investigated the direct impact of an increase of maritime transport costs resulting from regulatory measures and policies, in particular (GHG) emissions mitigation measures, on food price volatility in developing countries.
- **Localized impacts of maritime shocks and disruptions**: while a limited number of studies have addressed this issue, these mostly focused on global trade disruptions from recent shocks, and overlook how such disruptions impact smaller, trade-dependent economies.

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ANNEX 2

REPORT ON LIAISON WITH RELEVANT UN AGENCIES AND INTERNATIONAL ORGANIZATIONS ON THE IMPACT OF CHANGES IN MARITIME TRANSPORT COSTS RESULTING FROM GHG MITIGATION MEASURES ON FOOD SECURITY, AS ONE OF THE FACTORS INFLUENCING FOOD SECURITY

Background

1 Between October 2024 and January 2025, the Secretariat reached out to the following relevant UN Agencies and international organizations with regard to possible impacts of an increase in maritime transport costs on food security, as one of the factors influencing food security: Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD), UN Trade and Development (UNCTAD), United Nations Economic Commission for Africa (UN ECA), United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC), United Nations Economic and Social Commission for Western Asia (UN ESCWA), African Development Bank Group (AfDB), Inter-American Development Bank (IDB), International Grains Council (IGC), Organisation for Economic Co-operation and Development (OECD), World Food Programme (WFP), World Trade Organization (WTO), and World Bank (WB). A summary of this engagement is provided in paragraphs 3 to 23 below.

2 Most organizations contacted responded positively to the Secretariat's inquiry regarding possible exchanges on identifying the potential impacts of an increase in maritime transport costs on food security, as one of the factors influencing food security. The contacted organizations provided a total of 28 existing reports, studies and data sets considered relevant to the topic, which are summarized in annex 3. While expressing a general interest in the topic, and openness to possible (future) cooperation with IMO, none of the organizations contacted were in a position to conduct specific work or modelling to assess the potential impacts of the policy combinations of a basket of mid-term GHG reduction measures on food security within the timelines set by MEPC 82.

SUMMARY OF ENGAGEMENT WITH RELEVANT UN AGENCIES AND INTERNATIONAL ORGANIZATIONS

UN agencies

Food and Agriculture Organization of the United Nations (FAO)

3 In a letter to Dr. Qu Dongyu, Director-General of FAO, the Secretary-General requested that FAO provide any insights regarding any possible impacts on food security resulting from the future introduction of measures reducing the climate impact of global shipping.

4 An excerpt of FAO's response to this request is outlined below:

> The FAO recognizes the critical role that international shipping plays in global agri-food systems, particularly for net food-importing developing countries. Decarbonizing the maritime sector is essential to combating climate change; however, it is very important to ensure that this transition is implemented in a sustainable manner that should also minimize possible adverse impacts on global food security and nutrition.

Given the substantial proportion of global food trade transported via maritime routes, decarbonization of international shipping could have far-reaching implications for global food security. These impacts include: i) increased trade costs, as transitioning to decarbonized fuels may raise transportation costs; ii) supply chain adjustments, as reduced fleet speeds and other cost-saving measures may affect the efficiency and resilience of the transportation system; iii) resource market shifts, as the use of alternative fuels like ammonia could have ripple effects on energy and fertilizer markets, further raising products costs; and iv) potential heightened competition between biofuel production and agri-food systems, especially in the context of large-scale demand.

On the other hand, this transition might incentivize local food and biofuel production and foster the adoption of more sustainable agricultural practices.

It is essential to carefully analyse all systemic implications using sustainability measures to maximize the synergies and minimize the trade-offs between the decarbonatization of international shipping and global food security objectives.

5 In the intersessional period the Secretariat had several meetings/exchanges with FAO Secretariat representatives from the Markets and Trade Division, the Agri-food Economics and Policy Division, and the Office of Sustainable Development Goals, who provided valuable context and relevant information resources regarding the potential impacts of maritime transport costs on food security, based on FAO's areas of work.

6 Furthermore, the Secretariat met with the FAOs Director of the Office of Climate Change, Biodiversity and Environment in Baku, Azerbaijan, in the margins of COP 29, to discuss additional relevant information that FAO might have on the matter.

International Fund for Agricultural Development (IFAD)

7 The Secretariat had some exchanges with representatives from IFAD's External Relations Department as well as the IFAD Office of Technical Delivery. They informed the Secretariat that, at present, IFAD had no relevant studies on food security or the impact of increased maritime transport costs on food security.

UN Trade and Development (UNCTAD)

8 In the intersessional period, the Secretariat had several meetings/exchanges with representatives from the UNCTAD Secretariat Division for Africa, Least Developed Countries and Special Programmes, the Division on International Trade and Commodities and the Division on Technology and Logistics, as well as the UNCTAD Statistics Service, who provided relevant information resources regarding the potential impacts of maritime transport costs on food security, based on UNCTAD's areas of work.

9 UNCTAD informed the Secretariat that they were not in a position to conduct specific work or modelling within the timeline available, as it coincided with the preparation of several UNCTAD's flagship annual reports. They informed the Secretariat of their intention to start an assessment on the potential impacts of various disruptions affecting trade and international shipping on food security and agriculture, including on net-food-importing developing countries, in 2025, at their own initiative.

United Nations Economic Commission for Africa (UN ECA)

10 On 11 November 2025, the Secretary-General and the UN ECA Executive Secretary, Mr. Claver Gatete, met in Baku, Azerbaijan, in the margins of COP 29.

11 In the intersessional period, the Secretariat had several meetings/exchanges with representatives from the UN ECA Secretariat Climate Change, Food Security and Natural Resource Division, who informed the Secretariat that, at present, UN ECA was not in a position to conduct specific work on the topic.

United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP)

12 In November 2024, the Secretariat had an online meeting with representatives from the Transport Division of the UN ESCAP Secretariat, who informed the Secretariat that, to date, UN ESCAP has not published any study or analysis on the relationship between the impact on trade and food security, nor was planning to conduct specific work on the topic. UN ESCAP shared a report on sustainable maritime connectivity in the region.

United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC)

13 In November 2024, the Secretariat had an exchange with a representative from the International Trade and Integration Division of the UN ECLAC Secretariat, who informed the Secretariat that UN ECLAC is in the process of initiating a study to measure, among other things, the impact of transportation costs, connectivity and food security in the Caribbean.

United Nations Economic Commission and Social Commission Western Asia (UN ESCWA)

14 In November 2024, the Secretariat contacted a representative from the Climate Change and Natural Resources Sustainability Cluster of the UN ESCWA Secretariat to inquire about any relevant information on the potential impacts of an increase in maritime transport costs on food security from the future introduction of global GHG reduction measures for international shipping in the region. However, UN ESCWA did not provide any specific information on the matter.

International organizations

African Development Bank Group (AfDB)

15 In a letter to Dr. Akinwumi A. Adesina, President of the African Development Bank Group, the Secretary-General requested that AfDB provide any insights regarding any possible impacts on food security resulting from the future introduction of measures reducing the climate impact of global shipping and also extended an invitation to AfDB to participate in GHG-EW 6.

16 In the intersessional period, the Secretariat had several correspondence exchanges with representatives from the Vice Presidency for Agriculture, Human and Social Development, to inquire about any relevant information on the potential impacts of an increase in maritime transport costs on food security from the future introduction of global GHG reduction measures for international shipping. However, the Bank did not share any specific information on the subject matter.

Inter-American Development Bank Group (IDB)

17 In November 2024, the Secretariat had an online meeting and several exchanges with representatives from the Transport Division of IDB, who informed the Secretariat that, at present, they had not carried out any analytical work on the potential impact on food security from the entry into force of climate measures in the area of international shipping.

18 IDB did share relevant publications and information resources related to food security in the Latin America and Caribbean region, including disruptions caused by shocks in the supply chain within the region.

International Grains Council (IGC)

19 In the intersessional period, the Secretariat had various exchanges with the IGC Secretariat, including its Executive Director, Mr. Arnaud Petit, who provided several detailed information resources on trade data and price fluctuations for grains and wheats imports and exports.

Organisation for Economic Co-operation and Development (OECD)

20 In October 2024, the Secretariat had an online meeting with a representative from the Agricultural and Trade Directorate of the OECD Secretariat regarding a study on maritime transportation costs in the grains and oilseeds sector who provided relevant information resources regarding the relation between maritime transport costs and food security.

World Trade Organization (WTO)

21 In the margins of UNCTAD's 11th session of the Multi-year Expert Meeting on Transport, Trade Logistics and Trade Facilitation (23 to 24 October 2024), the Secretariat met with representatives from WTO to discuss IMO's ongoing work to assess the potential impacts of increased maritime transport costs resulting from GHG reduction measures in international shipping on food security. The Ministerial Declaration on the emergency response to food insecurity as one of the outcomes of WTO 12th Ministerial Conference (MC 12) is included in annex 3.

World Bank Group

22 In November 2024, the Secretariat had an online meeting with representatives from the World Bank's Transport Global Unit, who provided valuable context regarding transport and food security, notably in Africa, based on the Bank's areas of work. These representatives also informed the Secretariat about the preparation of a series of studies for the African region on this topic, using two types of models and various datasets from UN agencies, including FAO.

World Food Programme

23 Between November 2024 and December 2024, the Secretariat has exchanged correspondence with representatives of the Ocean Transport Service (SCDS), World Food Programme Supply Chain and Delivery Division. No specific data that directly links food security to an increase in maritime transport costs was available within the World Food Programme at the time of this exchange.

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ANNEX 3

KEY MESSAGES FROM RELEVANT INFORMATION RESOURCES PROVIDED BY RELEVANT UN AGENCIES AND INTERNATIONAL ORGANIZATIONS

Contents

Abbreviations

C&F	Cost and Freight
FAO	Food and Agriculture Organization of the United Nations
FIB	Food Import Bill
FOB	Free on board
GHG	Greenhouse gas
IDB	Inter-American Development Bank
IFAD	International Fund for Agricultural Development
IGC	International Grains Council
IMO	International Maritime Organization
LDC	Least developed country
NFIDC	Net-food importing developing country
OECD	Organisation for Economic Co-operation and Development
SIDS	Small island developing states
UN ECA	United Nations Economic Commission for Africa
UN ECLAC	United Nations Economic Commission for Latin America and the Caribbean
UN ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNCTAD	UN Trade and Development
UN GCRG	United Nations Global Crisis Response Group
WB	World Bank
WTO	World Trade Organisation

1. Background

This report contains a summary of information abstracted from publications by a number of UN agencies and international organizations, with relevance for assessing the potential impacts on food security of changes in maritime transport costs resulting from GHG mitigation measures, as one of the factors influencing food security.

The selected publications and abstracted information therein focus, inter alia, on essential food commodities, key agricultural inputs, maritime transport, trade development, and disruptions to global supply chains. The report also abstracted relevant information on impacts on food security induced by geopolitical disruptions, the COVID-19 pandemic, and climate change and environmental impacts with a view to providing a context for assessing how increases in maritime transport costs – resulting from the implementation of the mid-term GHG reduction measures – could impact food security as one of the determining factors.

This report covers publications issued between 2020 and 2024 by relevant UN agencies and international organizations, providing some insights into the magnitude of maritime transport cost and freight rate increases resulting from past events and their subsequent impacts on food security.

Abstracted, summarized information focuses primarily on global impacts, as well as those affecting net-food importing developing countries (NFIDCs), Least Developed Countries (LDCs), and Small Islands Developing States (SIDS).

The selection of relevant publications is non-exhaustive, and should not be interpreted as suggesting or recommending any policy options on how the IMO mid-term GHG reduction measures should be designed. The abstracted texts are verbatim from the original publications. The full publications can be found using the list source and page references.

2. Summary of relevant publications

Table 1 below provides an overview of selected publications and their relevance according to the following key criteria:

1. Essential food commodities;
2. Key agricultural input;
3. Maritime transport, trade developments and disruptions to global supply chains general;
4. Food security in general terms;
5. Food security in the context of geopolitical disruptions;
6. Food security in the context of the COVID-19 pandemic; and
7. Food security in the context of climate change and environment related impacts.

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Table 1: Summary of relevant publications on foods security according to specific criteria

UN Agency or international organization	Title of information source	Essential food commodities	Key agricultural input	Maritime transport, trade developments and disruptions to global supply chains	Food security in general terms	Food security in the context of geopolitical disruptions	Food security in the context of the COVID-19 pandemic	Food security in the context of climate change and environment related impacts
FAO	Food Outlook – Biannual report on global food markets	x		x	x			
FAO	The State of Food and Agriculture 2023 – Revealing the true cost of food to transform agrifood systems	x	x		x			
FAO	Achieving SDG 2 without breaching the 1.5 °C threshold: A global roadmap	x			x			x
FAO	The Impact of Disasters on Agriculture and Food Security 2023 – Avoiding and reducing losses through investment in resilience.	x	x		x			x
FAO	Food Outlook – Dynamic effects of shocks to shipping costs on the food import bill	x		x	x			
UN	The Impact of COVID-19 on Food Security and Nutrition	x					x	
UN ESCAP	Sustainable maritime connectivity in Asia and the Pacific 2023-2024.			x				x
UN Food Systems Hub	Building Africa's Food Sovereignty and Resilience through Sustainable Investments.	x			x			
UNCTAD	Towards a new trade agenda for the right to food.	x		x				
UNCTAD	Review of Maritime Transport 2021	x		x				
UNCTAD	Review of Maritime Transport 2022	x		x		x	x	

UN Agency or international organization	Title of information source	Essential food commodities	Key agricultural input	Maritime transport, trade developments and disruptions to global supply chains	Food security in general terms	Food security in the context of geopolitical disruptions	Food security in the context of the COVID-19 pandemic	Food security in the context of climate change and environment related impacts
UNCTAD	Review of Maritime Transport 2023	x		x				
UNCTAD	Review of Maritime Transport 2024	x		x		x		x
UNCTAD	The impact on trade and development of the war in Ukraine	x	x	x		x		
UNCTAD	Food security in LDCs: from crises to resilience?	x						
UNCTAD	A Trade Hope - The Impact of the Black Sea Grain Initiative	x	x	x		x		
UNCTAD	Maritime transport in times of polycrisis	x		x		x	x	x
UN GCRG	Global impact of the war in Ukraine: Energy crisis.	x		x		x		
AMIS Secretariat	Agricultural Market Information System.	x	x	x				
CCSA	How COVID-19 is changing the world: a statistical perspective			x			x	
IDB	The trade fallout of the war in Ukraine on Latin America and the Caribbean	x	x	x		x		
IFAD	The role of trade and policies in improving food security	x		x	x			
IGC	Grains Trade Perspectives	x	x	x		x		
IGC & WTO	Wheat maritime trade & food security dashboard.	x		x	x			
IGC	Share of fuel in total dry bulk freight costs for various commodities (wheat/durum, soyabeans, sorghums, maize and barley) and various	x		x				

UN Agency or international organization	Title of information source	Essential food commodities	Key agricultural input	Maritime transport, trade developments and disruptions to global supply chains	Food security in general terms	Food security in the context of geopolitical disruptions	Food security in the context of the COVID-19 pandemic	Food security in the context of climate change and environment related impacts
	routes based on the latest IGC freight rates							
OECD	Maritime Transportation Costs in the Grains and Oilseeds Sector: Trends, Determinants and Network Analysis	x		x	x	x		
SDG Pulse	International trade in open and transparent markets may help alleviate the effects of shocks and ensure food security	x		x	x			
WTO	Ministerial Declaration on the emergency response to food insecurity	x	x		x			

3. Key messages

3.1 FAO - Food Outlook – Biannual report on global food markets

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport; trade developments and disruptions to global supply chains; and food security in general terms
Date of publication	November 2023
Type of information source	Biannual report (104 pages)
Period under review	2021-2023
Relevance	The report forecasts positive outlook for food production and discusses trends in indicators such as ocean freights and food import bills
Source	FAO (2023). *Food Outlook – Biannual report on global food markets*. Rome. Retrieved 18 December 2024, from https://doi.org/10.4060/cc8589en

Short summary

The Food Outlook report is a product of the FAO Markets and Trade Division of the Economic and Social Development stream and is published twice a year, normally in June and November. It provides detailed and summary assessments of food markets with focus on wheat, coarse grains, rice, meat, sugar, fisheries, dairy and oil crops while commenting on how market indicators such as freight and food import bills relate to these food markets.

Global impact

- FAO's forecasts point to favourable production outlooks across most basic foodstuffs. However, global food production systems remain vulnerable to risks from extreme weather events, rising geopolitical tensions and policy changes, potentially tipping the delicate demand-supply balances and dampening prospects for international trade in food commodities and global food security (p. xii).
- Although the outlook for the dry bulk freight market is clouded by lingering fears of global economic recession and ongoing hostilities in parts of the world, some shipping industry analysts express cautious optimism about near-term prospects for the sector (p. 81).
- Aside from hopes for continued economic growth in China and India – the world's major importers of dry bulk commodities – positive outlooks also cite supportive supply-side fundamentals (p. 81).
- The report suggests that, according to private forecasts, the demand for dry bulk carriers is set to outpace the expansion in available tonnage in the year ahead, with the emissions-related requirements of the International Maritime Organization (IMO) seen as capping investment in new vessels, while also leading to slower bulker speeds and additional compliance costs (p. 81).

Impact on net food importing developing countries

- Food inflation accelerated in January and February 2023, before falling steadily in the following four months up to June 2023, then rising to 2.1 percent in July 2023, accelerated in January and February 2023, before falling steadily in the following four months up to June 2023, then (p.86).

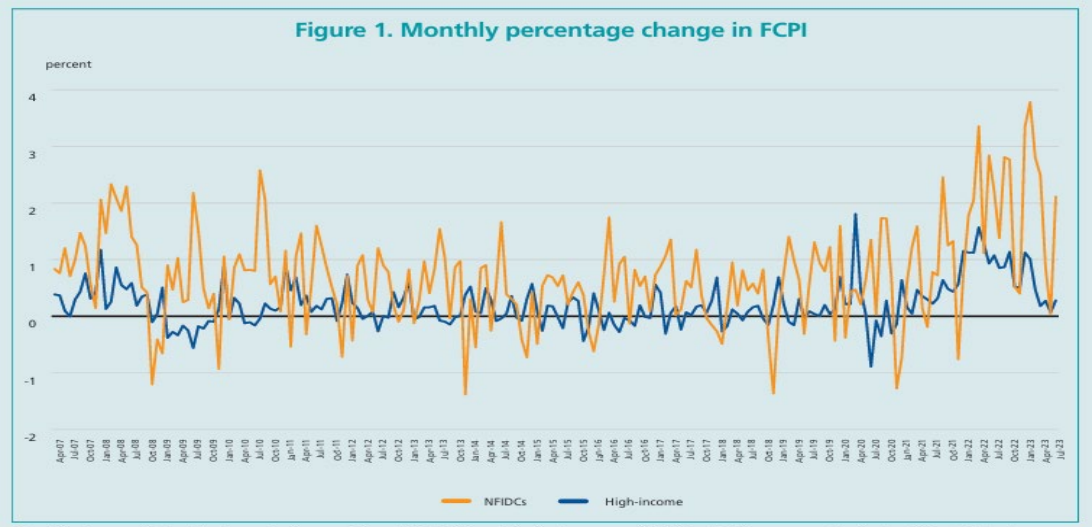


Figure 1 illustrating change in monthly Food Consumer Price Index (FCPI) compared across NFIDCs and high-income states (p. 86)

Impact on least developed countries

- Other factors that reduce the ability to pay for food imports, especially in low-income countries, include limited financial resources, mounting debt levels, high freight costs and insurance premiums, contractions in domestic economic activity and falling foreign exchange reserves (p. 83).

Impact on small island developing states

Not specified.

3.2 FAO - The State of Food and Agriculture 2023. Revealing the true cost of food to transform agrifood systems

Area	Main relevant findings
Main topic	Essential food commodities; key agricultural input; and food security in general terms
Date of publication	2023
Type of information source	Annual report (150 pages)
Period under review	2023
Relevance	The report emphasizes the importance of conducing targeted agrifood systems assessments, noting that quantified hidden costs present a greater burden relative to national income in low-income countries
Source	FAO (2023). *The State of Food and Agriculture 2023 – Revealing the true cost of food to transform agrifood systems*. Rome: Food and Agriculture Organization of the United Nations. Retrieved 15 December 2024, from https://openknowledge.fao.org/server/api/core/bitstreams/5aac5078-625d-4b94-b964-bea40493016c/content

Short summary

The State of Food and Agriculture 2023 was prepared by a multidisciplinary team from the FAO. The report looks into the true cost for sustainable agrifood systems, introducing the concept of hidden environmental, social and health costs. It proposes "true cost accounting" (TCA) to assess these impacts, underscores the need to integrate hidden costs into decision-making, and highlights the importance of data innovation, investment, and capacity building, particularly in low- and middle-income countries, to support effective policymaking.

Global impact

- This report estimates the expected value of the global hidden costs of agrifood systems in 2020 – from GHG and nitrogen emissions, water use, land-use change, unhealthy dietary patterns, undernourishment and poverty – at 12.7 trillion 2020 PPP dollars. This value is almost 10 percent of global GDP PPP in 2020. Per day, these costs are equivalent to 35 billion 2020 PPP dollars. As likewise evidenced by previous analyses, these results point to the alarming environmental, social and health consequences our agrifood systems impose on society and call for urgent transformation towards sustainability across all dimensions (p. 32).
- True cost accounting (TCA) is a fitting approach for conducting targeted agrifood systems assessments, for example, of dietary patterns, investments, organizations and products. The chosen unit of analysis will depend on the actor(s) for whom the results are most relevant (p. 49).
- Any agrifood systems intervention or management option can involve trade-offs and synergies, including between environmental and economic impacts. Targeted TCA assessments can help identify and manage them, thus aiding governments, businesses and other stakeholders to make more responsible decisions to improve sustainability (p. 49).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- The quantified hidden costs pose a greater burden relative to national income in low-income countries, where they are equivalent, on average, to 27 percent of GDP (in large part due to poverty and undernourishment), compared with 11 percent in middle-income countries and 8 percent in high-income countries. Addressing poverty and undernourishment remains a priority in low-income countries (p. 21).
- Low-income countries present mainly social hidden costs (see Figures 7 and Figure 8) in the form of poverty and productivity losses from undernourishment. This is especially true for countries such as Madagascar, the Niger and Uganda. However, other hidden costs can emerge in these countries, such as climate change-related costs in the Democratic Republic of the Congo (likely due to deforestation) and diet-related costs in Afghanistan and Nepal. In Ethiopia, multiple environmental concerns, such as climate change, land-related ecosystem service costs and nitrogen emissions, collectively contribute to hidden costs. In low-income countries, the priority might be for policies and investments that improve livelihoods, while acknowledging that, as these countries develop, productivity losses from changing diets are likely to increase, as seen in higher-income country groups (p. 40).

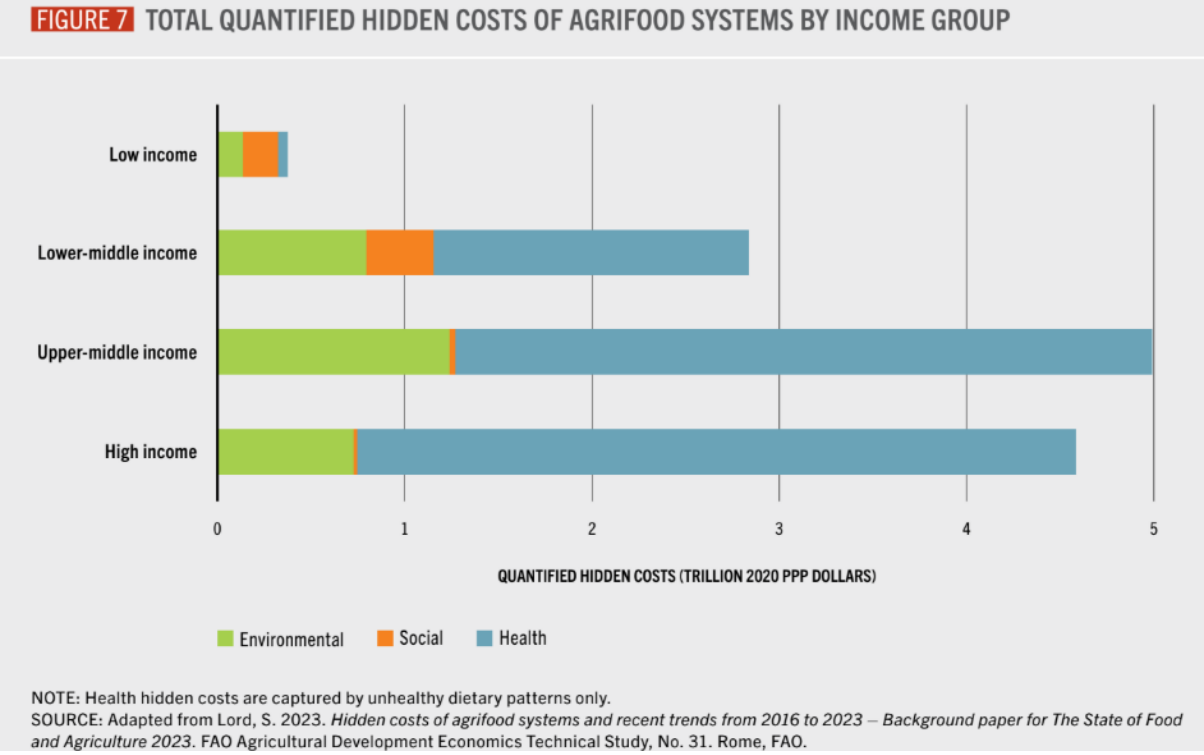
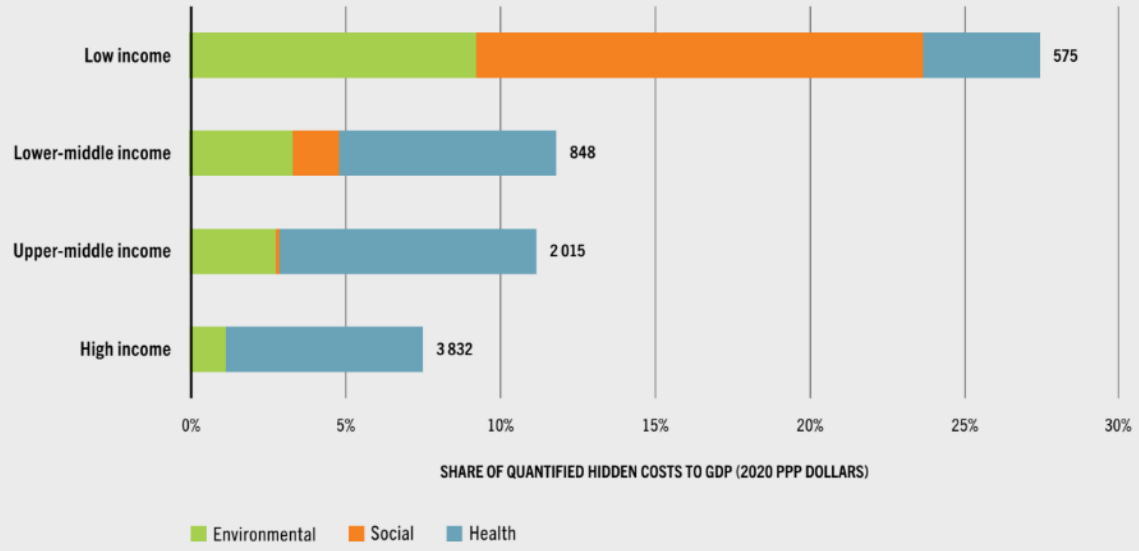


Figure 7 illustrating the total quantified hidden costs of agrifood systems by income group (p. 37)

FIGURE 8 SHARE OF QUANTIFIED HIDDEN COSTS OF AGRIFOOD SYSTEMS TO GDP BY INCOME GROUP (HIDDEN COSTS PER CAPITA ON THE RIGHT-HAND SIDE)



NOTE: Health hidden costs are captured by unhealthy dietary patterns only.
SOURCE: Adapted from Lord, S. 2023. *Hidden costs of agrifood systems and recent trends from 2016 to 2023 – Background paper for The State of Food and Agriculture 2023*. FAO Agricultural Development Economics Technical Study, No. 31. Rome, FAO.

Figure 8 illustrating the share of quantified hidden costs of agrifood systems to GDP by income group (hidden costs per capita on the right-hand side) (p. 37)

Impact on small island developing states

Not specified.

3.3 FAO - Achieving SDG 2 without breaching the 1.5 °C threshold: A global roadmap

Area	Main relevant findings
Main topic	Essential food commodities; food security in general terms; food security in the context of climate change and environment related impacts
Date of publication	2023
Type of information source	Booklet (50 pages)
Period under review	2023
Relevance	The report highlights the importance of aligning agrifood transformation with other sectors, such as energy and transportation
Source	FAO (2023). *Achieving SDG 2 without breaching the 1.5 °C threshold: A global roadmap, Part 1 – How agrifood systems transformation through accelerated climate actions will help achieving food security and nutrition, today and tomorrow, In brief.* Rome: FAO. Retrieved 19 December 2024, from https://doi.org/10.4060/cc9113en

Short summary

In 2022, nearly 738 million people faced hunger, 2.4 billion lacked access to adequate food, and over 3.1 billion couldn't afford healthy diets. Agrifood systems, responsible for 30% of global GHG emissions, contribute to climate change, creating a dilemma between increasing productivity and meeting climate goals. FAO's Global Roadmap aims to achieve SDG 2 (zero hunger) without exceeding the 1.5°C climate target. Starting with COP 28 in 2023, the roadmap will explore financing, investment, and technical assistance to support sustainable agrifood systems. The "In Brief" booklet version of the roadmap outlines key messages for policymakers and the public.

Global impact

- This 2023 report emphasizes existing efforts and climate commitments, detailing an integrated approach for a just transition, outlining food security, nutrition objectives and their emission implications. Additionally, it introduces ten domains of actions and 20 key milestones. This process highlights FAO's comprehensive strategy to address agrifood systems' challenges, striving for impactful global change while considering local nuances and collective action (p. 2).
- Transformation of agrifood systems alone can't ensure the 1.5 °C goal; fossil fuels remain the primary climate contributor and demand serious attention. Aligning agrifood transformation with other sectors like energy and transportation can mitigate climate impacts while improving food access, especially for the impoverished (p. 4).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.4 FAO - The Impact of Disasters on Agriculture and Food Security 2023 – Avoiding and reducing losses through investment in resilience

Area	Main relevant findings
Main topic	Essential food commodities; key agricultural input; food security in general terms; and food security in the context of climate change and environment related impacts
Date of publication	2023
Type of information source	Book (168 pages)
Period under review	Last 3 decades
Relevance	The book it discusses the trillions of dollars in agricultural production losses over the past three decades and highlights strategies for building resilience
Source	FAO (2023). *The Impact of Disasters on Agriculture and Food Security 2023 – Avoiding and reducing losses through investment in resilience*. Rome: FAO. Retrieved 27 December 2024, from https://doi.org/10.4060/cc7900en

Short summary

This book published by FAO presents evidence on the global impact of disasters on agriculture and food security over the last three decades. It estimates agricultural production losses over the past three decades and explores the risks that make agriculture vulnerable, including climate change, pandemics, epidemics, and armed conflicts. The book highlights strategies for building resilience, integrating disaster risk management into agricultural practices and policies, and calls for a deeper understanding of the context in which these solutions are applied.

Global impact

- Defined as serious disruptions to the functioning of a community or society, disasters are producing unprecedented levels of damage and loss in agriculture around the world. Their increasing severity and frequency, from 100 per year in the 1970s to around 400 events per year in the past 20 years, affect agrifood systems across multiple dimensions, compromising food security and undermining the sustainability of the agriculture sector (p. xii).
- Over the last 30 years, an estimated USD 3.8 trillion worth of crops and livestock production has been lost due to disaster events, corresponding to an average loss of USD 123 billion per year, or 5 percent of annual global agricultural GDP. In relative terms, the total amount of losses over 30 years is approximately equivalent to Brazil's GDP in 2022 (p. xii).
- Understanding interconnected and systemic risks and underlying disaster risk drivers is essential to build resilient agrifood systems. Climate change, pandemics, epidemics and armed conflict are all affecting agricultural production, value chains and food security. Therefore, gaining a better understanding of their interactions is essential for developing a comprehensive view of today’s risk landscape (p. xiii).

- Urgent action is needed to prioritize the integration of multisectoral and multi-hazard disaster risk reduction strategies into agricultural policies and programmes. This can be achieved by enhancing the available evidence, fostering the adoption of available innovations, facilitating the creation of more scalable farm-level risk management solutions, and strengthening early warning systems that lead to anticipatory action (p. xiii).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- Food supply chains may function during long-term, protracted conflicts, such as in Yemen, where food importers on all sides have adopted dynamic operational methods in a complex and politicized environment. However, this kind of functionality comes at a cost. For instance, food prices in Yemen doubled between 2015 and 2019, and have continued to rise since (p. 75).

Impact on small island developing states

- Over the last 30 years, disasters inflicted the highest relative losses on lower- and lower-middle-income countries, ranging between 10 and 15 percent of their total agricultural GDP, respectively. Disasters also had a significant impact on Small Island Developing States (SIDS), causing them to lose nearly 7 percent of their agricultural GDP (p. xii).

3.5 FAO - Food Outlook – Dynamic effects of shocks to shipping costs on the food import bill

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; and food security in general terms
Date of publication	June 2024
Type of information source	Food outlook – Special Feature (6 pages)
Period under review	2024
Relevance	This article is of major relevance to the scope as it assesses the impacts on global food import bill arising out of dynamic effects of shocks to shipping costs
Source	FAO (2024). *Food Outlook – Dynamic effects of shocks to shipping costs on the food import bill*. Rome. Retrieved 12 December 2024, from https://openknowledge.fao.org/server/api/core/bitstreams/26a354f4-ada9-474a-aae6-0e491744fba7/content

Short summary

This feature article examines the impact of rising shipping costs on food import bills (FIB), with a focus on net food importing developing countries (NFIDCs). It investigates how food import dependency influences their response to changes in maritime transportation costs.

Global impact

- This feature article aims to examine the dynamic effects of shocks to shipping costs and focuses on the impact on the FIB due to changes in ocean freight rates in the short term, i.e. relying on data sampled monthly (p. 71).
- The analysis distinguishes between modes of maritime transportation - dry bulk and container - and examines how these shocks affect net food-importing developing countries (NFIDCs) (p. 71).
- The cumulative effect of a 1 percent shock to the Baltic Dry Index reaches its maximum level of 0.12 percent after thirteen months before reverting towards zero. By contrast, in the right panel, the cumulative effect of a 1 percent increase in the Harpex Index peaks at 0.34 percent after 12 months. More than half of the changes in the FIB occur within the first six months from the shocks, emphasizing the need for policymakers to focus on short-term effects due to the fast propagation of trade disruptions across maritime transportation routes (p. 72).
- The results suggest that the import demand for food and agricultural goods does not, at least in the short run, react enough to the price shocks that are induced by changes in the shipping costs. The increase in the overall expenditures triggered by higher import prices is not compensated by the reduction in traded volumes, highlighting the relative inelastic nature of food demand (p. 72).

- The results also mean that, following an increase in shipping costs due to a shock, countries spend more on food supplies from the global market, at least in the short run (pp. 72-73).

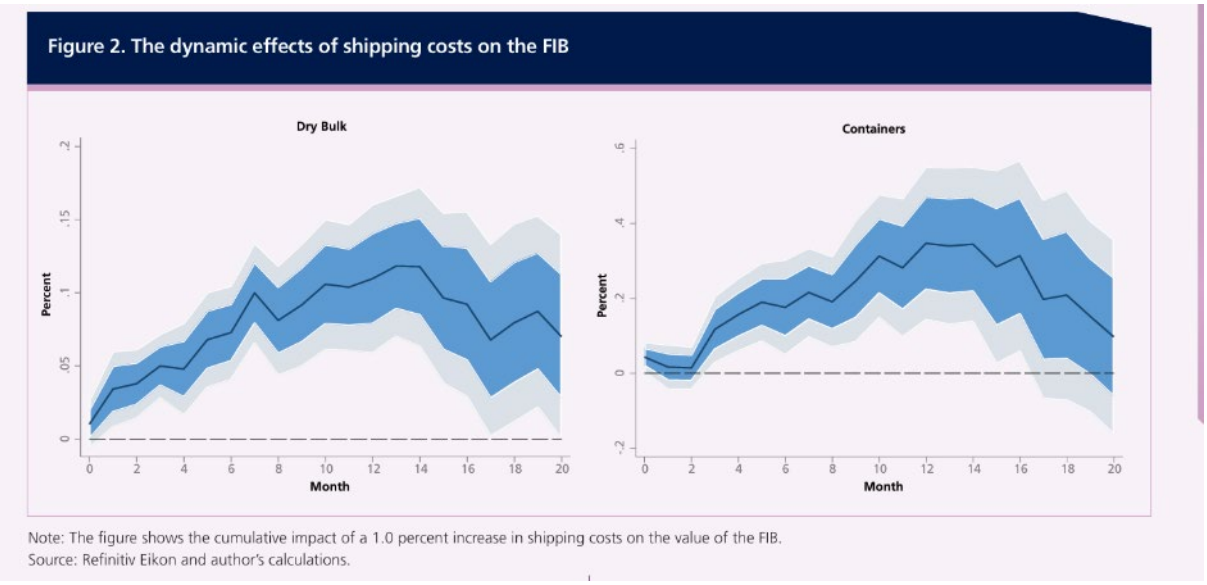


Figure 2 illustrating the cumulative impact of a 1 percent increase in shipping costs on the total value of the FIB (p. 72)

<u>Impact on net food importing developing countries</u>

- For dry bulk costs, there are no substantial differences between the NFIDCs' cumulative response (solid red line) and the baseline estimate using the full dataset (dashed blue line). Conversely, a 1 percent shock to container shipping costs increases the NFIDCs' food import bill by 0.43 percent after 12 months, with over half of the total cumulative effect occurring in just three months (p. 73).
- These results can be explained by three factors. First, food and agricultural products in NFIDCs are necessities with a few substitutes (Adam, 2011), making the reactions to import price shocks more inelastic in the short run compared to the full sample of countries. Second, NFIDCs have high trade imbalances and need to compensate backhaul problems with liner shipping companies (Rojon et al., 2021), which exacerbates the effect of the shock on container costs. Third, importing agrifood products by sea is relatively more costly for NFIDCs than for other countries, as the transport costs represent a higher share of the FIB for these countries (OECD, 2022). They also pay more due to geographic and economic remoteness (Korinek and Sourdin, 2010) (p. 73).
- NFIDCs are physically more distant from major exporters, served by fewer shipping routes, and marginalized by the global shipping network (Rojon et al., 2021; Fugazza and Hoffmann, 2017) (p. 73).

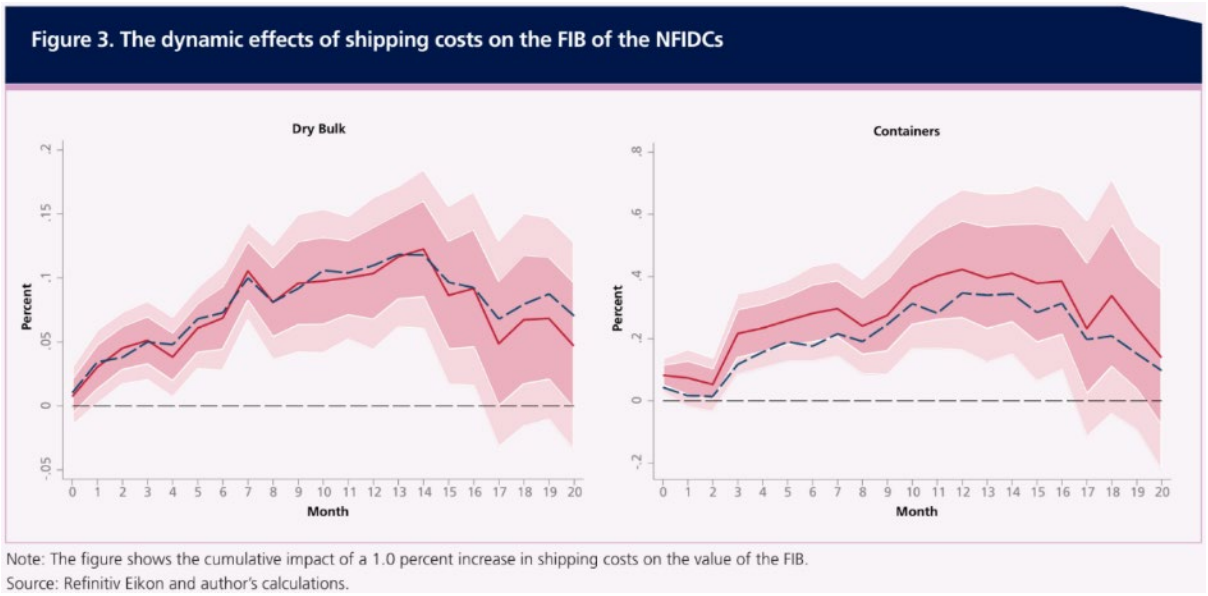


Figure 3 illustrating the dynamic effects of shipping costs on the FIB of the NFIDCs (p. 73)

- Since not all shocks are the same, national authorities must consider the extent of increases to dry bulk and container transportation costs. Countries highly dependent on container shipping for their imports are more vulnerable to cost increases. This vulnerability is even higher for NFIDCs, making it essential for these countries to address transportation shocks (p. 74).

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.6 UN - The impact of COVID-19 on food security and nutrition

Area	Main relevant findings
Main topic	Essential food commodities; and food security in the context of the COVID-19 pandemic
Date of publication	June 2020
Type of information source	Policy brief (23 pages)
Period under review	2020
Relevance	The policy brief outlines the UN's 2020 assessment of the COVID-19 pandemic's potential impact on food security, emphasizing pre-existing challenges and the need for urgent action to prevent a global food emergency
Source	United Nations (2022). *Policy Brief: The Impact of COVID-19 on Food Security and Nutrition*. UN. Retrieved 16 January 2025, from https://unsdg.un.org/sites/default/files/2020-06/SG-Policy-Brief-on-COVID-Impact-on-Food-Security.pdf

Short summary

This policy brief summarizes the UN's assessment in 2020 of the possible impact of the COVID-19 pandemic on food security and nutrition. It highlights the pre-existing challenges of large populations already living with food crises before the pandemic and calls for urgent actions to prevent a global food emergency. It stresses the importance of, among other factors, food supply chains in building resilience and achieving the SDGs.

Global impact

- The COVID-19 pandemic is a health and human crisis threatening the food security and nutrition of millions of people around the world. Hundreds of millions of people were already suffering from hunger and malnutrition before the virus hit and, unless immediate action is taken, we could see a global food emergency (p. 2).
- Prior to the onset of this pandemic, more than 820 million people were already identified as chronically food insecure. The latest data shows that the food security of 135 million people was categorised as crisis level or worse (pp. 2-3).
- Deep global economic shocks caused by COVID-19 will impact the cash flow and financial liquidity of producers, small and medium agribusinesses to financial institutions, due to inhibited production capacity, limited market access, loss of remittances, lack of employment, and unexpected medical costs (p. 4).
- Ensuring humanitarian access and establishing common humanitarian services, including aviation, shipping, storage and transport, as well as engineering services in areas affected by the pandemic (p. 15).

FIGURE 6: THE ENTIRE FOOD SYSTEM IS CRUCIAL FOR BUILDING RESILIENCE AND DELIVERING ON THE SDGS

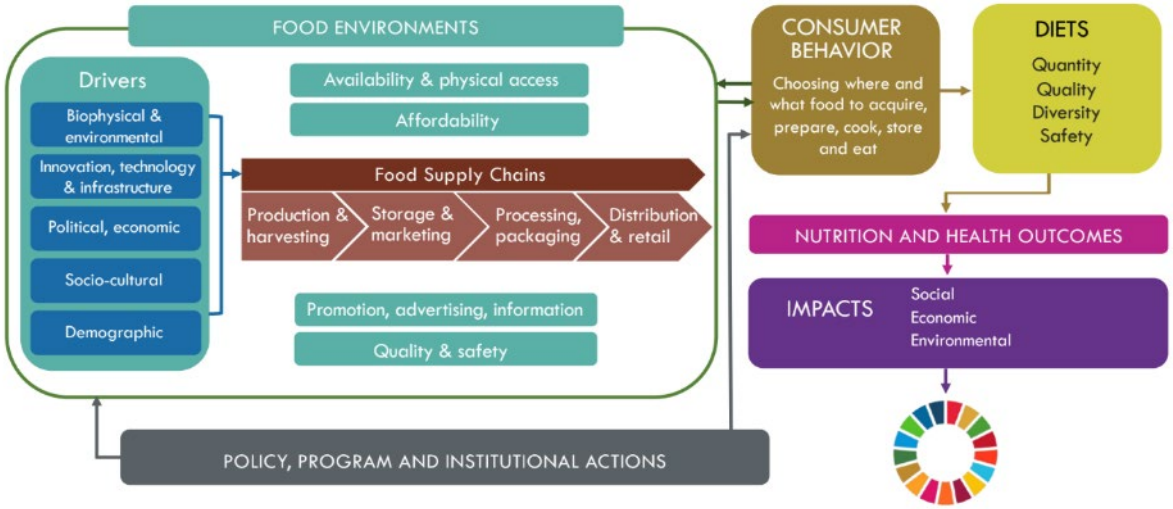


Figure 6 illustrating that the entire food system is crucial for building resilience and delivering the SDGs (p. 22)

- Food systems need to be transformed to work better with nature and for the climate (p. 22).

<u>Impact on net food importing developing countries</u>
Not specified.

<u>Impact on least developed countries</u>
Not specified.

<u>Impact on small island developing states</u>
Not specified.

3.7 UN ESCAP - Sustainable maritime connectivity in Asia and the Pacific 2023-2024

Area	Main relevant findings
Main topic	Maritime transport, trade developments and disruptions to global supply chains
Date of publication	September 2024
Type of information source	Report (250 pages)
Period under review	2023 - 2024
Relevance	This paper discusses the potential impact of higher maritime transport costs on economies in the Asia-Pacific region
Source	United Nations Economic and Social Commission for Asia and the Pacific. (2024). *Sustainable maritime connectivity in Asia and the Pacific 2023-2024*. Retrieved 20 January 2025, from https://repository.unescap.org/handle/20.500.12870/7414?locale-attribute=es

Short summary

This report provides detailed analysis of the current state of maritime connectivity in the Asia-Pacific region and proposes initiatives such as green shipping corridors to promote sustainable and resilient practices for the maritime sector.

Global impact

- Meanwhile, the imperative to comply with green regulations and adopt eco-friendly technologies in the shipping and ports sector may exacerbate the technological and economic disparities among developing countries. The global push for decarbonization in shipping could potentially lead to heightened logistics costs, impacting developing nations to a greater extent (p. 76).
- According to simulations by the United Nations Conference on Trade and Development (UNCTAD), a 10%, 30%, and 50% increase in shipping logistics costs could result in a reduction of global GDP by 0.01%, 0.04%, and 0.08%, respectively. In terms of 2022 values, a 0.08% reduction translates to an approximate $80 billion decrease in global GDP (p. 76).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- This burden[1] is particularly pronounced for Small Island Developing States (SIDS) and least developed countries, given their heavy reliance on maritime transportation.

[1] Refers to a 10 per cent, 30 per cent, and 50 per cent increase in shipping logistics costs, as referred in p. 76.

These nations may encounter additional economic challenges, further exacerbating their difficulties (p. 76).

Impact on small island developing states

Please refer to the information provided above.

3.8 UN Food Systems Hub - Building Africa's Food Sovereignty and Resilience through Sustainable Investments

Area	Main relevant findings
Main topic	Essential food commodities; and food security in general terms
Date of publication	June 2023
Type of information source	Policy paper (42 pages)
Period under review	Not specified
Relevance	The policy paper mentions the megatrends shaping food systems in Africa and provides options to consider regarding value chains, infrastructure, and essential food commodities to achieve Africa's agri-food systems transformation
Source	United Nations Interdepartmental Task Force on African Affairs (2023). *Building Africa's Food Sovereignty and Resilience through Sustainable Investments*. Retrieved 24 December 2024, from *https://www.unfoodsystemshub.org/docs/unfoodsystemslibraries/stocktaking-moment/unfss-2-special-sessions/idtfaa---africa-special-session---un-food-systems-summit-2---policy-paper.pdf?sfvrsn=e19159a_3*

Short summary

The policy paper is an outcome of the consultations and meetings organized by the United Nations Interdepartmental Task Force on African Affairs in 2023 aimed at finding ways to unlock capital and investments needed to finance Africa's agri-food systems transformation. The policy paper concludes with strategic policy options to implement the African Common Position on Food Systems, supported by the 2030 Agenda for Sustainable Development and the African Union Agenda 2063.

Global impact

- Our analysis of the food system compacts submitted by forty African Member States suggests that about US$76 billion in annual investments throughout the value chains will be required in response (p. 13).
- The infrastructure gap impedes Africa's agri-food systems transformation. The Programme for Infrastructure Development in Africa (PIDA) estimates the continent's large infrastructure deficit is holding it back. The road access rate in Africa is only 34%, compared with 50% in other parts of the developing world, while transport costs are 100% higher (p. 19).
- Africa, more than any region in the world, must act with urgency on its agri-food systems: It has the highest prevalence of hungry people. In 2021, more than one-third of African people faced hunger. A fifth of the African population (278 million) is malnourished (pp. 19-20).
- The critical challenge of funding the agriculture sector depends on addressing existing investor risks that affect the financing costs and competitiveness of the agri-food systems value chain (infrastructure, renewable energy, transport, irrigation systems,

etc.) in African countries. More public instruments must be developed to mitigate these investor risks (p. 26).

Impact on net food importing developing countries

- The challenges arising from continually fluctuating commodities prices and Africa's limited value addition to its natural resources render Africa vulnerable to the external shocks derived from export dependency and therefore necessitate a holistic rethinking and an innovative approach to the question of how Africa's commodities wealth can drive the continent's development (p. 18).

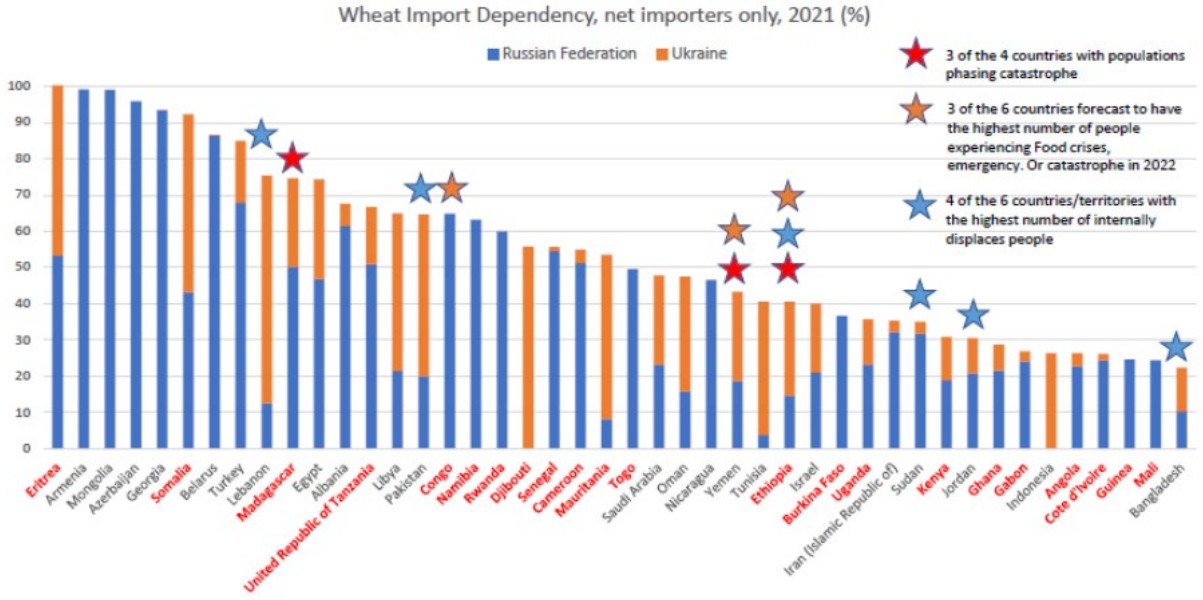


Figure 8: Wheat import dependencies| FAO - Max Torero, Chief Economist 2023

Figure 8 illustrating wheat import dependencies in NFIDCs in Africa such as Cote D'Ivoire, Egypt, Gabon, Kenya, Namibia, Senegal and Tunisia (p. 19).

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.9 UNCTAD - Towards a new trade agenda for the right to food

Area	Main relevant findings
Main topic	Essential food commodities; and maritime transport, trade developments and disruptions to global supply chains
Date of publication	March 2021
Type of information source	Policy brief (4 pages)
Period under review	2021
Relevance	The policy brief offers insights into global trade dynamics that affect food security, particularly for net food importing developing countries
Source	UN Trade and Development (2021). *Towards a new trade agenda for the right to food*. UNCTAD. Retrieved 11 January 2025, from https://unctad.org/system/files/official-document/presspb2021d1_en.pdf

Short summary

This policy brief examines whether the World Trade Organization's Agreement on Agriculture should be wound down and offers policy recommendations for an effective and balanced reform of the Agreement, aimed at better aligning trade policy with food security objectives and the needs of developing countries.

Global impact

- Access to food is a fundamental human right. Trade plays a key role in food security but an excessive exposure to global markets also increases risks (p. 1).
- Estimates from the FAO suggest that in 2018, before the onset of the pandemic, the prevalence of severe food insecurity in the population was as high as 20 per cent in sub Saharan Africa and 17 per cent in South Asia, followed by 10 per cent in the Middle East and North Africa, 9 per cent in Latin America and the Caribbean and 3 per cent in East Asia and the Pacific (p. 2).

Impact on net food importing developing countries

- Since 1995, food imports per capita in net food importing developing countries have increased by 300 per cent and, in low-income food-deficit countries, by over 500 per cent. In 2019, only four of 12 developing regions registered a positive net balance in basic food trade (see figure). In Africa, agricultural production is insufficient to meet food security needs and, in 2016-2018, about 85 per cent of food was imported from outside the continent. Combined with rapid population growth, net food imports in Africa are expected to triple by 2025 and undernourishment is projected to increase by one third. In the Caribbean, the ratio of food trade deficit to total merchandise exports increased from 5 per cent in 1995 to a high of 32 per cent in 2019 (p. 2).

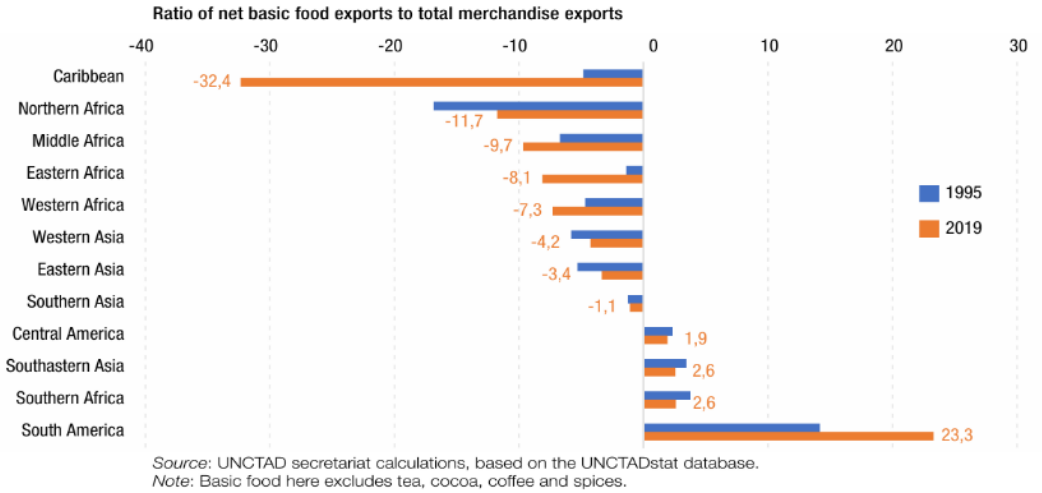


Figure illustrating the ratio of net basic food exports to total merchandise exports (p. 3).

- Real prices for grains in global food markets, adjusted for inflation, have been stable and on a declining trend since the highs in 2012–2013. However, as shown in the grains and oilseeds index of the International Grains Council, market prices for cereals and oilseeds, both major items in the food import baskets of the least developed countries and net food-importing developing countries, remain volatile and at a historically high level. This is particularly significant in some countries in sub-Saharan Africa, in which food accounts for 40–60 per cent of household consumption (pp. 2-3).

Impact on least developed countries
Please refer to the information provided above.

Impact on small island developing states
Not specified.

3.10 UNCTAD - Review of Maritime Transport 2021

Area	Main relevant findings
Main topic	Maritime transport, trade developments and disruptions to global supply chains
Date of publication	Fall 2021
Type of information source	Annual report (117 pages)
Period under review	2020-2021
Relevance	This annual report offers an analysis of global developments in shipping and seaports during the year under review, serving as a reliable source of comprehensive information and data for the maritime sector since 1968
Source	UN Trade and Development (2021). *Review of Maritime Transport 2021. UNCTAD*. Retrieved 25 January 2025, from https://unctad.org/system/files/official-document/rmt2021_en_0.pdf

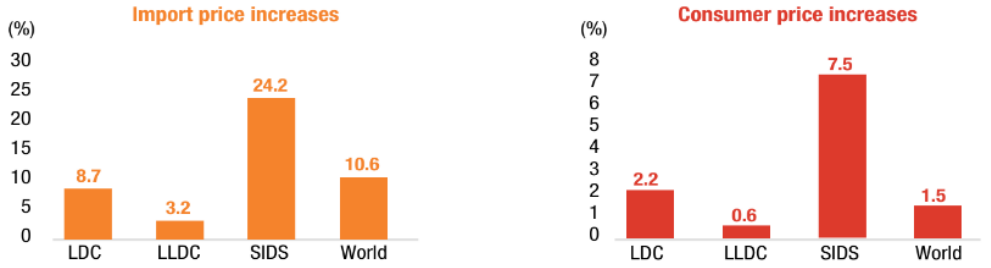
Short summary

In this report, UNCTAD forecasts that freight rates will remain under pressure from cost challenges and ongoing market disruptions, making regulatory intervention increasingly important to monitor market behaviour, ensure transparency in the setting of rates, fees, and surcharges, and address unfair market practices.

Global impact

- If sustained, the current surge in container freight rates, will significantly increase both import and consumer prices. UNCTAD's simulation model suggests that global import price levels will increase on average by 11 per cent as a result of the freight rate increases (figure 2) (p. xvii).

Figure 2 Simulated impact of current container freight rate surge on import and consumer price levels



Sources: Based on data provided by Clarksons Research, *Shipping Intelligence Network*, the International Monetary Fund, *International Financial Statistics* and *Direction of Trade Statistics*, UNCTADstat, and the World Bank, *World Integrated Trade Solution* and *Commodity Price Data (The Pink Sheet)*.

Note: The impact of container freight rate surges on prices is assessed based on a 243 per cent increase in the China Containerized Freight Composite Index between August 2020 and August 2021. The simulation model assumes that freight rates in August 2021 will be sustained over the remaining simulation period (September 2021 to December 2023) and all other factors are held constant over the entire simulation period (August 2020 to December 2023).

Figure 2 illustrating the impact of container freight rate surges on prices (p. xvii).

- The current historical highs in freight rates are largely driven by pandemic-induced shocks and unexpected upward swings in shipping demand. But in the longer term, shipping and port prices are driven by structural factors such as port infrastructure, economies of scale, trade imbalances, trade facilitation, and shipping connectivity, – all of which have lasting impacts on maritime transport costs and trade competitiveness. An analysis based on a new UNCTAD-World Bank transport costs dataset, shows that significant structural improvements could reduce maritime transport costs by around four per cent. Interventions and policies that address the structural determinants of maritime transport costs can thus help mitigate the impacts from cyclical factors and disruptions (p. xviii).
- Other structural issues that will increase prices include the new regulations on decarbonizing shipping (p. xviii).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- Higher container freight rates will also have a sizeable impact on consumer prices. If container freight rates remain at their current high levels, then in 2023 global consumer prices are projected to be 1.5 per cent higher than they would have been without the freight rate surge. The impact is expected to be more significant for smaller economies that depend heavily on imported goods for much of their consumption needs. In SIDS, the cumulative increase in consumer prices is expected to be 7.5 per cent and in the Least Developed Countries (LDCs) 2.2 per cent (p. xvii).
- In LLDCs, the increase in consumer prices is lower, at 0.6 per cent, owing to their limited dependence on maritime transport for imports (p. 67).

Impact on small island developing states

- Hardest hit will be small island developing states (SIDS) who depend for their merchandise imports primarily on maritime transport and how are simulated face a cumulative increase of 24 per cent with a time lag of about a year (p. xvii).

3.11 UNCTAD - Review of Maritime Transport 2022

Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; food security in the context of geopolitical disruptions; and food security in the context of the COVID-19 pandemic
Date of publication	Fall 2022
Type of information source	Annual report (195 pages)
Period under review	2021-2022
Relevance	This annual report offers an analysis of global developments in shipping and seaports during the year under review, serving as a reliable source of comprehensive information and data for the maritime sector since 1968
Source	UN Trade and Development (2022). *Review of Maritime Transport 2022. UNCTAD*. Retrieved 28 December 2024, from *https://unctad.org/system/files/official-document/rmt2022_en.pdf*

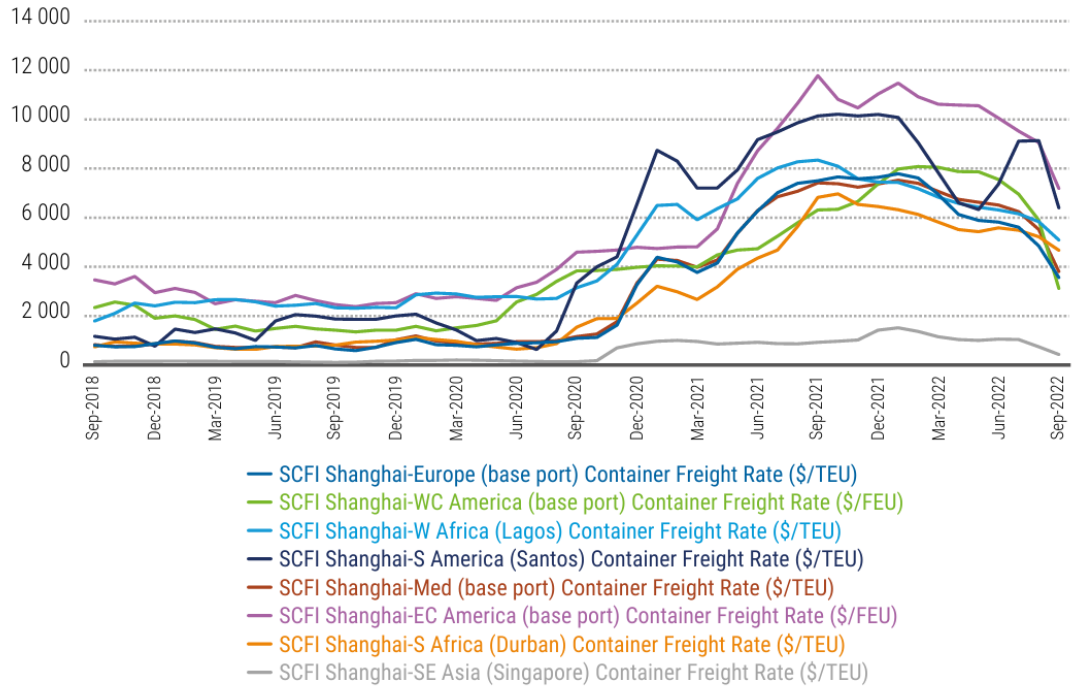
Short summary

In this report, UNCTAD calls for increased investment in maritime supply chains to enhance sustainability and resilience to future crises, citing the post-COVID surge in shipping demand and geopolitical conflicts as key drivers of higher freight costs and rising prices for food and other consumer goods.

Global impact

- In 2021, the shortage of shipping capacity and continued disruptions caused by COVID-19, combined with a rebound in trade volumes boosted container freight rates to record levels. By mid-2021, rates had peaked at four times their pre-pandemic levels. Container carriers also faced extra expenses, but were able to post record profits. Spot container freight rates surged on most routes, including those to developing regions. For example, in 2019 on the China to South America (Santos) route the rates per TEU were around $2,000 but by December 2020 were $6,543, and by December 2021 had reached $10,196. Over the same period, December 2020-December 2021, rates per TEU on the Shanghai to South Africa (Durban) route increased from $2,521 to $6,450 and on the Shanghai to West Africa (Lagos) route increased from $2,521 to $7,452 (figure 6) (p. xxi).

Figure 6 Shanghai containerized freight index (SCFI) monthly spot rates, September 2018 to September 2022, selected routes

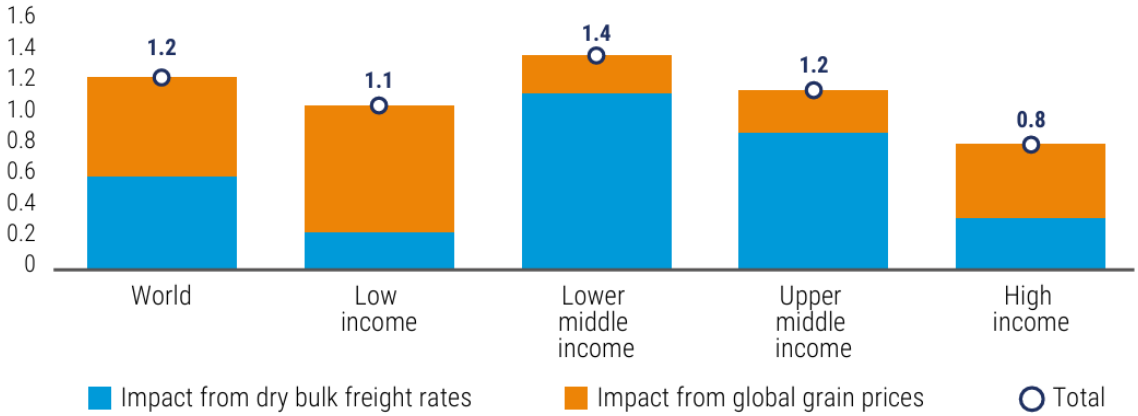


Source: UNCTAD secretariat, based on data from Clarkson Shipping Intelligence Network.

Figure 6 illustrating the Shanghai containerized freight index (SCFI) monthly spot rates from September 2018 to September 2022 for selected routes (p. xxi).

- Dry bulk freight rates also increased because of the war in Ukraine, rising energy costs, and the prolonged pandemic. An UNCTAD simulation projects that higher grain prices and dry bulk freight rates can contribute to a 1.2 per cent increase in consumer food prices (figure 7) (p. xxiii).

Figure 7 Impact of higher dry bulk freight rates and global grain prices on consumer food prices, selected country groups (percentage change)

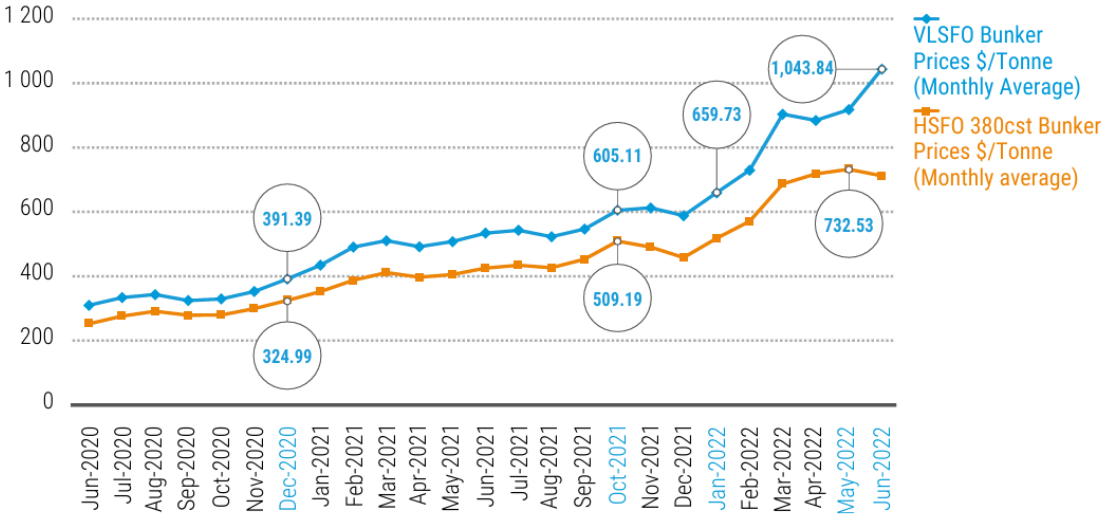


Source: UNCTAD calculations based on data provided by Clarksons Research, Shipping Intelligence Network, the IMF, International Financial Statistics, Direction of Trade Statistics and Consumer Price Index, UNCTADstat, and the World Bank, World Integrated Trade Solution, Commodity Price Data (The Pink Sheet) and A Global Database of Inflation.

Figure 7 illustrating the percentage change in the impact of higher dry bulk freight rates and global grain prices on consumer food prices across selected country groups (p. xxiii).

- The pandemic had already been driving up food prices, but as Russian and Ukrainian grain exports were hindered by port disruptions, prices soared. Between January and March 2022, the global food price index increased by about 18 per cent (p. 15).
- Since the beginning of the pandemic, container carriers have had to deal with logistical constraints and higher fuel prices (figure 3.5), but have benefited from massive hikes in freight rates which have boosted their profits (p. 64).
- The war in Ukraine has led to higher fuel costs and marine bunker prices. Prices for very low sulphur fuel oil, which in February 2022 were $730 per ton, reached record highs of more than $1,000 per ton in June 2022. Prices also rose for heavy sulphur fuel oil, which is used by the 30 per cent of container ships that are fitted with scrubbers – increasing from an average of $571 to $712 per ton (figure 3.5). In response container shipping lines increased fuel surcharges by around 50 per cent and could increase them further (p. 67).

Figure 3.5 Bunker prices, heavy fuel oil and very low sulphur fuel oil, monthly averages, from June 2020 to June 2022



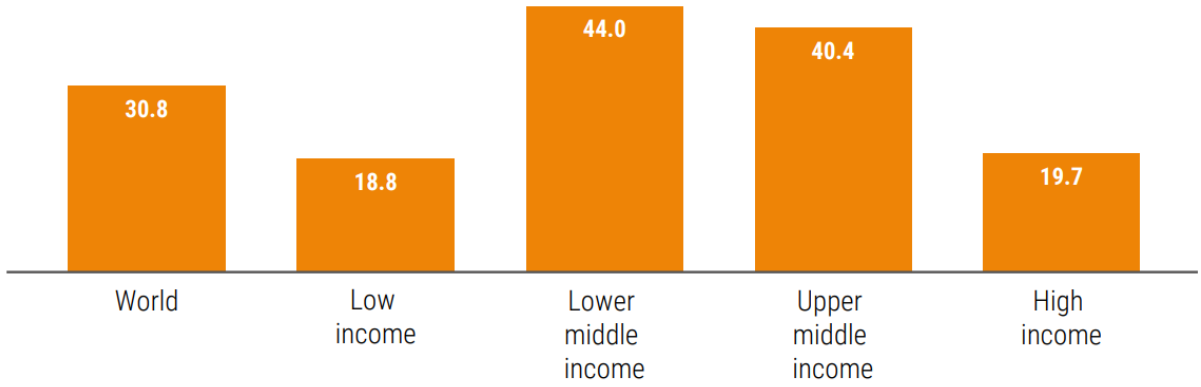
Source: UNCTAD, based on data provided by Clarksons Research Shipping Intelligence Network.

Figure 3.5 illustrating the monthly averages of bunker prices for heavy fuel oil and very low sulphur fuel oil, from June 2020 to June 2022 (p. 65).

<u>Impact on net food importing developing countries</u>

- Food price increases are expected to be slightly higher in middle-income countries whose economies rely more on dry bulk shipping (figure 3.11) (p. 69).

Figure 3.11 Share of grains imported by bulk ships in total food imports, selected country groups, 2019



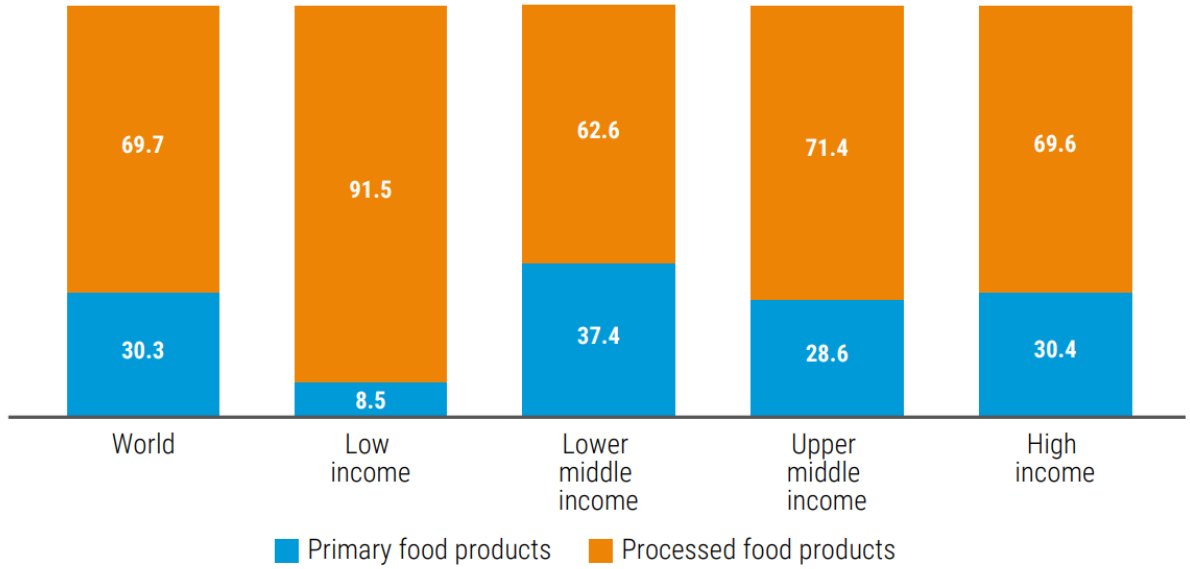
Source: UNCTAD calculations based on data provided by Sea/ (www.sea.live) and Food and Agriculture Organization, Food Balances.

Figure 3.11 illustrating the percentage share of grains imported by bulk ships in total food imports for selected country groups in 2019 (p. 70)

Impact on least developed countries

- Smaller, low-income economies which have less food processing capacity tend to import processed foods which are mainly transported by containers (figure 3.12)

Figure 3.12 Share of primary and processed food products in food imports mainly for household consumption, selected country groups, 2020



Source: UNCTAD calculations based on data provided by World Bank, World Integrated Trade Solution.

Figure 3.12 illustrating the share of primary and processed food products in food imports mainly for household consumption for selected country groups in 2020 (p. 70)

Impact on small island developing states

UNCTAD has estimated that consumer prices would be 1.5 per cent higher in 2023 than they would have been without the container freight rate surge. Higher freight rates overall hit hardest at the least developed countries and small island developing states which rely more on imports of containerized goods (p. 69).

3.12 UNCTAD - Review of Maritime Transport 2023

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains
Date of publication	Fall 2023
Type of information source	Annual report (157 pages)
Period under review	2022-2023
Relevance	This annual report offers an analysis of global developments in shipping and seaports during the year under review, serving as a reliable source of comprehensive information and data for the maritime sector since 1968
Source	UN Trade and Development (2023). *Review of maritime transport 2023 - Towards a green and just transition*. Retrieved 20 December 2024, from https://unctad.org/system/files/official-document/rmt2023_en.pdf

Short summary

In this report, UNCTAD focusses on the shipping industry's drive towards decarbonization, led by the IMO, and identifies the challenges of meeting the targets set out in the 2023 IMO GHG Strategy, primarily due to uncertainty around the most effective methods for reducing GHG emissions and transitioning to zero or near-zero GHG emission technologies, fuels and/or energy sources.

Global impact

- Starting in early 2022, seaborne trade, in particular dry bulk and tanker shipments, has been impacted by the war in Ukraine. The war led to changes in shipping patterns and increased the distances travelled for commodities, especially oil and grain. (p. xv).
- Shipments of grains travelled longer distances in 2023 than any other year on record. Although grain shipments from Ukraine resumed in 2022 thanks to the Black Sea Initiative, several grain-importing countries had to rely on alternative grain exporters. They are instead buying from the United States of America, or Brazil, which requires longer hauls (p. xvi).
- Global inflation reached a multi-decade high of about 8 per cent in 2022 and early 2023. Inflation rates vary by country groupings, with developing countries expected to reach 7.3 per cent and advanced economies 3.3 per cent in 2023 (IMF). The Middle East and Africa recorded the highest consumer price increases, particularly during the first quarter of 2023 (UNCTAD, 2023b) (p. 3).
- A further impact of the war in Ukraine has been the substitution of import origins and, in some cases, commodity substitution (WTO, 2023b). This underscores the importance of alternative sources of supply and an open trading system that allows for shifting the source of imports. During 2022, reduced grain exports from Ukraine were partly offset by increased shipments from other existing suppliers such as Australia, Brazil and Canada (p. 16).

- Energy prices, particularly gas and coal prices, reached unprecedented highs in 2022, boosting import bills in 2022 and impacting the most vulnerable households. Prices also affected food security; between January 2020 and May 2023, the FAO food price index rose by 21 per cent, although global food prices have displayed a downward trend since mid-2022. This was due to several reasons, including trade-enabling conditions provided by the Black Sea Initiative (see section B.3) (p. 3).
- Fuel costs account for a significant portion of the overall ship operating costs. Transitioning to cleaner fuels may be more expensive and add to these costs. Depending on factors such as vessel size, efficiency and the distance travelled, fuel costs can account for up to two thirds of the overall expenses making it by far the largest component of the carrier's variable cost base. Consequently, the shift towards cleaner fuels will generate additional costs and will make fuel an ever more critical component in the cost structure of shipping operations (p. 67).
- It will be important to understand how freight rates and the cost of new, low- or zero-carbon bunker fuels will be established and incorporated into the final costs. For example, a mechanism or framework could be developed to help define the basis used to determine the shipping rates and surcharges levels. This would help standardize the calculation of these rates and charges, enhance transparency and promote greater collaboration in shipping and trade (p. 67).
- The proposed midterm measures of IMO are expected to generate funds that could support the maritime sector's decarbonization efforts. Some of the funds generated by these measures could assist developing countries impacted by potential increases in maritime logistics costs. They could also help them enhance the resilience of their critical port infrastructure to the impacts of climate change and seize the business opportunities arising from the energy transition and decarbonization in shipping. Some of the funds generated could be invested in developing countries, including SIDS and LDCs, to mitigate transition costs or reduce trade costs, thanks to trade and transport facilitation intervention measures in ports and hinterland connections. As complying with the new IMO requirements entails administrative costs, funds generated could also help bridge these costs (p. 75).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- Most regions recovered in terms of COVID-19 pandemic disruptions and shipping connectivity. By the second quarter of 2023, regional averages for the LSCI in Asia, Latin America and the Caribbean and Oceania reached record highs. Meanwhile, the average LSCI for Africa also increased, but remained below its pre-pandemic values. North America and Europe both saw their average LSCI drop in 2022, only recording a recovery in the second quarter of 2023 (p. xvii).
- Shifting grain trade patterns are well illustrated in the case of Africa. Grain imports from Ukraine, crucial to the food security of many African economies, declined by 14.9 per cent in 2022, forcing these economies to adapt their trading patterns (WTO, 2023b). Egypt for instance, coped with an 81 per cent fall in wheat imports from Ukraine during the first eight months of the war by replacing the source of imports with the Russian Federation, the United States and the European Union (WTO, 2023b). Ethiopia replaced the loss of wheat supply from the Russian Federation and Ukraine with shipments from the United States and Argentina (p. 16).

Impact on small island developing states
Not specified.

3.13 UNCTAD - Review of Maritime Transport 2024

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains general; food security in the context of geopolitical disruptions; and food security in the context of climate change and environment related impacts
Date of publication	Fall 2024
Type of information source	Annual report (166 pages)
Period under review	2023-2024
Relevance	This annual report offers an analysis of global developments in shipping and seaports during the year under review, serving as a reliable source of comprehensive information and data for the maritime sector since 1968
Source	UN Trade and Development. (2024). *Review of maritime transport 2024 – Navigating maritime chokepoints* https://unctad.org/system/files/official-document/rmt2024_en.pdf

Short summary

In this report, UNCTAD highlights the adverse impacts of chokepoints in maritime trade routes, notably the Red Sea and Ukraine, on freight supply, freight rates, and consumer prices.

Global impact

- Due to limited alternative routes, disruptions can lead to negative impacts in supply chains and to systemic consequences that affect food security, energy supply and the global economy (p. 17).
- The disruptions to the Suez Canal, the Red Sea and the Panama Canal significantly impacted freight rates. In time, this could lead to a rise in global consumer prices and a decline in real GDP, with a disproportionate impact on SIDS and LDCs. Higher prices would also present a significant food security risk (p. 63).
- Evidence from a new Trade-and-Transport Dataset developed by UNCTAD and the World Bank (2024) shows that developing countries, particularly SIDS and LDCs, have higher maritime transport costs than developed countries (p.63).
- A simulation exercise was conducted to assess the impact of the freight rate increases (from October 2023-June 2024) on prices and economic activity. The simulation concluded that global consumer price levels will increase by 0.6 per cent by around the end of 2025 due to the Red Sea crisis and the Panama Canal disruption (figure III.9, panel (a))[2](p.78).

[2] The simulation was conducted using the standard Global Trade Analysis Project (GTAP), version 7 model (Corong et al., 2017) and the GTAP version 11 database (Aguiar et al., 2023). The simulation result compares changes from an initial equilibrium to a new equilibrium (see technical note 1, for details of the methodology). To specify a time horizon for these changes, an estimation result reported in UNCTAD, 2021, and indicating a one-year lag for the passthrough from freight rates to consumer prices, was used.

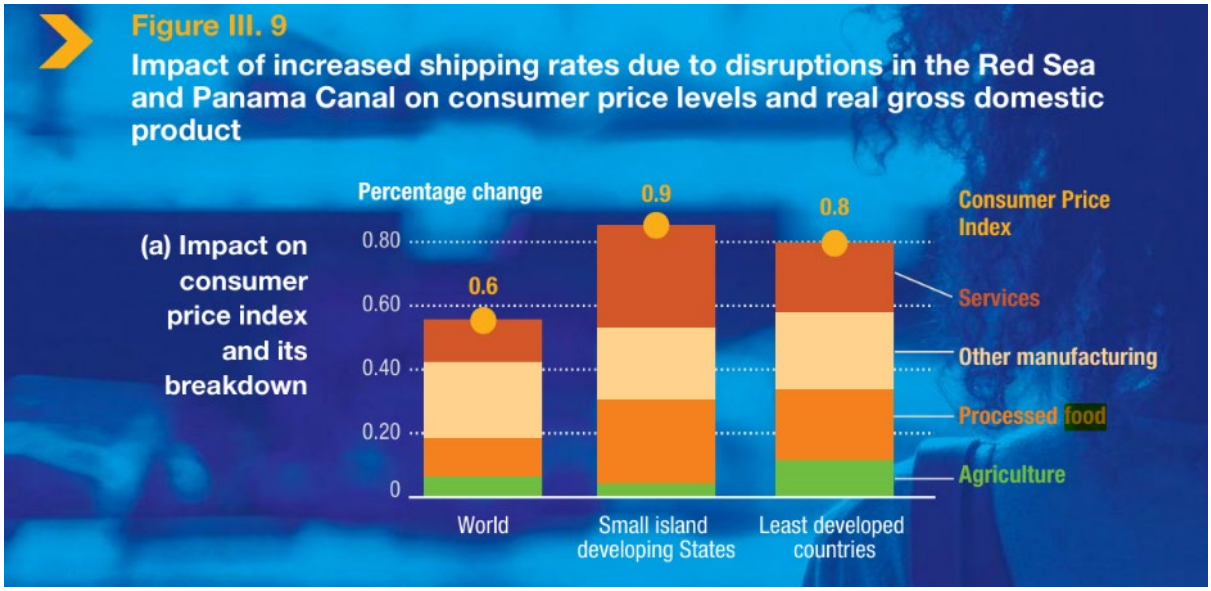


Figure III.9 panel (a) illustrating the percentage change in shipping rates due to disruptions in the Red Sea and Panama Canal, and its impact on consumer price levels (p.78).

- The simulation also shows that real GDP will be reduced by 0.06 per cent globally (figure III.9, panel (b)). (p. 79).

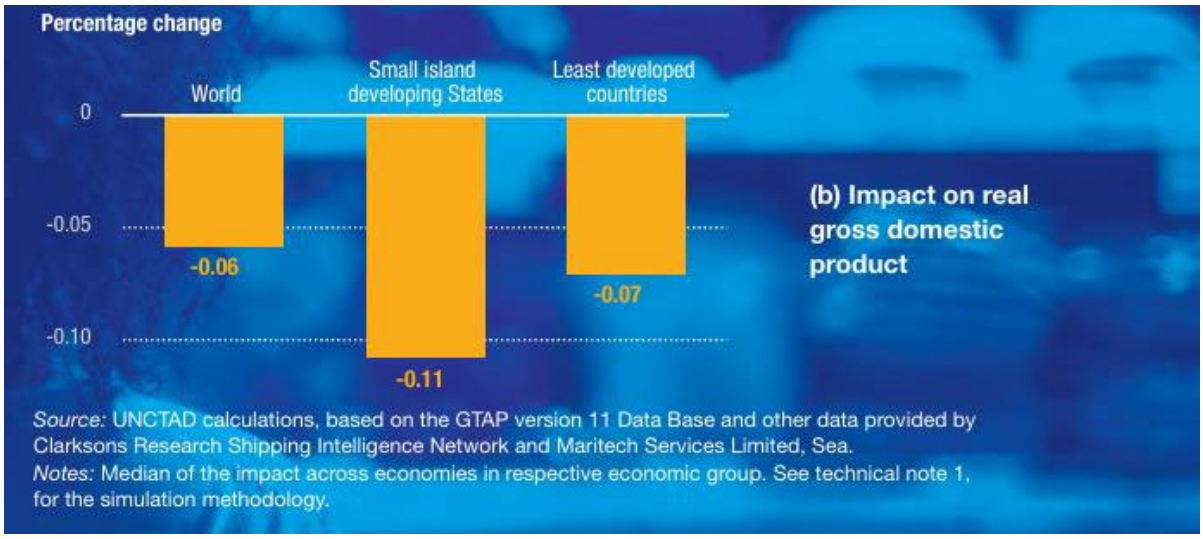


Figure III.9 panel (b) illustrating the percentage change in shipping rates due to disruptions in the Red Sea and Panama Canal, and its impact on real gross domestic product (p.78).

- Since January 2024, the ETS was extended to the shipping industry, making ships accountable for 50 per cent of emissions on voyages to and from the European Union and 100% of emissions for port calls and transits within the European Union (p.34).
- According to estimates by OceanScore, the additional ETS-related expenses for shipping companies could triple (p.35).
- In early 2024, shipping was included in the European Union ETS, which, for the first time, imposed a cost on maritime carbon emissions. This inclusion has led operators to introduce surcharges to cover the additional CO_2 costs charged to shippers. These costs can vary significantly depending on specific port call rotations. With route diversions due to disruptions in the Red Sea, this will result in higher costs. For example, a 20,000–24,000 TEU vessel on a Far East–Europe route around the Cape

of Good Hope will incur an estimated additional cost of $0.4 million per voyage at current CO_2 prices (p.71).
- Under the ETS, ships will have to pay for 40 per cent of their emissions in 2024, rising to 70 per cent in 2025 and 100 per cent in 2026. These rising ETS costs will have an impact on the shipping industry, including ports, likely leading to higher freight rates and charges, which operators will continue to pass on to shippers and, ultimately, consumers (p.71).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
- LDCs are expected to face a 0.8 per cent rise in consumer prices, a higher impact than the world average. Of this total increase, food prices alone will add 0.34 percentage points (p. 79) (please refer to simulation in footnote 21).

Impact on small island developing states
- In this simulation, SIDS would be the most affected economic group, with a simulated consumer price impact of 0.9 per cent, due to their heavy reliance on maritime (p. 79).
- Specifically, processed food prices are expected to rise by 1.3 per cent in SIDS, contributing 0.26 percentage points to the overall consumer price increase, as SIDS depend heavily on processed food imports by sea (p. 79).
- The negative impact on SIDS is double the world average, underscoring their heavy economic reliance on seaborne trade and their limited ability to replace imported goods with domestic production (p. 79).
- This result highlights the significant food security risk in SIDS and LDCs from the global chokepoint disruptions (p. 79).

3.14 UNCTAD - The impact on trade and development of the war in Ukraine

Area	Main relevant findings
Main topic	Essential food commodities; key agricultural inputs; maritime transport, trade developments and disruptions to global supply chains; and food security in the context of geopolitical disruptions
Date of publication	March 2022
Type of information source	Rapid Assessment (9 pages)
Period under review	2022
Relevance	The paper discusses how the ongoing military conflict between the Russian Federation and Ukraine led to a significant increase in maritime freight costs, contributing to consumer price index hikes in selected economies and raising concerns about potential food insecurity, especially in the supply of wheat
Source	UN Trade and Development (2022). *The impact on trade and development of the war in Ukraine. UNCTAD Rapid Assessment*. Retrieved 21 January 2025, from https://unctad.org/system/files/official-document/osginf2022d1_en.pdf

Short summary

UNCTAD prepared this assessment of the impact of the ongoing military conflict between the Russian Federation and Ukraine on trade and development, and interrelated issues in the areas of finance, technology, investment and sustainable development.

Global impact

- The results confirm a rapidly worsening outlook for the world economy, underpinned by rising food, fuel and fertilizer prices, heightened financial volatility, sustainable development divestment, complex global supply chain reconfigurations and mounting trade costs (p. 2).
- Due to higher fuel costs and rerouting efforts, current container shipping carrying capacity is being constrained. This is evident from the ongoing supply chain crisis and a potential shift from land to maritime transport (between Asia and Europe). The impact of the war in Ukraine can be expected to lead to even higher freight rates (p. 7).
- The disruption has already been felt across smaller tankers, which are key for the Black Sea and Baltic Sea regional oil trade. Black Sea–Med Aframax and Suezmax tanker earnings jumped from about $10,000 per day on 18 February 2022, to over $170,000 per day on 25 February 2022. The underlying freight costs increased by about 400% (p. 7).

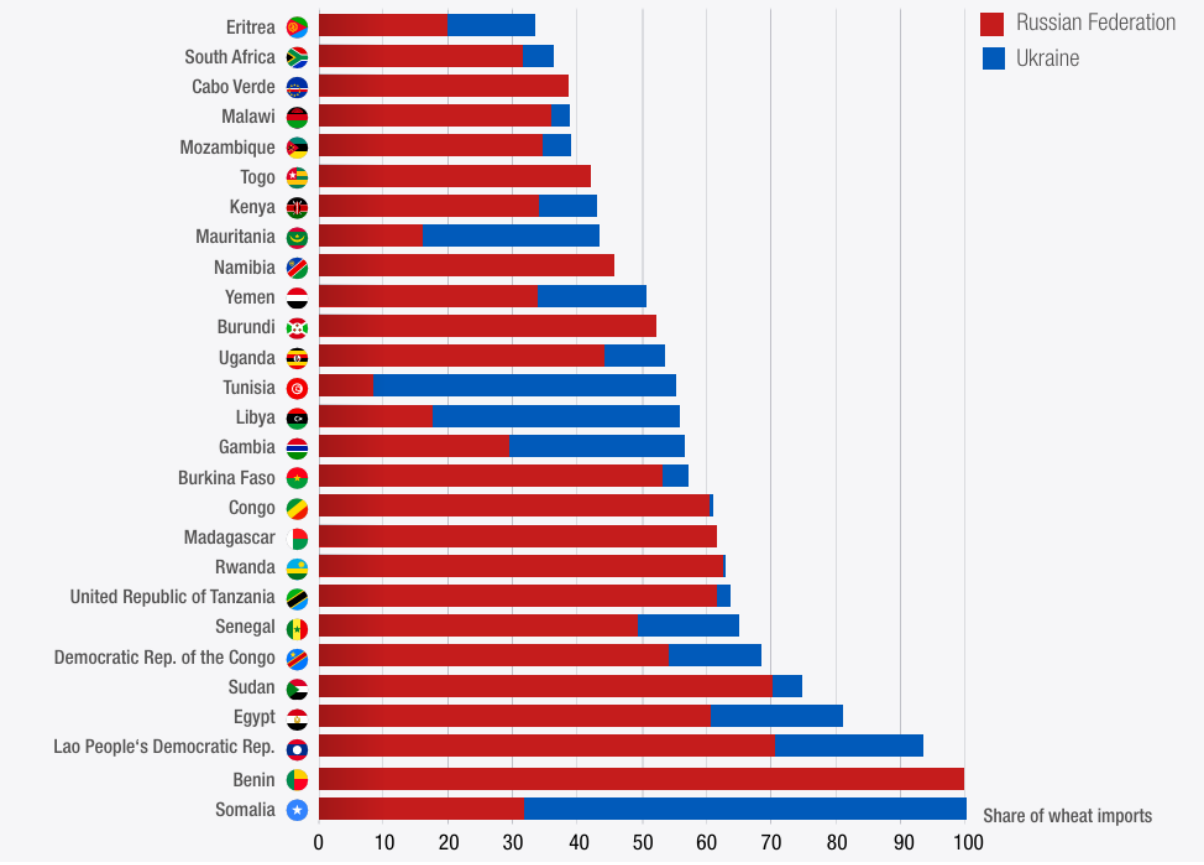
Impact on net food importing developing countries

- The rise in food and fuel prices stemming from the war is already accelerating inflation in many countries. The adverse distributional impacts will hit the poorest segments of populations, as they tend to spend a disproportionately high share of their income on food. At the same time, fuel- and food-import dependent countries will see worsening balance of payments and rising exchange rate pressure (p. 8).

Impact on least developed countries

- This rapidly evolving situation is alarming for developing countries, and especially for African and least developed countries, some of which are particularly exposed to the war in Ukraine and its effect on trade costs, commodity prices and financial markets. The risk of civil unrest, food shortages and inflation-induced recessions cannot be discounted, particularly given the fragile state of the global economy and the developing world as a result of the COVID-19 (coronavirus disease) pandemic (p. 2).
- Wheat markets are a case in point. In 2018–2020, Africa imported $3.7 billion in wheat (32 per cent of total African wheat imports) from the Russian Federation and another $1.4 billion from Ukraine (12 per cent of total African wheat imports). The corresponding imports of wheat from the two countries by the least developed countries were, respectively, $1.4 billion (29 per cent) and $0.5 billion (10 per cent). A look at specific African countries, including some least developed countries, reveals a far higher degree of dependence for many on wheat imports from the Russian Federation and Ukraine than these overall percentages. As many as 25 African countries, including many least developed countries, import more than one third of their wheat from the two countries, and 15 of them import over half (figure 3)

Figure 3. Wheat Dependence in African and Least Developed Countries
(Percentage)



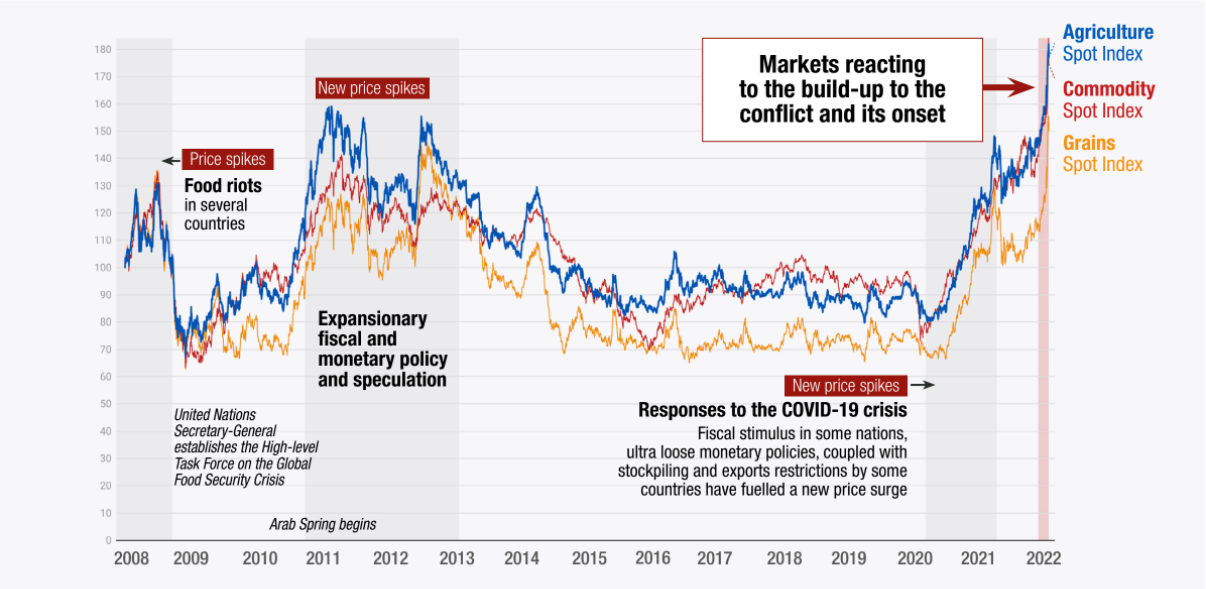
Source: UNCTAD calculations, based on data from the UNCTADstat database (accessed 4 March 2022).

(p. 5).

Figure 3 illustrates wheat dependence in African and Least Developed Countries by includes mainly North African and East African economies, as well as a few countries already struggling with internal conflicts and precarious food security situations (p. 5).

- Furthermore, there is limited scope to replace imports from the Russian Federation and Ukraine through intra-African trade, as the regional supply of wheat is comparatively small, and many parts of the continent lack efficient transport infrastructures and storage capacity (p. 5). In this context, and considering country-specific shocks, climate change, export restrictions and stockpiling, there might be a potential for food insecurity crises in some regions, especially if increased costs of fertilizers and other energy-intensive inputs negatively impact the next agricultural season. A further rise in the costs of inputs is a significant risk factor in Africa, as the costs of urea and phosphate – two major components of fertilizer – had already risen by 30 per cent and 4 per cent, respectively, by the end of 2021 (p. 5).

Figure 4. Rising prices elevate the alarm for food security and political stability
Price index (Base year =100)



Source: UNCTAD Secretariat based on data from Thomson Reuters (Bloomberg Commodity Index).

Figure 4 illustrating how, in general, political stability an increases in agrifood commodity prices are highly correlated (p. 6).

<u>Impact on small island developing states</u>
Not specified.

3.15 UNCTAD - Food security in LDCs: from crises to resilience?

Area	Main relevant findings
Main topic	Essential food commodities
Date of publication	February 2023
Type of information source	Presentation (8 pages)
Period under review	Not explicitly specified, but includes figures with data from 2014 to 2023
Relevance	The presentation is of limited relevance to this scope because it does not speak to the potential impact of increased maritime transport costs on food prices. However, it provides valuable context regarding food security in LDCs
Source	UN Trade and Development (2023). *Food security in LDCs: from crises to resilience? UNCTAD*. Retrieved 19 December 2024, from https://www.wto.org/library/events/event_resources/agri_2802202310/83_376.pdf

Short summary

This presentation examines the structural challenges faced by LDCs, including their disproportionate exposure to shocks and the high levels of food insecurity exacerbated by limited access to credit and insurance, which hinder the development of the agricultural sector. It emphasizes the need for investments in the sector and the importance of open international markets to prevent further food security crises in LDCs.

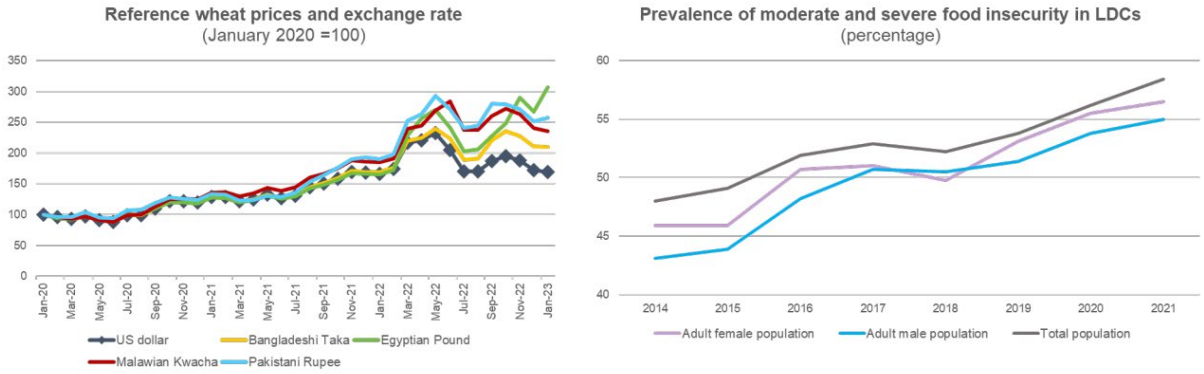
Global impact
Not specified.

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- Prospects for maize for 2022/23 have been deteriorating, while the outlook for wheat markets have become more optimistic (slide 4).
- Many LDCs or NFIDCs benefitted only weakly of declining international prices for food & fertilizers (slide 5).

Distributional impacts across and within countries remain key



Figures illustrating the distributional impacts on wheat prices and the prevalence of food insecurity in select LDCs and NFIDCs (slide 5).

- The current situation remains delicate, hence in the short- to medium-term international support continues to be crucial to avoid a cascading of crises (slide 7).
- International trade and open markets play a crucial role for food security (slide 7).

<u>Impact on small island developing states</u>
Not specified.

3.16 UNCTAD - A Trade Hope - The Impact of the Black Sea Grain Initiative

Area	Main relevant findings
Main topic	Essential food commodities; key agricultural input; maritime transport, trade developments and disruptions to global supply chains; and food security in the context of geopolitical disruptions
Date of publication	March 2023
Type of information source	Report (16 pages)
Period under review	2022
Relevance	The report discusses how geopolitical disruptions in the Black Sea were mitigated through the signing of a memorandum of understanding, and provides an account of the tonnage of grain exported under the Initiative, as well as its impact on food prices
Source	UN Trade and Development (2023). *A Trade Hope - The Impact of the Black Sea Grain Initiative*. UNCTAD. Retrieved 2 January 2025, from https://unctad.org/system/files/official-document/osginf2023d3_en.pdf

Short summary

This report outlines how the signing of the Black Sea Grain Initiative (BSGI) in July 2022, by the Russian Federation, Türkiye, Ukraine, and witnessed by the United Nations, was instrumental in facilitating the safe export of grain, fertilizers, and other foodstuffs from Ukrainian ports in the Black Sea. This agreement helped mitigate the impact of the military conflict between the Russian Federation in Ukraine was having on global food and fertilizer supplies, preventing further disruptions to the global economy.

Global impact

- Developing countries have benefitted the most from the Initiative, supporting food security among the most vulnerable. Wheat and corn are among the world's most used food staples. Under the Initiative, corn and wheat accounted for 77 per cent of exports (p. 4).

1.1 Delivering food to the world

as of 5 March 2023

+23,000,000

tonnes of grain were exported under the Initiative

Developing countries have benefitted the most from the Initiative, supporting food security among the most vulnerable.

Wheat and corn are among the world's most used food staples. Under the Initiative, corn and wheat accounted for 77 per cent of exports.

Figure 1: Developing countries received the largest share of food exports

Share of food exports to country groups by development status

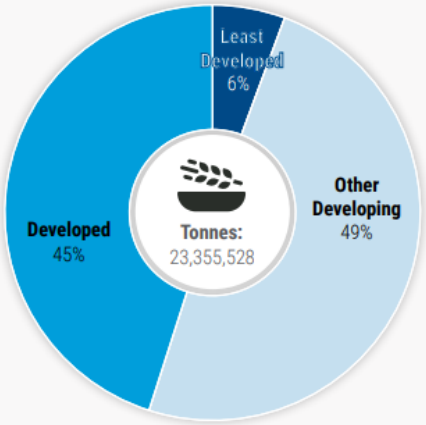
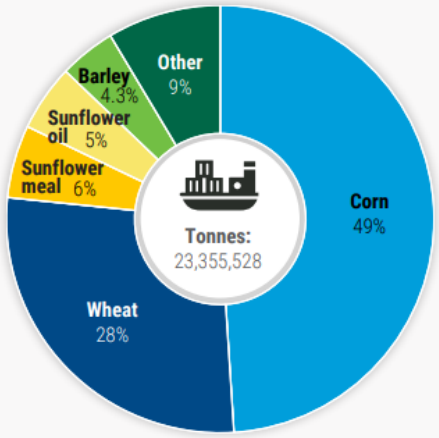


Figure 2: Corn and wheat make up the majority of food exports

As a share of total cargo shipped (%)



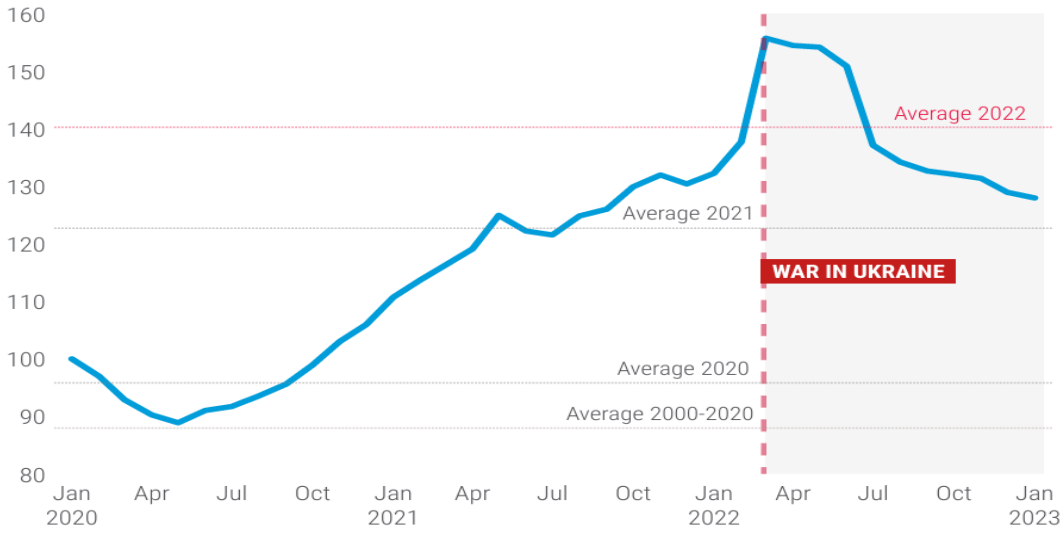
Source: UNCTAD secretariat based on data from the Joint Coordination Centre as of 5 March, 2023.
Note: Cargo may be processed and re-exported from the primary destination.

Figures 1 and 2 illustrating the tonnage of grain exported under the Initiative, categorized by recipient country groups and food staples (p. 4).

- FAO reported that food prices are almost 18 per cent lower than their all-time high in March 2022, following the start of the war in Ukraine. This downward trend in prices was supported by the efforts of the Black Sea Grain Initiative. However, price levels are still high when compared to pre-war and pre-pandemic levels. Food prices in January 2023 were 45 per cent above the average over the past two decades. Furthermore, concerns persist for the stability of future food prices, which may be undermined by climatic factors, risk of market disruptions, export restrictions, high energy costs, and weakening global demand for food (p. 11).

Figure 13. The Initiative has helped to reverse rising food prices, but affordability remains a challenge

FAO Food Price Index (100=January 2020)



Source: FAO

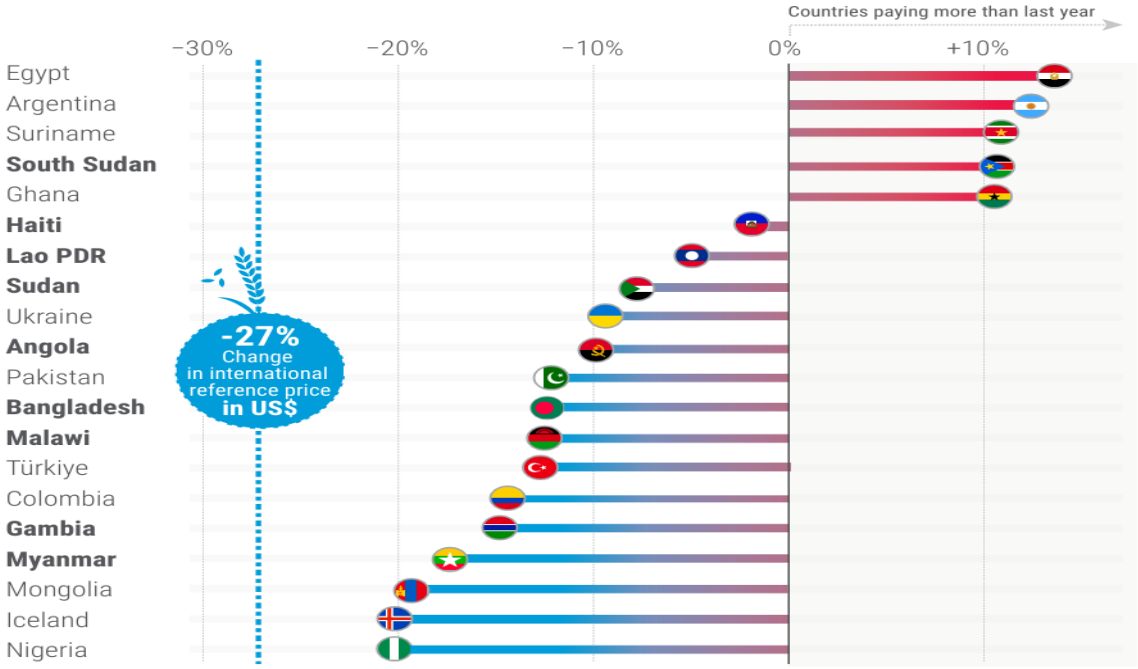
[3] Vos R et al (2023). Is food price inflation really subsiding? IFPRI Blog.

Figure 13 illustrating how food prices have come down from record levels but remain high (p. 11).

Impact on net food importing developing countries

- While most developing countries are paying lower prices when compared to record highs seen in May 2022, currency depreciations have partly eroded the benefits of declining international prices. In some cases, depreciations have been so sharp that the wheat price in domestic currency surpasses record levels. This is the case, for instance, in Egypt, Suriname, South Sudan and Ghana (p. 13).

Figure 15. Currency depreciations reduce or even offset benefits from lower wheat prices
Change in wheat reference prices January 2023 compared to May 2022 peak, by currency



Source: Refinitiv- Eikon and World Bank's Pink Sheet (February 2023)
Note: Countries in bold are least developed countries (9). The selected countries depicted in the graph are those for which exchange rate movements offset more than 25% of the decline in US dollar-denominated wheat prices.

Figure 15 illustrating the impact of currency depreciations resulting from lower wheat prices in selected countries, including Egypt, Pakistan and Mongolia, which are classified as NFIDCs (p. 13).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Please refer to the information provided above.

Impact on small island developing states
Please refer to the information provided above.

3.17 UNCTAD - Maritime transport in times of polycrisis

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; food security in the context of geopolitical disruptions; food security in the context of the COVID-19 pandemic; food security in the context of climate change and environment related impacts
Date of Publication	August 2024
Type of information source	Note by the UNCTAD Secretariat (21 pages)
Period under review	2019-2024
Relevance	This note by UNCTAD discusses the impacts of disruptions to global supply chains, international shipping and logistics, including from the COVID-19 pandemic, the war in Ukraine, and the 2021-2022 crunch in global logistics
Source	UN Trade and Development. (2024). *Maritime transport in times of polycrisis*. Retrieved 6 January 2025 from https://unctad.org/system/files/official-document/cimem7d32_en_0.pdf

Short summary

This note by UN Trade and Development (UNCTAD) presents that global supply chains, transport networks and logistics are facing significant geopolitical, economic, health, climate and environmental, technological, and infrastructure and operational disruptions (referred as "polycrisis"). The note presents also results from the Global Supply Chain Forum, held in May 2024 and jointly organized by UNCTAD and the Government of Barbados, whose findings reinforce the need to build more resilient global logistics, particularly for small island developing states (SIDS). It proposes that the maritime sector adapts to these disruptions by embracing digitalization, risk management, and sustainability.

Global impact

On maritime decarbonization:

- Shipping decarbonization measures entail costs that are likely to drive up maritime logistics costs. Increases in maritime logistics costs can potentially negatively impact trade and economic output, particularly in developing countries such as SIDS and LDCs. These economies already pay relatively higher transport costs for imports and exports and have limited capacity to mitigate increases in maritime logistics costs (paragraph 27, p. 6).

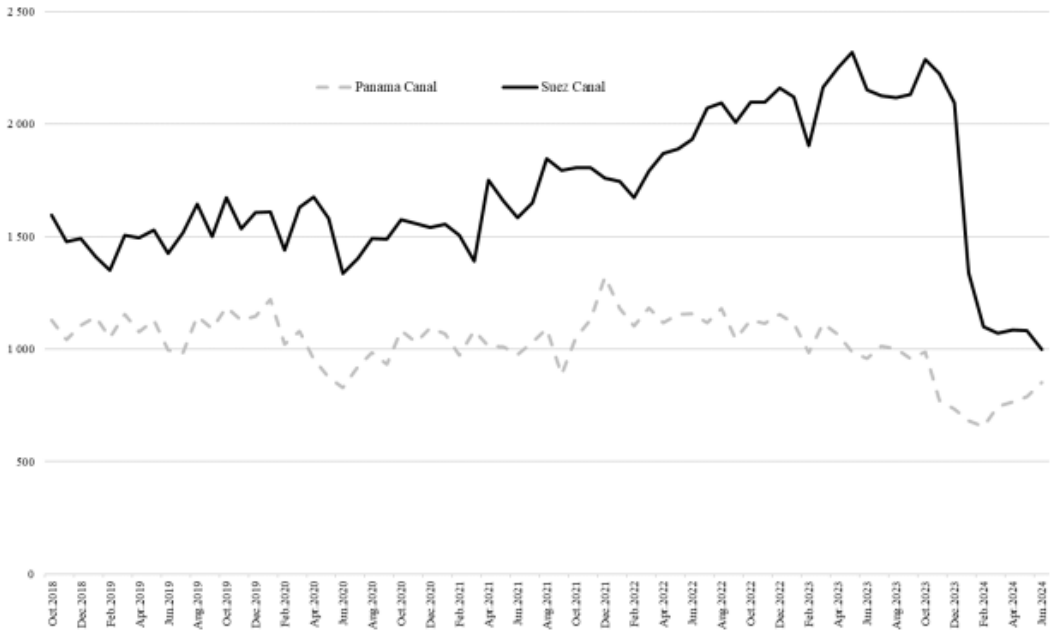
On building resilient maritime transport and logistics:

- Maritime transport and logistics that underpin global supply chains and deliver international trade are evolving amid multiple crises and overlapping risks. In 2020 and against the backdrop of an already challenging global geopolitical and trade policy landscape, the COVID-19 pandemic laid bare the vulnerability of global supply chains

and underlying maritime transport networks and logistics. These have been further underscored by the war in Ukraine that started in 2022 and caused upheaval in Black Sea-dependent shipping and trading networks. The war in Ukraine redefined trading patterns, particularly for energy and grain, and heightened food and energy security concerns. It led to changes in exporter and importer markets for oil and grain commodities and increases in distances travelled, fleet deployment, port call configuration and vessel routing (paragraph 42, p. 8).

- In late 2023 and into the first half of 2024, attacks on ships have disrupted shipping operations in the Red Sea and the Suez Canal. The average number of Suez Canal ship transits in June 2024, compared to December 2023, fell by 70 per cent. The largest drops were recorded by liquified natural gas carriers (-95 per cent), car carriers (-91 per cent) and containerships (-88 per cent). The number of transits by all other ship segments also declined, with crude carriers recording the smallest reduction (-31 per cent). At the same time, reduced water levels in the Panama Canal have led to restrictions on ship transits, a two-year trend that was exacerbated in 2023. By June 2024, the number of vessel transits through the Panama Canal and the Suez Canal were down by over half compared to their respective peaks (figure 2). Most of the decline in the Suez Canal occurred since December 2023, with the onset of the Red Sea crisis, while the number of transits through the Panama Canal have been decreasing over the last two years. These simultaneous disruptions have amplified unpredictability, risks and costs for maritime transport, logistics and trade (paragraph 43, p. 10).

Figure 2
Panama Canal and Suez Canal: Number of monthly transits



Source: UNCTAD secretariat calculations, based on data from Clarksons Research.

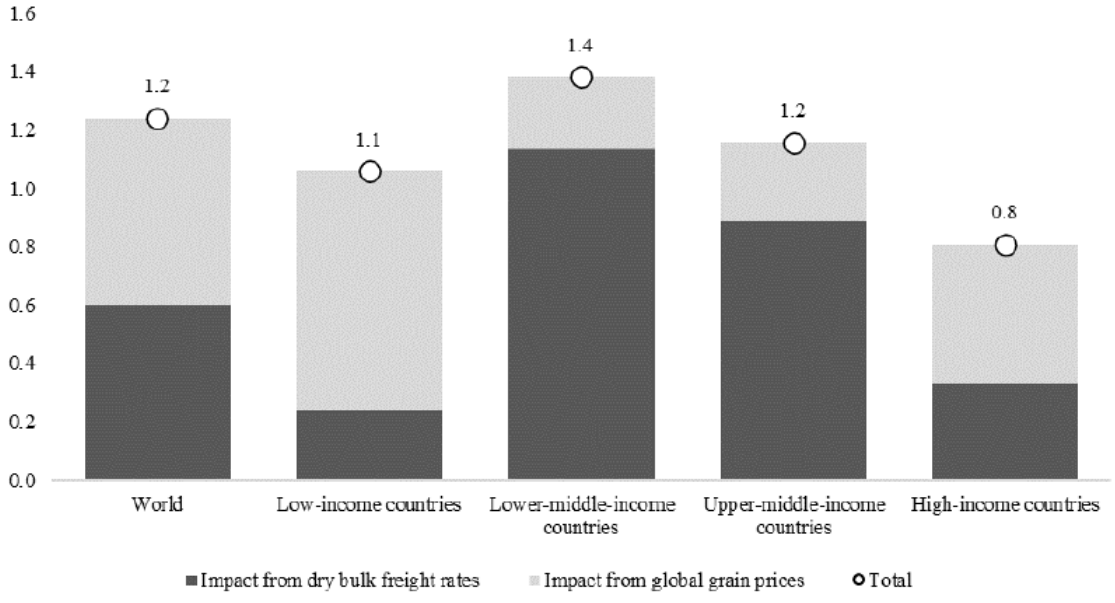
Figure 2 illustrating the number of monthly transits in the Panama Canal and Suez Canal (p. 11).

- Disruptions may trigger shifts in globalization patterns, supply chain configuration and production models, with implications for maritime transport and logistics, as growing trade policy tensions, the COVID-19 pandemic, the global logjam in logistics in 2021–2022, the war in Ukraine and, more recently, challenges faced in the Red Sea, Suez Canal and Panama Canal have exposed the limitations of extended supply

chains and the just-in-time business model[3]. Upheaval arising from more frequent disruptions has uncovered the risks and vulnerability generated by extended supply chains and overreliance on a few suppliers and markets. This holds true for food and energy and for parts and components that are key to strategic manufacturing activity. The 2021–2022 semiconductors shortage is illustrative of the challenges facing supply chains amid a highly disrupted maritime transport and trading environment (paragraph 45, pp. 11-10).

- Disruptions have also implications for energy and food security. The war in Ukraine affected energy and food prices and raised concerns about energy and food security (paragraph 48, p. 12).
- Disruptions are also increasing maritime transport and logistics costs. Soaring and volatile freight rates, higher surcharges aimed at covering additional fuel costs, security, congestion, equipment management and repositioning have been driving an inflated cost environment. Cost increases are ultimately reflected in increased consumer prices and production costs. UNCTAD finds that the pandemic, the war in Ukraine and the 2021–2022 crunch in global logistics have caused shipping rates to surge and consumer prices to jump, thereby fuelling inflation. The disruption-induced surge in container shipping costs, which peaked in early 2022, sharply increased consumer prices for many goods, with vulnerable economies such as SIDS the most affected. Likewise, the war in Ukraine caused dry bulk freight rates and grain prices to increase. Simulations by UNCTAD showed that the impact of these increases led to 1.2 per cent hike in consumer food prices, with higher increases being observed in middle- and low-income countries (figure 3) (paragraph 49, p. 12).

Figure 3
Impact of higher freight rates and grain prices on consumer food prices
(Percentage increase)



Source: UNCTAD, 2022a.

Figure 3 illustrating the impact of higher freight rates and grain prices on consumer food prices (p.13)

- With self-reliance and national security concerns growing in importance, some countries are also looking at reshoring and nearshoring as resilience-building

[3] For a detailed discussion on the growing disruption affecting maritime transport and trade, see the 2020–2024 editions of Review of Maritime Transport.

measures. UNCTAD finds that, since 2022, the geographical proximity of international trade has remained relatively constant, showing minimal nearshoring or "farshoring" trends. However, there has been a rise in the political proximity of trade, indicating that bilateral trade patterns have been favouring trade between countries with similar geopolitical stances (a pattern generally referred to as "friend-shoring"). Some East Asian and Latin America economies may find opportunities to integrate more into supply chains affected by geopolitical concerns (paragraph 54, p. 15).

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.18 UN Global Crisis Response Group (GCRG) - Global impact of the war in Ukraine: Energy crisis

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport; trade developments and disruptions to global supply chains; food security in the context of geopolitical disruptions; food security in the context of the COVID-19 pandemic
Date of publication	August 2022
Type of information source	Brief (29 pages)
Period under review	2022
Relevance	This report discusses the adverse impacts which the ongoing military conflict between Ukraine and the Russian Federation has had on food prices, energy costs and how that has resulted in rising costs of living across the globe, as one of the geopolitical disruptions impacting food security
Source	United Nations Global Crisis Response Group (2022). *Global impact of the war in Ukraine: Energy crisis*. Retrieved on 22 December 2024, from https://unctad.org/system/files/official-document/un-gcrg-ukraine-brief-no-3_en.pdf

Short summary

This report is the third in a series published by the Global Crisis Response Group of the United Nations in August 2022 investigating the impact of the ongoing military conflict between the Russian Federation and Ukraine. In this paper, the GCRG reported that:

Global impact

- Prices of commodities in global markets were still high but stabilizing (p. 3).
- Shipping costs had slowly begun to decrease, especially for bunker and tanker ships (p. 3)
- Most consumers have not seen commodity price declines translated into lower inflation rates (p. 4).
- Food prices have fallen, yet are still high, above pre-pandemic levels, and the fertilizer shortage remains a concern. Prices were already high at the beginning of January 2022, and increases have been broad based, affecting almost all food categories (p. 4).
- In 2020, almost 3.1 billion people could not afford a healthy diet, up by 112 million compared with in 2019, due to the impact of the coronavirus disease (COVID-19) pandemic and related measures. The cost-of-living crisis, and soaring food prices, make it even more challenging for increasing numbers of people to afford a minimally nutritious and healthy diet (p. 4).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.19 AMIS - Agricultural Market Information System (AMIS)

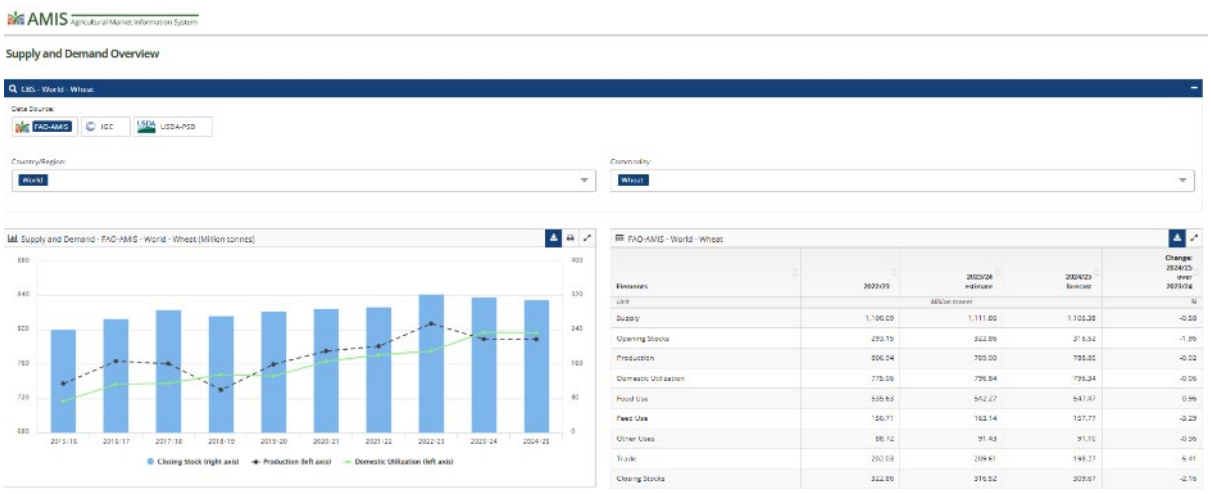
Area	Main relevant findings
Main topic	Essential food commodities; key agricultural inputs
Date of launch	2011
Type of information source	Database
Period under review	2011 to date
Relevance	The database captures and publicizes price data on food commodities
Source	AMIS Secretariat. (2011). *Market Database*. Retrieved on 19 January 2025, from Agricultural Market Information System (AMIS): https://app.amis-outlook.org/#/market-database/supply-and-demand-overview

Short summary

Agricultural Market Information System (AMIS) is an inter-agency platform to enhance food market transparency and policy response for food security. By collating pricing data from principal trading countries of agricultural commodities, AMIS provides easy access to vital information on 80-90% of the trade in grains, enhancing transparency and reducing the likelihood of arbitrary price hiking. By so doing, AMIS is contributing to reducing market uncertainty and strengthen global food security.

The work of AMIS is coordinated by an inter-agency Secretariat, which his hosted by the Food and Agriculture Organization of the United Nations (FAO).

Global impact



AMIS dashboard captured as of 28 January 2025.

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.20 Committee for the Coordination of Statistical Activities (CCSA) - How COVID-19 is changing the world: a statistical perspective

Area	Main relevant findings
Main topic	Maritime transport; trade developments and disruptions to global supply chains; food security in the context of the COVID-19 pandemic
Date of publication	2021
Type of information source	Report (88 pages)
Period under review	2020 - 2021
Relevance	This report analyses the impact of COVID-19 on food security and it has been included in this analysis due to its relevance as external "shock" impacting food prices
Source	Committee for the Coordination of Statistical Activities. (2021). *How COVID-19 is changing the world: a statistical perspective*. Retrieved on 22 December 2024, from https://unstats.un.org/unsd/ccsa/documents/covid19-report-ccsa_vol3.pdf

Short summary

In this paper, the CCSA adopts a statistical approach to measuring the impact of the COVID-19 pandemic on various aspects of the economy of selected countries.

Global impact

- Shipping activity – as measured by vessel port calls-likely declined by around 10 percent (p. 3).
- Europe and North America, two regions where maritime trade is heavily reliant on consumer goods, were deeply impacted by the disruption. The exporting Asian economies saw a relatively minor decline in vessel port calls as tight management of the pandemic ensured business continuity and a rapid resumption of economic activity (p. 24).
- Oceania experienced the most significant impact of all regions early in the year, but the decline in vessel port calls moderated in the second and third quarters (p. 24).
- In contrast, Latin America and the Caribbean saw their situation deteriorate during the second half of the year, with port calls declining by 16.3% during the fourth quarter of 2020 (p. 24)

Impact on net food importing developing countries
Not specified.

Impact on least developed countries

- Between September 2020 and January 2021 FAO collected data in 20 countries to assess food insecurity within the context of COVID-19, using the Food Insecurity Experience Scale (FIES). Results are reported for Burkina Faso and Sierra Leone (p. 42).

- In both cases, even though the prevalence of food insecurity was significant, the results of projecting the prevailing rate of food insecurity were higher for the post pandemic than before. 70% of the respondents in both countries identified COVID-19 as the main reason for food insecurity in 2020 (p. 43).

Impact on small island developing states
Not specified.

3.21 IDB - The trade fallout of the war in Ukraine on Latin America and the Caribbean

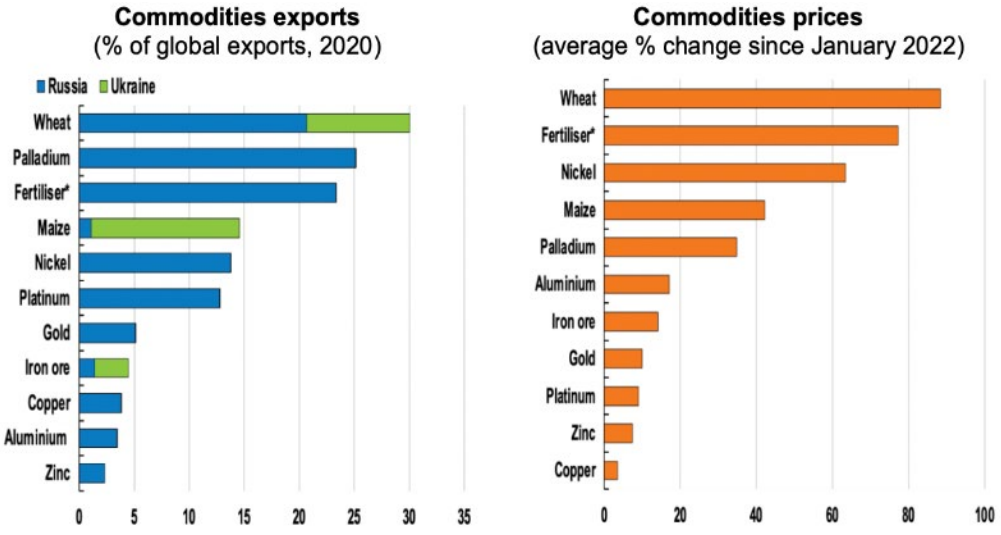
Area	Main relevant findings
Main topic	Essential food commodities; key agricultural input; maritime transport, trade developments and disruptions to global supply chains; food security in the context of the COVID-19 pandemic
Date of publication	July 2022
Type of information source	Policy Brief (13 pages)
Period under review	2022
Relevance	This policy brief analyses the impact of geopolitical disruptions on food security in food exporting countries
Source	Inter-American Development Bank. (2022). *The trade fallout of the war in Ukraine on Latin America and the Caribbean*. Retrieved 7 January 2025, from http://dx.doi.org/10.18235/0004336

Short summary

The paper evaluates how the ongoing military conflict between the Russian Federation and Ukraine has affected the global economy by creating surges in commodity prices and resulting in a sizeable food security shock for some countries of the Latin America and Caribbean region.

Global impact

- Russia and Ukraine are major exporters of commodities, commanding large shares of global markets in agriculture crops, metals and fertilizers. The conflict has brought export flows to a halt due to the destruction of production facilities, the blockage of trade routes and the impact of international economic sanctions (p. 2).



Figures illustrating the percentage increase in commodity prices (p. 2).

- Russia and Ukraine are insignificant trading partners for LAC, jointly accounting for less than 1% of combined exports and imports. Accordingly, the direct trade fallout of the war is expected to be limited. However, for specific countries, sectors, value chains and firms the disruption of trade flows with both countries may be extremely challenging, both on the export and import side (p. 5).
- Imports from Russia: in fertilizers dependence is the highest in Honduras (77%), Nicaragua (73%), and Peru (61%); but countries such as Nicaragua also import up to (82%) of cereals. In Brazil, dependence in fertilizers is lower in percentage, but it is the largest importer of the world (p. 6).
- Exports to Russia: Paraguay (51% of bovine meats); Brazil (37% of peanuts); Argentina and Uruguay (42%-38% of butter, respectively) (p. 6).
- On the import side, the disruption in imports in grains and fertilizers, coupled with raising energy prices, may spark food insecurity and drive lower productivity and competitiveness in the agriculture sector (p. 6).
- On the export side, the suppression of key markets may result in income reduction for firms and their workers (p. 6).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.22 IFAD - The role of trade and policies in improving food security

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; food security in the context of the COVID-19 pandemic
Date of publication	February 2022
Type of information source	IFAD Research Series (38 pages)
Period under review	Not specified
Relevance	This paper analyses the effects of trade on food security.
Source	International Fund for Agricultural Development. (2022). *The role of trade and policies in improving food security*. Retrieved 7 January 2025 from https://www.ifad.org/documents/d/new-ifad.org/77_research-pdf

Short summary

In this paper, uses the food system approach to analyse the implications of trade in agricultural and foods products for food systems outcomes.

Global impact

- Positive effects of trade on food security are not always evident. Given the fact that only 10-15% of global food production is traded internationally, the availability of food is determined by local factors, among which poor rural infrastructure is mentioned as a primary constraint (pp. 1-2).
- High import dependency creates risks for food security because of fluctuations in supply and price on the international market, which may result from harvest failures and/or policy changes. This means that the stability of food access and availability remains a challenge, especially in regions and countries that rely heavily on food imports and are characterized by low domestic food availability. Chances of supply disruption are further increased if the importing country is dependent on one or two suppliers (p. 9).

Impact on net food importing developing countries

- Figure 7 shows that for a number of countries in sub-Saharan Africa, increasing imports have led to a higher import dependency over the last three decades[4]. For many products, the figures show imports account for high shares of domestic consumption.

[4] In composing this figure, import volumes of separate food items are transferred from kilogrammes into kilocalories and related to Food and Agriculture Organization of the United Nations (FAO) food availability data from the Food Balance Sheets statistics. Food import dependency is defined as the share of imports in food availability of a country. See https://www.fao.org/faostat/en/#data/FBS.

This, in particular in the case of sugars, is vegetable oils and fish (>50 per cent in most selected countries)[5].

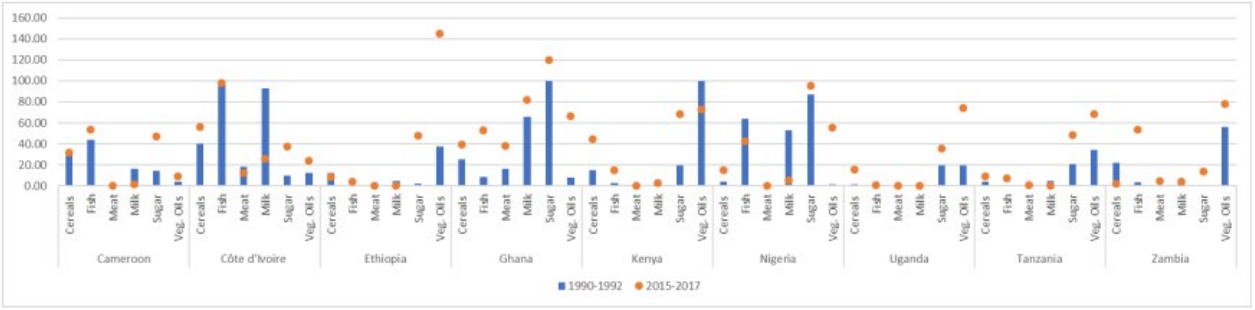


Figure 7 illustrating the share of imports in domestic food supply (in kcal/capita/day) in selected sub-Saharan African countries. Source: FAO Food Balance Sheets (FBS), https://www.fao.org/faostat/en/#data/FBS. Note: FBS import in tonnes is converted to kcal/capita/day based on the ratio between FBS food supply in tonnes and FBS food supply in kcal/capita/day (author's own calculation).

- Figure 8 indicates that food security risks related to import dependency are especially relevant for countries in North Africa and the Near East, in many African countries and the Caribbean, and in several Latin American countries. Also, population-rich countries in East Asia (such as China, Indonesia and the Philippines) depend significantly on food imports.

Figure 8 illustrating the global state of food security (2017). Source: Mapmania

- North Africa and the Middle East, the region with the highest import dependency for its food supply and one that is particularly dependent on international trade for staple foods such as cereals, sugar, sweeteners and vegetable oils (FAO, 2018b). This region is characterized by high population growth and a low availability of cultivable land and water. It is economically highly dependent on the international prices of fossil fuels, which have fallen sharply since 2013. The growing wheat import dependence is of particular concern in the region, where consumer food subsidies

[5] For some products (e.g. sugars in Ghana and Nigeria), percentages are above 100, which means that production (and stocks) are very low and the country mainly imports this product, yet there are some exports that bring domestic supply available below the level of imports.

are a widely used policy instrument to combat price fluctuations and keep food affordable (FAO, 2018b; Le Mouël and Schmitt, 2018) (p. 11).

- Evidence from several African countries shows that past commodity price shocks had serious impacts on food security as household purchasing power fell because of price increases, income falls or job losses resulting from currency devaluation and cuts in public sector spending (p. 11).

Impact on least developed countries
Please refer to the information provided above.

Impact on small island developing states
Not specified.

3.23 Internal Grain Council (IGC) - Grains Trade Perspectives

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; food security in the context of climate change and environment related impacts
Date of publication	February 2023
Type of information source	Presentation (16 pages)
Period under review	2021–2023
Relevance	This presentation discusses the dynamics of the trade and consumption of wheat globally
Source	International Grains Council. (2023). *Grains Trade Perspectives*. Retrieved 17 December 2024, from https://www.wto.org/library/events/event_resources/agri_2802202310/83_375.pdf

Short summary

The IGC presentation highlights that wheat consumption has increased by more than 100% in the last decade due to growth population and that 50% of the wheat produced is consumed in Asia.

There are new areas of production and the trade particularly of milling wheat will increase.

Global impact

- Why trade finance matter in food security (slide 6):

+85% of grains transportation is by ocean;

  - +85% of grains transportation is by ocean;
  - More than 50% of the grains journey is over 30 days; More than 50% of the grains journey is over 30 days;
  - Net importing countries would have also to address foreign reserve exchange as main operations are in $; Net importing countries would have also to address foreign reserve exchange as main operations are in $;
  - Interest rate increased the cost of trade operation (usually 180 days for payment); Interest rate increased the cost of trade operation (usually 180 days for payment);
  - To avoid system risk on finance sector: banking sector needs to freeze assets as collateral security.

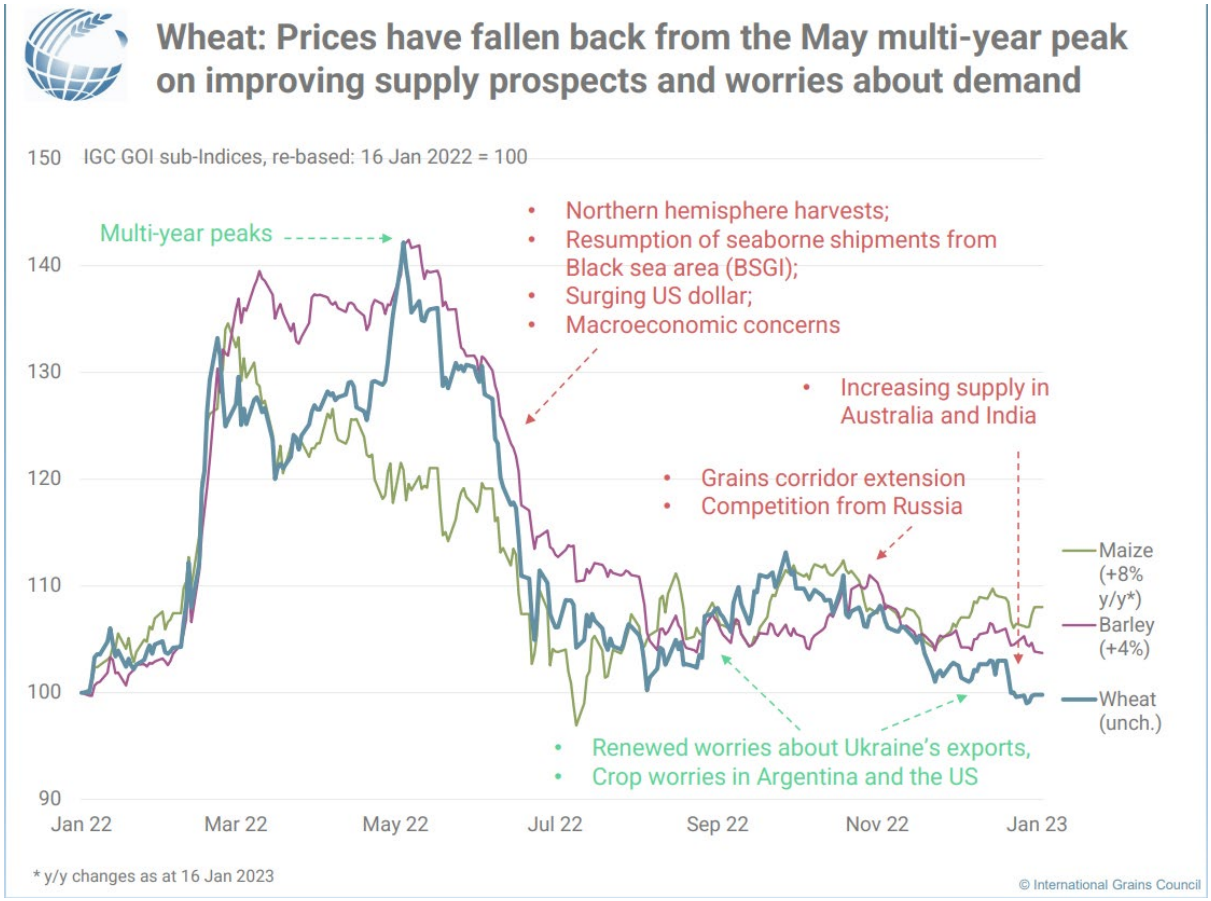


Figure illustrating wheat prices from January 2022 to January 2023 (slide 7).

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.24 International Grains Council (IGC)/ World Trade Organization (WTO) - Wheat maritime trade & food security dashboard

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; food security in general terms
Date of publication	On-going
Type of document	Statistical dashboard on Global maritime trade & food security
Period under review	2014 - 2024
Relevance	This dashboard by IGC and WTO presents short-term trends in international wheat maritime trade flows in response to changing market conditions, as well as the trends between 2014 and 2024 of production to consumption ratios in net food importing developing countries.
Source	World Trade Organization. (2025). Wheat maritime trade & food security. Retrieved 22 January 2025, from WTO trade data: https://globaltradedata.wto.org/real-time-data-based-on-non-wto-data-sources

Short summary

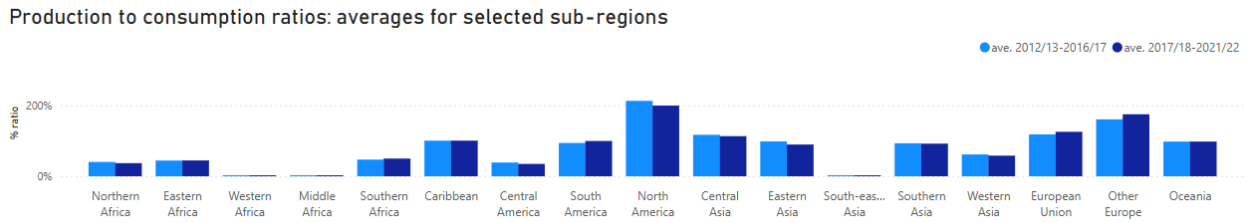
This dashboard was developed jointly by the International Grains Council (IGC) and the World Trade Organization (WTO) and offers a tool for monitoring short-term trends in international wheat maritime trade flows in response to changing market conditions and enables the analysis of longer-term trends. It covers bi-weekly and cumulative exports and imports for selected exporters and importing regions based on a July/June international trade year, as well as estimates for current line-ups at main exporters' ports and expected arrivals to covered importing regions.

Global impact

Extracted from the wheat trade & food security dashboard on 7 December 2024:

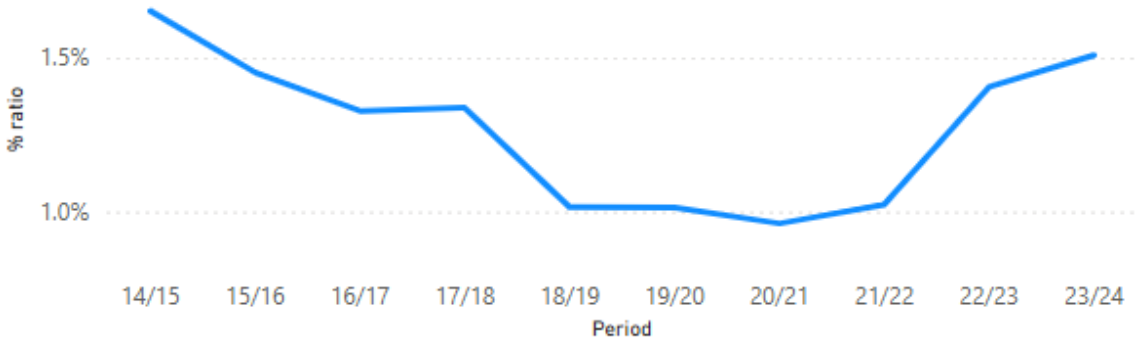
- Being one of the most common food staples, wheat is crucial for food security in many parts of the world. While around one quarter of world wheat consumption is traded, the share is much higher for some developing net importing countries, which highlights the importance of well-functioning international trade channels for their food systems.
- With maritime routes representing the main or the only means to import or export grains for most countries, this underscores the relevance of the monitoring and analysis of up-to-date shipping data, which can also provide insights into trade logistics.

On the production to consumption tab within the wheat trade & food security dashboard:



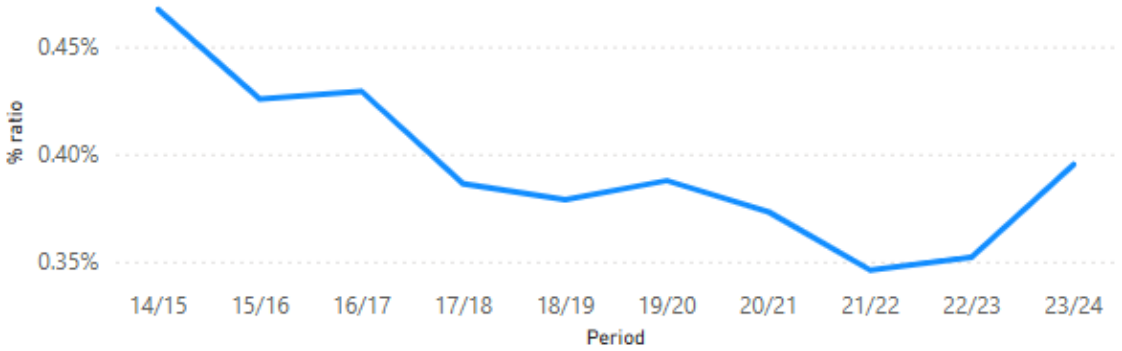
Tab "Production to consumption ratios": Production to consumption ratios: averages for selected sub-regions.

- Calculated indicators suggest little improvement in production to consumption ratios over the past decade, on average, for some net importing regions, including all parts of Africa. All African regions have average ratios of less than 50%, with particularly low indicators noted for Middle and Western Africa.
- This chart shows that the five-year average production to consumption ratios have declined slightly for some parts of Asia over the past decade. Notably, the indicator for Eastern Asia dropped from the average of around 100% during 2014/15-2018/19 to 89% over the following five years, mainly reflecting a falling ratio for China. In contrast the level of production-to-consumption improved markedly for South America and Other Europe over the past five years (largely owing to growing production in Argentina, Brazil and the Russian Federation, respectively), with the former region's average ratio over the past five years reaching 100%.
- The five-year average production to consumption ratios has declined slightly for some parts of Asia over the past decade. Notably, the indicator for Eastern Asia dropped from the average of around 100% during 2014/15-2018/19 to 89% over the following five years, mainly reflecting a falling ratio for China.
- In contrast the level of production-to-consumption improved markedly for South America and Other Europe over the past five years (largely owing to growing production in Argentina, Brazil and the Russian Federation, respectively), with the former region’s average ratio over the past five years reaching 100%.

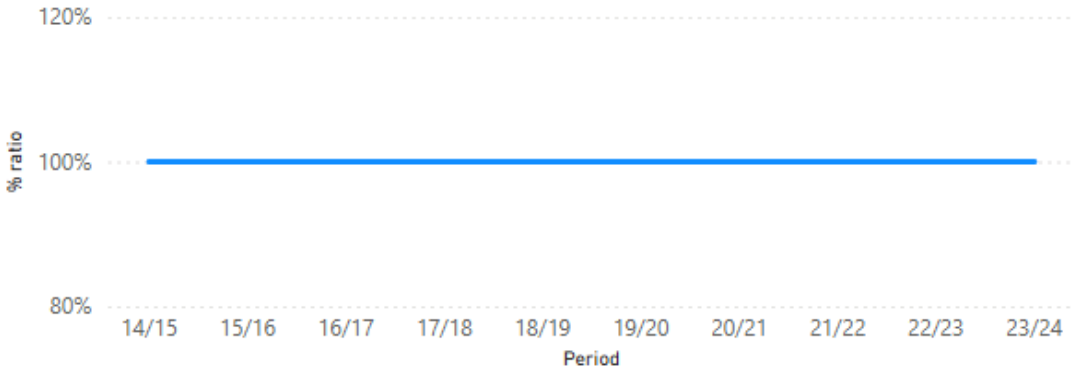


Tab "Production to consumption ratios": Production to consumption ratio in Western Africa.

Tab "Production to consumption ratios": Production to consumption ratio in South-eastern Asia.

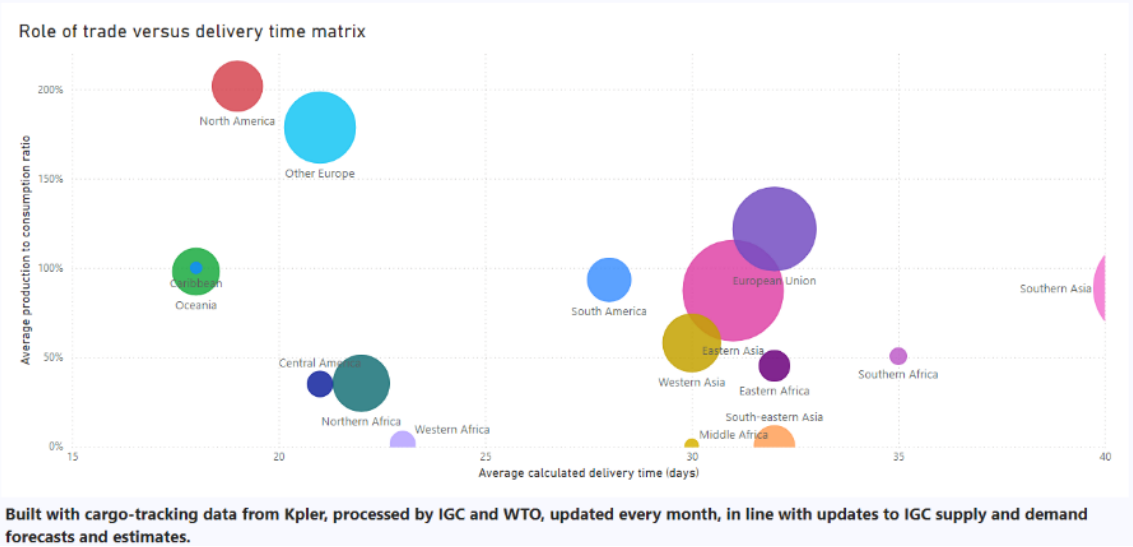


Tab "Production to consumption ratios": Production to consumption ratio in Middle Africa.



Tab "Production to consumption ratios": Production to consumption ratio in the Caribbean.

Impact on net food importing developing countries



Built with cargo-tracking data from Kpler, processed by IGC and WTO, updated every month, in line with updates to IGC supply and demand forecasts and estimates.

Tab "Production to consumption ratios": Role of trade versus delivery time matrix.

- Role of trade versus delivery time matrix (updated at the beginning of each month): Some regions, including Western Africa, South-eastern Asia, Middle Africa and the Caribbean, are almost totally reliant on imports for their domestic consumption of wheat, although the absolute volume of wheat consumption in the latter two regions is relatively small compared to other areas. At the same time, South-eastern Asia and Middle Africa have one of the longest average delivery times of around 30 days (based on calculated journey-related data over the past three seasons).

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.25 International Grains Council (IGC)- Share of fuel in total dry bulk freight costs for various commodities (wheat/durum, soyabeans, sorghums, maize and barley) and various routes based on the latest IGC freight rates

Area	Main relevant findings
Main topic	Essential food commodities; key agricultural inputs
Date of access	January 2025
Type of information source	Dataset
Period under review	November 2024
Relevance	This dataset captures fuel as a component of freight on trade between select ports.
Source	International Grains Council (2024). Share of fuel in total dry bulk freight costs for various commodities (wheat/durum, soyabeans, sorghums, maize and barley) and various routes based on the latest IGC freight rates.

Short summary

This dataset by the International Grain Council contains data on the proportion/percentage of the freight between port pairs that is accounted for by fuel. Data on trade for at least 40 destination ports from the major grain exporter regions/countries are provided.

Global impact

Average of share of fuel in freight costs											
Destination	**Origin**										
	Argentina	***Australia***	***Brazil***	***Canada***	***EU***	***India***	***India2***	***Russia***	***UK***	***Ukraine***	***USA***
Algeria	26%	43%	29%	35%	20%				20%	22%	36%
Angola					37%						
Bangladesh	38%	44%	39%	30%	35%	41%	43%	29%		26%	33%
Brazil	13%			49%							40%
Chile	19%			27%							21%
China	41%	49%	43%	38%	37%			38%		34%	41%
Chinese Taipei	40%	47%	42%	38%							41%
Colombia	25%		28%	24%							14%
Djibouti				26%	22%						26%
Egypt	46%	47%	50%	29%	24%			28%		24%	36%
EU	37%	56%	40%	40%	23%			32%	17%	29%	36%
Ghana				39%				37%		33%	
India		44%						27%		24%	
Indonesia	42%	47%	44%	35%	40%	48%	49%	34%		31%	43%
Iran		47%	39%	33%	28%			30%		25%	35%
Iraq		47%		30%	37%						39%
Japan	41%	49%	43%	37%					35%		41%
Jordan	39%	51%			24%			24%			52%
Kenya	38%		40%	36%	41%			31%		28%	34%
Libya		44%			25%						
Malaysia	42%	47%	44%			47%	48%				47%
Mexico	28%		31%	26%				40%			9%
Morocco	26%		28%	35%	21%			29%		25%	36%
Nigeria	37%			34%	27%			33%		30%	34%
Oman	39%	52%	43%	30%	33%			30%		27%	44%
Pakistan	36%	46%	38%	33%				28%		25%	35%
Russia	32%		36%	39%	20%						32%
S Korea								38%			
Saudi Arabia	38%	50%	34%		26%			24%	23%	21%	42%
South Africa	27%	47%	32%	44%	40%			45%		41%	43%
South Korea	41%	50%	43%	38%	37%			38%		37%	42%
Sri Lanka		48%		31%	37%						31%
Sudan	35%	45%	38%	26%	23%			24%			27%
Thailand	41%	51%	44%	40%						33%	47%
Tunisia	27%		30%	36%	22%			25%		21%	37%
Turkey	46%		48%	39%	23%			26%		21%	39%
UK				36%	30%					33%	33%
Venezuela	24%		26%	23%							15%
Vietnam	40%	47%	42%	38%				35%		31%	44%
Yemen	33%	42%			26%			19%		17%	22%

Dataset by IGC illustrating the share of fuel in freight as of November 2024.

Impact on net food importing developing countries

Not specified.

Impact on least developed countries

Not specified.

Impact on small island developing states

Not specified.

3.26 OECD - Maritime Transportation Costs in the Grains and Oilseeds Sector: Trends, Determinants and Network Analysis

Area	Main relevant findings
Main topic	Essential food commodities; key agricultural input; maritime transport, trade developments and disruptions to global supply chains; and food security in general terms; food security in the context of geopolitical disruptions; food security in the context of the COVID-19 pandemic
Date of publication	2022
Type of information source	Policy paper (55 pages)
Period under review	2007-2021
Relevance	This policy paper examines maritime transportation costs in the grains and oilseeds sector using the database on ocean freight rates developed by the International Grain Council (IGC).
Source	Deuss, A., Maggi, F., & Frezal, C. (2022). *Maritime Transportation Costs in the Grains and Oilseeds Sector: Trends, Determinants and Network Analysis*. Paris: OECD Publishing. Retrieved 17 January 2025, from https://doi.org/10.1787/b1cdf6b7-en

Short summary

More than 80% of global trade in grains and oilseeds is carried by ships. This paper explores to what extent trade in the grains and oilseeds (soybeans, wheat, sorghum, maize and barley) is impacted by maritime transport costs. Grains and oilseeds are essential food commodities and also are used as feedstock for rearing livestock. The staple crops continue to experience growing demand with trade in oilseeds and grains growing by around 70% in volume terms over the last decade.

Global impact

- Distance is the most important determinant of freight rates; a 10% increase in the sailing distance between origin and destination ports leads to an estimated 2.5% increase in freight rates. For economies whose import and export trading partners are far removed from them, this can be significant (p. 4).
- The quantity shipped has no significant impact on the freight rates of grains and oilseeds. This means that there are no scale economies in shipping in this sector and that countries that ship large quantities do not exhibit significantly lower freight rates than countries shipping smaller quantities (p. 4).
- The free-on-board (fob) price of the food products did not appear to have a significant effect on freight rates over the long term (2010-2021) (p. 5).
- The role of freight rates in consumer prices reinforces the importance to have reliable, transparent and timely information on freight rates and on the components and determinants of freight rates (p. 5).
- Trade costs of these essential commodities do not only affect the prices of these goods in importing countries, but they also influence the domestic prices of bread, meat and other food products (p. 6).

- Even though ocean freight rates are an important component of trade costs for grains and oilseeds, there are no recent and in-depth studies available on this topic. This is particularly relevant since the COVID-19 pandemic has sent shockwaves through global maritime transport and shipping costs have soared to multi-year high levels in recent months (p. 6).
- A select number of ports play a crucial role in importing and exporting grains and oilseeds, which implies that any disruption or logistical problem can quickly escalate and have serious impacts on shipments and thus availability of commodities (p. 36)

Impact on net food importing developing countries
Not specified.

Impact on least developed countries
Not specified.

Impact on small island developing states
Not specified.

3.27 SDG PULSE - International trade in open and transparent markets may help alleviate the effects of shocks and ensure food security

Area	Main relevant findings
Main topic	Essential food commodities; maritime transport, trade developments and disruptions to global supply chains; food security in general terms
Date of publication	2024
Type of information source	Online chapter
Period under review	2018-2022
Relevance	The online chapter discusses how the goal to end hunger is falling further behind schedule
Source	SDG PULSE. (2024). Chapter "International trade in open and transparent markets may help alleviate the effects of shocks and ensure food security". Retrieved on 19 December 2024, from https://sdgpulse.unctad.org/trade-agriculture-biotrade/#

Short summary

The online chapter discusses the importance of a well-functioning global trade system in ensuring that the Goal 2 of the 2030 Agenda which aims to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" is realised by 2030. To achieve this goal, global market access to nutritious food through international trade and cross-border cooperation is essential.

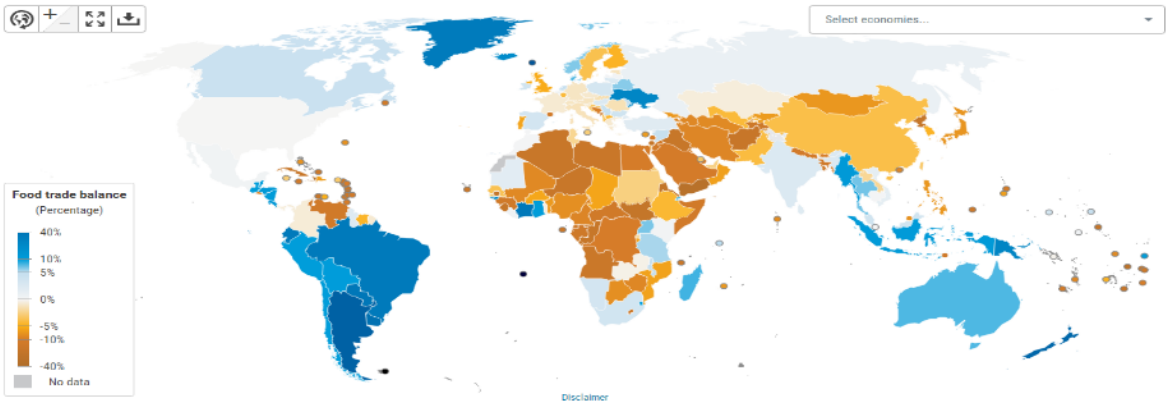
Global impact

- “Globally, in pure calorie terms, there is enough food to feed the world. The average person living on the planet needs a minimum of 1 830 kcal per day to avoid undernourishment and about 2 360 kcal per day for optimal health. In 2021, the food available per person amounted to 2 978 kcal per day, up from 2 854 kcal in 2011”. This is because the factors which affect food production are unevenly distributed across time and space, highlighting the need for a truly diversified global food market.

- Two thirds of economies worldwide are net food importing countries with many of them, including many LDCs, in the Middle East and Africa. Contrast that with South America which has several net food-exporting countries (map 1). The average NFIDC recorded a net food import balance that was 4.4 percent of its total imports with SIDS reaching 13% of total imports.

Map 1. Both large net food exporters and importers are found in the global south

Trade balance in basic food as a ratio to total imports, 2018-2022, percentage

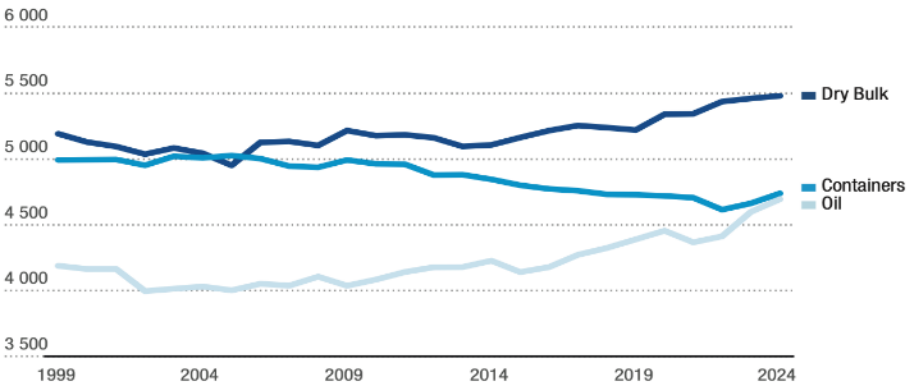


Source: UNCTAD calculations based on UNCTADstat (UNCTAD, 2024a)
Notes: The trade balance in basic food is calculated as exports minus imports of basic food excluding tea, coffee, cocoa and spices (SITC 0 + 22 + 4 less 07) between 2018 and 2022. The percentage displayed is reached by dividing this trade balance with total imports of all goods for the economy in the same period.

Map 1 illustrating trade balance in net food exporters and importers.

- Trade helps countries, especially LDCs, to balance out their food deficits, increasing both the total amount of calories supplied and the diversity of food available for consumption while a well-functioning global value chain in the agro-food sector creates opportunities for producers in developing economies, contributing to local economic development.
- Recent disruptions in the Black Sea, Red Sea and Panama Canal accelerate an increase in shipping distances. Diverting ships around Africa generates extra miles and longer transit times, resulting in additional operational costs, risks, legal claims for delayed vessels, disrupted shipments, damaged ships, and spoiled cargo. Longer transit times resulting in off-schedule deliveries necessitate higher inventories and negatively affect just-in-time delivery systems. The Red Sea crisis alone has led the average container shipping spot rates to increase notably.

Figure 10.
Recent disruptions in the Black Sea, Red Sea and Panama Canal accelerate an increase in shipping distances.
Average distance travelled in nautical miles



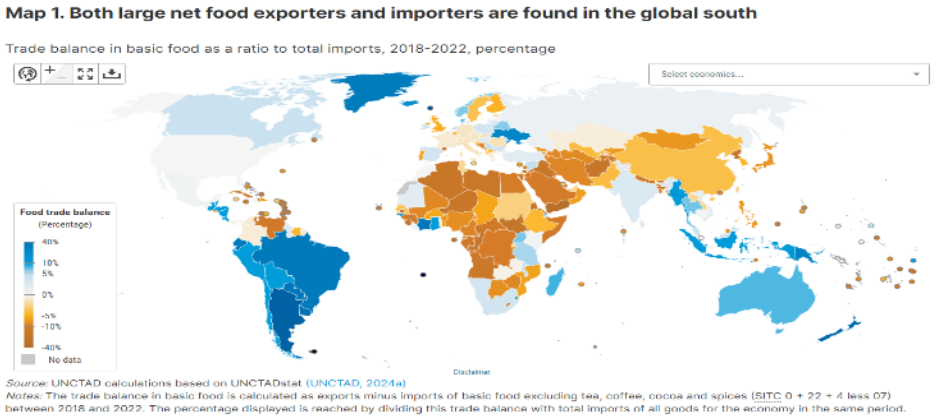
Source: UNCTAD (2024b) based on data from Clarksons Reseach (2024b)
Note: Distances for 2024 are forecasts.

Figure 10 illustrating the increase in shipping distances from recent disruptions from 1999 to 2024.

- Conflicts and weather extremes are major drivers of food crises, contributing to increasing hunger, in addition to other conditions where people cannot afford to buy food in appropriate quantities and quality. Economic downturns and high food prices are increasingly making adequate nutrition out of reach for people with limited means *(FAO et al., 2023)*.

Impact on net food importing developing countries

- Two thirds of economies worldwide are net food importing countries with many of them, including many LDCs, in the Middle East and Africa. Contrast that with South America which has several net food-exporting countries (map 1). The average NFIDC recorded a net food import balance that was 4.4 percent of its total imports with SIDS reaching 13% of total imports.



Map 1 illustrating trade balance in net food exporters and importers.

Impact on least developed countries/small island developing countries

- LDCs are particularly exposed to food insecurity. In 2022, about 690 million people, or 61 per cent of their population, faced moderate or severe food insecurity, compared to around 46 per cent in SIDS and 8 per cent in high-income countries (figure 2). For LDCs, this marks a 9-percentage point increase from 2018. However, the prevalence of moderate and severe food insecurity varies significantly among LDCs, with an average of 89 per cent in Sierra Leone and 29 per cent in Myanmar *(FAO, 2024a)*.

3.28 World Trade Organization (WTO) 12th Ministerial Conference (MC 12) – Ministerial Declaration on the Emergency Response to Food Security

Area	Main relevant findings
Main topic	Food commodities; key agricultural input; food security in general terms
Date of publication	17 June 2022
Type of information source	Ministerial Declaration
Period under review	Not applicable
Relevance	
Source	World Trade Organization 12th Ministerial Conference (MC 12) – Ministerial Declaration on the Emergency Response to Food Security *WTO | Ministerial conferences - Twelfth WTO Ministerial Conference - Geneva Switzerland*

Short summary

WTO's 12th Ministerial Conference (MC12) took place from 12 to 17 June 2022 at WTO headquarters in Geneva. Ministers from across the world attended to review the functioning of the multilateral trading system, to make general statements and to take action on the future work of the WTO.

The MC12 outcome package on agriculture comprised a *Ministerial Declaration* on the emergency response to food insecurity and a *Ministerial Decision* on exempting World Food Programme (WFP) humanitarian food purchases from export prohibitions or restrictions. Both respond to demands from the international community for immediate action by WTO members to address food shortages and soaring food prices and ensure that the most vulnerable can access emergency food aid.

The Declaration underlines the strong commitment by WTO members to take concrete steps to facilitate trade, which plays a vital role in improving global food security, and improve the functioning and resilience of global food markets. It also reaffirms the importance of not imposing export prohibitions or restrictions on agri-food trade in a WTO-inconsistent manner.

In November 2022 the Work programme on food security to help least-developed countries (LDCs) and net food-importing developing countries (NFIDCs) increase their resilience to food insecurity was established as mandated by the Declaration on the Emergency Response to Food Insecurity adopted at the 12th Ministerial Conference. The Programme was established under the auspices of the Committee on Agriculture.

Extracted from the Declaration.

Global impact
Not specified.

Impact on net food importing developing countries
Please see below.

Impact on least developed countries

- 3. We commit to take concrete steps to facilitate trade and improve the functioning and long-term resilience of global markets for food and agriculture, including cereals, fertilizers, and other agriculture production inputs. Particular consideration will be given to the specific needs and circumstances of developing country Members, especially those of least-developed and net food-importing developing countries.
- 5. We resolve to ensure that any emergency measures introduced to address food security concerns shall minimize trade distortions as far as possible; be temporary, targeted, and transparent; and be notified and implemented in accordance with WTO rules. Members imposing such measures should take into account their possible impact on other Members, including developing countries, and particularly least-developed and net food-importing developing countries.
- 8. We reaffirm the importance of effective implementation and monitoring of the Marrakesh Decision on Measures Concerning the Possible Negative Effects of the Reform Programme on Least-Developed and Net Food-Importing Developing Countries. In this regard, we commit to having a dedicated work programme in the Committee on Agriculture to examine how this Decision could be made more effective and operational pursuant to Article 16 of the Agreement on Agriculture and to consider concerns raised by Members in their current and future submissions. The work programme shall consider the needs of LDCs and NFIDCs to increase their resilience in responding to acute food instability including by considering the best possible use of flexibilities to bolster their agricultural production and enhance their domestic food security as needed in an emergency.
- 9. We understand the importance of providing technical and financial assistance to LDCs and NFIDCs, including through international and regional financial institutions, with a view to improving their agricultural productive capacity, infrastructure and access to agricultural inputs.

Impact on small island developing states
Not specified.