Hacettepe University Graduate School of Social Sciences

Department of Economics

THREE ESSAYS ON FOOD SECURITY: SUSTAINABLE DEVELOPMENT, STRUCTURAL DRIVERS AND AGRICULTURAL PRICE DYNAMICS

Nisa Şansel TANDOĞAN AKTEPE

Ph.D. Dissertation

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to my little Bunny, Arya Derin,
I've always known that
there's nothing we can't overcome together,
and never will be.
This work is dedicated to you,
my beautiful daisy.
We will keep turning
dreams into reality together.

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ABSTRACT

TANDOGAN AKTEPE, Nisa Sansel. *Three Essays on Food Security: Sustainable Development, Structural Drivers and Agricultural Price Dynamics,* Ph.D. Dissertation, Ankara, 2025

This dissertation constitutes of three essays that focus on the role of food (in)security in sustainable development, identifying structural drivers of food (in)security with the COVID-19 period and the determination of the factors influencing agricultural price changes by taking three distinct crises (Global Food Crisis (2008–2009), also called the global financial crisis; Russia–Türkiye aircraft crisis (2015–2016), and the COVID-19 pandemic (2019–2021)) into account. The first framework provides insight into the significant role of food security/insecurity in sustainable development. This chapter unbares the vicious circle between the food security and SDGs because a factor can serve as both a primary cause and a trigger or outcome, even some factors can act as both the cause and consequence of a determinant. Initiating action on these interconnected factors can trigger a butterfly effect within that vicious circle, potentially transforming it into a virtuous circle, ensuring the foundation for sustainable development.

In the second study, we investigate to identify structural drivers of food (in)security with the COVID-19 period, during which food (in)security emerged as a prominent global concern. The study was conducted on the 2004-2022 period and 138 countries and applied through System GMM model. Based on the six key factors (economic, governmental, agricultural, political, demographical and environmental) and one external shock (COVID-19 pandemic), we provide a general picture of the topic and yielded striking findings about food (in)security. The findings we obtained reveal the importance of the lagged value of the prevalence of undernourishment, inflation, food production, rural population, cereal import dependency and COVID-19 pandemic. Among them, the variables including the lagged value of *PoU (prevalence of undernourishment)*, COVID-19 pandemic, food production, inflation and cereal import dependency from the most to the least influential have been determined as triggering and aggravating factors on the food insecurity. The rural population appears the only positive influence on food security in our analysis. Taking some measures and improvements grounded on better production, distribution, income level, infrastructure and policies may exhibit considerable potential on production growth, stronger national food systems and thus reducing the severity of food insecurity.

The third focal point of our study is to examine the determinants of agricultural price fluctuations in Türkiye between 2002 and 2021, with particular attention to the impacts of three major crises (Global Food Crisis (2008–2009), also called the global financial crisis; Russia–Türkiye aircraft crisis (2015–2016), and the COVID-19 pandemic (2019–2021)) of different causes. To capture both short- and long-term dynamics, the Autoregressive Distributed Lag (ARDL) model is employed. The findings indicate that, among the selected agricultural products and potential explanatory variables, the most influential

drivers of price changes are government effectiveness, regulatory quality, nitrogen use, water pricing, money supply, exchange rate, and GDP, each within their respective categories.

Keywords

Food Security, Agricultural Product Prices, Sustainable Development Goals, Global Food Crisis, COVID-19 Pandemic, Global Crises

ÖZET

TANDOGAN AKTEPE, Nisa Sansel. *Gıda Güvenliği Üzerine Üç Makale: Sürdürülebilir Kalkınma, Yapısal Etkenler ve Tarımsal Fiyat Dinamikleri*, Doktora Tezi, Ankara, 2025

Bu tez, sürdürülebilir kalkınma bağlamında gıda güvenliği/güvensizliğinin rolünü, COVID-19 dönemiyle birlikte gıda güvenliği/güvensizliğini belirleyen temel faktörlerin tespitini ve üç farklı kriz çerçevesinde tarımsal ürün fiyatlarındaki değişimleri etkileyen unsurların analizini konu alan üç makaleden oluşmaktadır.

Birinci bölüm, gıda güvenliği/güvensizliğinin sürdürülebilir kalkınmadaki önemli rolüne dair derinlemesine bir çerçeve sunmaktadır. Bu bölümde, gıda güvenliği ile Sürdürülebilir Kalkınma Amaçları (SKA'lar) arasındaki döngü ortaya konulmaktadır. Öyle ki bazı unsurlar, bir faktörün hem ana faktörü ve/veya tetikleyici faktörü olarak hem de sonucu olarak işlev görürken, kimi durumlarda bir etkenin hem nedeni hem de sonucu olarak rol oynayabilmektedir. Bu karşılıklı etkileşim içinde olan faktörlere yönelik müdahaleler, söz konusu kısır döngü içinde bir kelebek etkisi yaratarak, sürecin verimli bir döngüye dönüşmesini sağlayarak sürdürülebilir kalkınmanın temellerinin güçlendirilmesine katkı sunabilmektedir.

İkinci çalışmada, COVID-19 döneminde küresel bir sorun olarak öne çıkan gıda güvenliği/güvensizliğinin yapısal belirleyicilerini tespit etmeye yönelik bir analiz gerçekleştirilmektedir. Çalışma, 2004-2022 dönemini ve 138 ülkeyi kapsamakta olup, analiz için Sistem-GMM modeli tercih edilmektedir. Altı temel faktör (ekonomik, yönetimsel, tarımsal, politik, demografik ve çevresel faktörler) ile bir dış şok (COVID-19 pandemisi) temelinde genel bir çerçeve sunularak gıda güvenliği/güvensizliğine ilişkin çarpıcı sonuçlar elde edilmiştir. Elde edilen sonuçlar, yetersiz beslenme yaygınlığının gecikmeli değeri, enflasyon, üretim, kırsal nüfus, tahıl ithalatına bağımlılık ve COVID-19 pandemisinin gıda güvenliği/güvensizliği üzerindeki etkilerini ortaya koymaktadır. Bu değişkenler arasında, en çok etkili olandan en az etkili olana doğru sırasıyla yetersiz beslenmenin gecikmeli değeri, COVID-19 pandemisi, üretim, enflasyon ve tahıl ithalatına bağımlılık, gıda güvenliğini tetikleyen ve daha da kötüleştiren etkenler olarak belirlenmiştir. Buna karşın, yalnızca kırsal nüfusun gıda güvenliği üzerinde olumlu bir etkisi olduğu görülmektedir. Üretim, dağıtım, gelir düzeyi, altyapı ve politikalara yönelik iyileştirmeler ve alınacak önlemler, üretim artışı, daha sağlam ulusal gıda sistemleri ve dolayısıyla da gıda güvensizliğinin şiddetinin azaltılması açısından oldukça önemlidir.

Çalışmanın üçüncü odak noktası, farklı sebeplerden kaynaklanan krizlerin (Küresel Gıda Krizi/Küresel Finansal Kriz (2008–2009), Rusya-Türkiye Uçak Krizi (2015–2016), ve COVID-19 pandemisi (2019–2021)) etkilerini göz önünde bulundurarak, 2002-2021 dönemi için Türkiye'deki tarımsal ürün fiyatlarındaki değişimlerin gerisindeki belirleyicilerin analiz edilmesidir. Fiyat değişiminde etkili olan faktörlerin uzun ve kısa vadeli etkilerini değerlendirebilmek amacıyla Otoregresif Dağıtılmış Gecikmeli Modeli (ARDL) uygulanmıştır. Tarımsal ürünlerdeki fiyat değişimlerine yönelik olarak seçilen ürünler ve

potansiyel belirleyiciler aracılığıyla elde edilen sonuçlar; ilgili kategoriler altındaki kamu yönetimi etkinliği, regülatif kalite, azot kullanımı, su fiyatı, para arzı, döviz kuru ve gayrisafi yurtiçi hasıla (GSYİH) değişkenlerinin, fiyat değişimlerin de en etkili faktörler olduğunu ortaya koymaktadır.

Anahtar Sözcükler

Gıda Güvenliği, Tarımsal Ürün Fiyatları, Sürdürülebilir Kalkınma Hedefleri, Küresel Gıda Krizi, COVID-19 Pandemisi, Küresel Krizler

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ABBREVIATIONS

ADB	Asian Development Bank
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criteria
AR	Autoregressive
ARDL	Autoregressive Distributed Lag
BIST	Borsa Istanbul
BPG	Breusch-Pagan-Godfrey
CPI	Consumer Price Index
C-VAR	Co-integrated Vector Autoregressive
DIF-GMM	Differenced Generalized Method of Moments
EBRD	European Bank for Reconstruction and Development
EU	European Union
FAO	The Food and Agriculture Organization
FE	Fixed Effects Model
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HIV	Human Immunodeficiency Virus
IFPRI	International Food Policy Research Institute
IFAD	International Fund for Agricultural Development

ILO	International Labour Organization
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
POLS	Pooled Ordinary Least Squares
RE	Random Effect Model
REER	Real Effective Exchange Rate
SDG	Sustainable Development Goal
SVAR	Structural Vector Autoregression
SVECM	Structural Vector Error Correction Model
SYS-GMM	System Generalized Method of Moments
TURKSTAT	Turkish Statistical Institute
UK	United Kingdom
UN	United Nations
UN.ESCAP	UN Economic and Social Commission for Asia and the Pacific
UNCTAD	UN Trade and Development
UNDP	United Nations Development Programme
UNNCD	United Nations Convention to Combat Desertification
US	United States
USDA	United States Department of Agriculture
VEC	Vector Error Correction
VECM	Vector Error Correction Model

WFP	World Food Programme
WHO	World Health Organization
WPI	Water Price Index
WTO	World Trade Organization

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INTRODUCTION

With the currently problems and hard conditions in the world, it is unnervingly seen that as long as nothing changes, humanity will face increasingly challenging days ahead in every aspect. Such that the term “crisis” currently evokes a multitude of concepts including global warming, proxy wars, pandemics, food insecurity and more, unlike the perception of negative financial circumstances before. Especially in recent years, the extreme events such as pandemics and global warming, which have affected the whole world, have once again brought the food insecurity problem on the agenda. While the extreme events experienced lead countries to ask the question of self-sufficiency, the supply-demand problem that emerged with the changing world order has also come to light. Undoubtedly that there are numerous drivers and triggering factors behind these problems such as consumption frenzy, a remarkable decreasing amount of agricultural production and efficiency, paying less attention to the agricultural sector than other sectors etc. Therefore, even if coping with these situations is an extremely tough issue because of including also using natural resources unconsciously and their depletion to a great extent, in order to intervene before it is too late and to prevent worse outcomes, action must be taken from some point. Otherwise, the existing system, which threatens the "food" being essential requirement of humanity, will annihilate whole humanity, not to be restricted with the economies, environment, society, human health etc. In this sense, the present dissertation is constituted on the purpose of addressing some issues on food security from different perspectives and set a comprehensive framework. This study employs a general-to-specific framework, starting with the role of food security in sustainable development and gradually narrowing its focus to the structural drivers of food insecurity and the dynamics of agricultural pricing. By delving into the subject in depth, this approach enables a deeper understanding of the core of the issue, allowing for the identification of both the key factors leading to food insecurity and those resulting from it. The findings aim to provide a solid foundation for actionable steps and policy recommendations to reduce food insecurity, which are expected to serve as a valuable guide not only for enhancing food security but also within the broader context of sustainable development.

The first study handles the issue in terms of the key role of food insecurity in sustainable development and addressed the issue in detail. Although food security had not been a primary concern in previous periods, recent unfavorable incidents have underscored its increasing significance, bringing it to the forefront of policy and academic discourse. It is much more vital issue than thought because it has multidimensional impacts on society, economics and development rather just being "nutritional requirement". Its pivotal role is obvious when considering that food security underlies the many goals of sustainable development set by United Nations. For this purpose, this part gives insight into the relationship between food security and sustainable development. The study including crises, food inflation, climate change and loss in production gives an impressive outline. The analysis reveals a bilateral relationship between food insecurity and sustainable development. Food insecurity adversely affects sustainable development, while positive changes in sustainable development have a beneficial impact on food security. This interconnectedness can be viewed as a vicious circle that has the potential to transform into a virtuous circle through timely intervention. Within this cycle, the primary causes of food insecurity include demographic characteristics, food inflation, crises, climate change, and inadequate agricultural production; and the potential outputs seem on social welfare principally as health, education and social order. These outputs will be in a higher level with the positive changes in food security and moreover they ameliorate national interests and sustainable development.

The second focus is on factors influencing the number of undernourished people (representing food insecurity). Because food security needs multidimensional system improvement and should provide *availability, accessibility, utilization* and *stability,* meeting the four conditions and having control over the factors, especially with the unexpected issues such as COVID-19 pandemic and the Russia-Ukraine war, make the issue more complex. Therefore, this paper aims to elucidate this issue on eight potential variables under six main factors (economic factor, environmental factor, demographical factor, governmental factor, political factor, agricultural factor) along with an external shock (COVID-19 pandemic) as an exogenous factor. In this comprehensive study, 138 countries (consisting of approximately 94 percent of the world population) were examined based on the period from 2004 to 2022. The striking findings obtained by

System-GMM model reveal that the variables including the lagged value of *PoU*, COVID-19 pandemic, food production, inflation and cereal import dependency, from the most to the least influential, are triggering and aggravating factors on the prevalence of undernourished people; and rural population is the only decreasing factor. The result highlights the necessity and the importance of long-term structural reforms which involve better production, distribution, income level, infrastructure and policies, rather than the provisional solutions.

The last part of the dissertation tries to unravel the major determinants behind price changes, which represents one of the most critical factors causing food insecurity, in selected representative agricultural products. Undoubtedly that crises have a significantly incremental effect on price volatility because prices are affected by crises and react to them very quickly. When it comes to food crisis, changes in agricultural product prices are inevitable. However, apart from the crises, there are also other numerous factors sparking off this change affecting every segment of society. Considering "food" as a basic need for life, it should be available, accessible and utilized by everybody, and for that reason the prices should be stabilized and preserved at optimum level. Because keeping that level is contingent upon several factors, analyzing the potential factors makes a great contribution to understand the high-impact ones and establish the policy towards these ones. For this purpose, this part of the dissertation elaborates on this issue under four categories as governmental effects, agricultural inputs, macroeconomic indicators, and climatic conditions. Because these factors represent both national, international and global measures, the results are more effective in terms of distinguish between the issues that can be intervened and not. Moreover, selection of the agricultural products as subsistence goods and industrial goods (cash crops) displays the differences depending on the agricultural product. In this direction, among the most significant ones, the findings obtained by using ARDL model reveal the increasing impact of nitrogen use and decreasing impact of GDP on prices for maize and wheat in the long run. For short run, while the governmental effect has a decreasing impact on prices, changes in regulatory quality has an increasing impact. When the results on three crises including global food crises, Türkiye-Russia aircraft crisis and COVID-19 pandemic are examined, unfortunately it is not possible to

mention about a general result because the direction of impact has changed depending on the products and the terms.

CHAPTER 1

THE KEY ROLE OF FOOD INSECURITY IN SUSTAINABLE DEVELOPMENT: FROM VICIOUS CYCLE INTO VIRTUOUS CIRCLE

1.1. INTRODUCTION

The humanity has been faced to many different-sourced extreme events and upheavals in recent years. While certain crises like political conflicts and financial downturns may have a relatively temporary impact on the nations or the global economy, others such as climate change and pandemics have enduring and far-reaching consequences for the humanity. The analysis of these extreme facts reveals a central concern impacted by all of them: food insecurity. This issue has been exacerbated with each new event globally, further intensified by shifts in human lifestyles and preferences.

Firstly, defined at the World Food Summit as the "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (United Nations (UN), 1975), food security problem has evolved parallel to four contemporary dimensions. Today, this dimension includes four concepts: *availability, accessibility, utilization,* and *stability* (Food and Agriculture Organization of the United Nations (FAO), 2006). Among these dimensions, *food availability* means ensuring sufficient food within the context of supply and demand systems. *Food* a*ccessibility* encompasses both economic and physical access to food. *Food utilization* covers the impact of insufficient food intake and utilization. Finally, *food stability* focuses on the resilience of countries in the face of volatility or circumstances that could lead to instability.

In addition to the existing challenges related to agricultural issues impacting food security, problems such as food accessibility and acquisition further exacerbate the situation. Even with sufficient food supply and increased production, it doesn't restrain the hunger, malnutrition and food riots and serve the purpose unless the equal accessibility and acquisition are ensured (Falk, 2020).

Indeed, these dimensions of food security elucidate the requirements for a sustainable economy encompassing social, environmental, and political aspects. The 2030 Agenda for Sustainable Development, adopted by UN member states in 2015, sets 17 goals aimed at promoting global peace and prosperity. Notably, at least 11 of these goals are directly or indirectly linked to food security. Therefore, ensuring food security plays a crucial role in economies and influences various dynamics such as poverty, employment, and social justice conditions of these countries. This chapter aims to delve into the significant role of food security/insecurity in sustainable development, highlighting its greater importance for economies rather than the provisional growth and development.

As the reasons and consequences of food insecurity form a vicious circle, examining its influencing factors provides a comprehensive overview of its role. Section 2 outlines the primary determinants of food insecurity. Section 3 presents its consequences, while Section 4 explores the relationship between food insecurity and sustainable development. The final section summarizes the findings of the chapter.

1.2. SUSTAINABLE DEVELOPMENT

1.2.1. The Concept of Sustainable Development

The concept of development is a concept that has historically emerged from the difference in economic development between the countries that entered the industrialization process and succeeded in industrialization following the Industrial Revolution and the countries that fell behind/could not be included in this process. For this reason, development has gained a different dimension since the 20th century, when this difference began to be evaluated from a social perspective. The addition of a number of social development goals, in addition to economic development, to the development pursuits of countries has made it necessary to add a much more dynamic perspective to the phenomenon of development. While it is generally referred as economic growth in 1950s; indicators of a social nature as well as indicators of an economic natures in 1960s, and new socioeconomic indicators such as human development, social welfare, education, infant mortality in the late 1970s are included in this concept (Turhan, 2020). The progress of the development dynamics in question can be followed in Table 1.1. below.

Table 1.1. The progress of development over time

PERIOD	PERSPECTIVES	MEANINGS OF DEVELOPMENT
1800 >	Classical Political Economy	Remedy for progress
1850 >	Colonial Economics	Resource Management, Trusteeship
1870 >	Latecomers	Industrialization
1940 >	Development Economics	Economic growth
1950 >	Modernization Theory	Growth, Political and Social Modernization
1960 >	Dependency Theory	Accumulation – National, Autocentric
1970 >	Alternative Development	Human Flourishing
1980 >	Human Development	Capacitation, Enlargement of People's Choices
1990 >	Post-development	Authoritarian Engineering, Disaster
2000	Millenium Development Goals	Structural Reforms

Source: Pieterse (2001)

That notion has gained a global nature after World War II as many significant changes, such as the acceleration of technological advancements and industrial developments, rapid population growth, and the rise in exploitation of natural resources, occurred. Moreover, this period was a turning point where development was regarded as a project following the speech "Point Four Program" by U.S. President Truman in 1949. He proposed sharing American know-how across various-fields particularly in agriculture, industry and health to help third world nations which are not aligned with NATO or the Soviets. This was shown as a technical assistance program which will raise living standards and provide the welfare of individual on the development path. Indeed, this was a veil that obscured the primary objective of making American hegemony permanent.

> *We must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas. More than half the people of the world are living in conditions approaching misery. Their food is inadequate. They are victims of disease. Their economic life is primitive and stagnant. Their poverty is a handicap and a threat both to them and to more prosperous areas. For the first time in history, humanity possesses the knowledge and skill to relieve suffering of these people. The United States is pre-eminent among nations in the development of industrial and scientific techniques. The material resources which we can afford to use for assistance of other peoples are limited. But our imponderable resources in technical knowledge are constantly growing and are inexhaustible. I believe that we should make available to peace-loving peoples the benefits of our store of technical knowledge in order to help them realize their aspirations for a better life. And, in cooperation with other nations, we should foster capital investment in areas needing development. (Truman, 1949)*

The country or region classification was made before in some statements, primarily by Wilfred Benson, a former member of the Secretariat of the International Labour Organization, as the "under-developed areas" in 1942 (Benson, 1942) and by Rosenstein-Rodan as the "economically backward areas" in 1944 (Rosenstein-Rodan, 1944). However, it only acquired relevance in Truman's this speech in 1949 (Esteva, 2010). This speech transmogrified the notion of "development" and served the American hegemony. Besides, 'more than half the people of the world' became 'underdeveloped'. According to Esteva (2010), this means that the people abandon being what they were and their diversity, and transformed into a distorted reflection of others' reality. Moreover, this identity of heterogeneous and diverse majority was defined as the identity of a simply homogenizing and narrow minority. Consistently with this idea, Escobar (1992) states that development is the force shaping the contemporary Third World, operating subtly and often unnoticed. Through this discourse, the addressees (individuals, governments and communities) were placed in circumstances that lead them to perceive themselves as such, and treated in accordance with this designation consequently.

The attainment of development awareness by post-colonial societies following their independence, along with the actions of developed economies to assert dominance by controlling underdeveloped countries, is cited as the key driver behind the post-war progress of development economics (Freyssinet, 1985).

Besides, Rostow (1956) presents the process of self-sustained growth. According to this growth, characterized by new, high-productivity production functions, tends to naturally increase per capita output. It shifts income to individuals who not only save a significant portion of the growing income but also reinvest it into highly productive ventures. This growth generates a chain of effective demand for additional manufactured goods, creates a need for larger urban areas, whose capital costs may be substantial, yet whose population and market structures facilitate the continuous process of industrialization. Lastly, it generates a variety of external economic effects that ultimately contribute to the emergence of new leading sectors when the initial momentum of the leading sectors starts to diminish. When looking into “Four Asian Tigers” case, the government savings is one of the pivots representing their remarkable economic growth and development during the latter part of the 20th century because it indicates the effectiveness of macroeconomic policies, and their indirect impact on inflation and exchange rate. For the countries under “Tigers” (Hong Kong, Singapore, South Korea and Taiwan), the overall gross national saving rate was very high at an average rate of 31% of GDP over the past decade (Chow, 2010). This persistently high savings level can be ascribed to fundamental determinants shaping long-term trends in private savings, including economic growth, demographic dynamics, and the degree of financial uncertainty experienced by households (Loayza et al., 2000). Therefore, it accelerated the development process.

By 1987, the notion of “sustainable development” was introduced into the literature through a Brundtland report (1987). Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” and the importance of environmental matters integration to development strategies was included and emphasized in this report. Moreover, it highlights that the necessities of a new orientation in international relations, and changes in both domestic and international policies of every nation for the

pursuit of sustainable development. The process that began with this development can be seen as a significant milestone for the concept of development. With the contribution of Amartya Sen, sustainable development evaluated by the perspective on capabilities, which give individuals real freedoms to achieve their potential doings and beings, and associated to the precious life (Sen, 1999). In parallel with this innovative approach, UNDP defined the human development as "a process of enlarging people's choices" in 1990 (UNDP, 1990). In accordance with UNDP, in principle, these choices can be infinite and change over time. But for all levels of development, three elements are essential for people to lead a long and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living. If these essential choices are not available, many other opportunities remain inaccessible". After the evolution of the development notion in time, a generally accepted fact has emerged regarding the importance of human capital and human development. Hence, the notion gained an extensive meaning including health, welfare, environment etc. as well, rather than referring only economic growth.

1.2.2. The Progress of Development Goals

When looking at the evolution of the definition of sustainable development over time, it is inevitable that the factors capable of achieving such development also vary. For this reason, the development goals from the 2000s to the present have been further developed in line with the changing conditions and requirements that have emerged over time.

By the 1990s, numerous influential reports were prepared and various lists of development goals were created (Barbier and Burgess, 2021). These can be specified as "Shaping the 21st Century" (OECD, 1996), the "Human Development Report 1997" (UNDP, 1997) and "We the Peoples" (Annan, 2000). The *Shaping the 21st Century* report, created by OECD Development Assistance Committee, sets a series of measurable international development goals and aims to reduce global poverty. This report is of pivotal importance in the development process and perspective as it introduces a new approach to development aid, forms the foundation of international development goals, provides cooperation between developed and developing countries, and ensures measurability and accountability. The *Human Development Report 1997*

published by UNDP, expands the concept of development beyond the dimension of poverty, focusing on a human-centered approach to development. In this regard, the scope of the Human Development Index has been broadened and the issues such as human security, poverty and income distribution, women's rights and gender equality, and the democratic governance have gained greater importance. Thus, this report makes a significant contribution to the provision of fairer and more sustainable development strategies. The *We the Peoples* report, published by the United Nations in 2000, aims to use globalization in a positive sense by addressing some of the urgent challenges faced by the world's people. In this regard, it covers various issues such as governance, employment, education, health, aid for the poor and new investment opportunities, and security. It highlights the responsibilities and commitments of the international community to achieve global goals, and presents a vision of how collaboration and cooperation can be achieved. In September 2000, after all these opinions, the 189 member countries under the United Nations gathered to fight poverty and signed the Millennium Declaration, commonly known as the "Millennium Development Goals (MDGs)" (UN, 2015a). These goals were constituted of 8 primary objectives, as can be seen in Figure 1.1. A large majority of these objectives consist of targets related to economic and social dimensions, except for Goal 7 related to the environmental sustainability. However, this approach has faced some criticism regarding its effectiveness in achieving the goal. For instance, Easterly (2009) asserts that the MDGs were intended as a key instrument to stimulate development efforts in low-income countries; however, they ultimately became inadequately and arbitrarily structured to measure the progress in addressing poverty and deprivation. Despite the relative effectiveness of the MDGs, all targets were not achieved after the 15-year implementation period (2000-2015). Therefore, the SDGs were introduced to update and advance the global development agenda (Mensah, 2019).

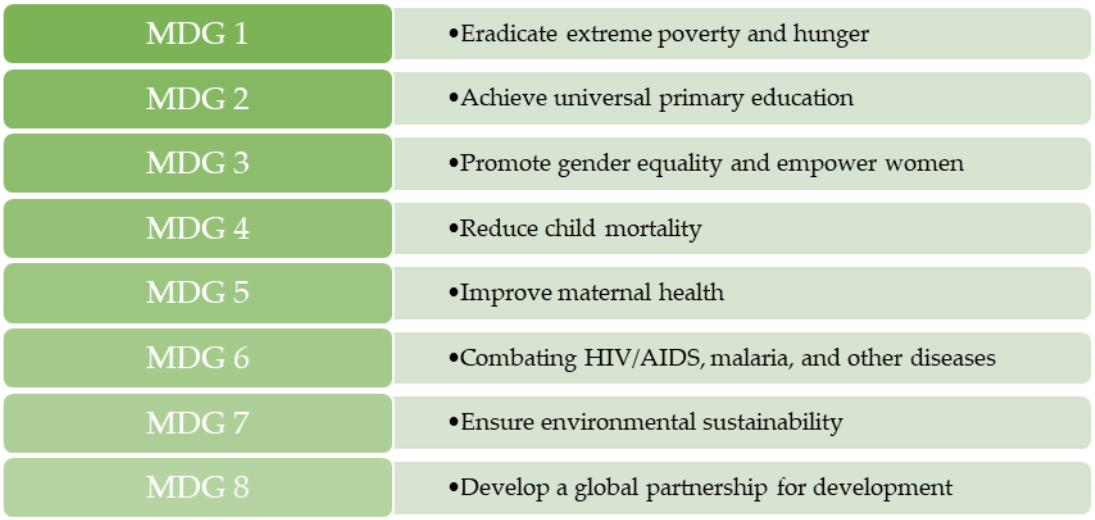


Figure 1.1. Millennium Development Goals (MDGs)

In 2015, the 17 Sustainable Development Goals (SDGs), known as the "UN 2030 Agenda", were adopted by the United Nations (UN) General Assembly. In this context, the 17 main goals were decomposed into 169 sub-goals, with the aim of setting attainable targets within the framework of the 2030 Global Agenda. Another striking point in SDGs, differently from the MDGs, is the focus on environment, and the aim to complete what they could not achieve. This difference grounds sustainable development on three pillars; social, economic and environmental development, and its integrated and balanced manner (UN, 2015b). Barbier (1987) described the general aim of sustainable development process as “to maximize the goals across all these systems (biological system, economic system and social system) through an adaptive process of trade-off”, hence this development needs the intersection of the optimal levels for all these goals (see Figure 1.2.). Because the goals are integrated and indivisible, progress in one goal can also advance other goals, such as positive impact of decreasing climate change on health, life on land, and life below water. However, this interaction may not always be positive because it also has trade-offs and tensions which may cause difficult choices and may result in winners and losers (Mensah, 2019). This can be exemplified as the negative impact of biofuel production for energy security on food security (Mensah and Enu-Kwesi, 2018), or the destructive impact of deforestation for agricultural production to increase food security on biodiversity (Espey, 2015). In this regard, countries should develop a detailed and strategic roadmap towards achieving

their goals, prioritizing those that can create multidimensional impacts, while also aiming to achieve all objectives.

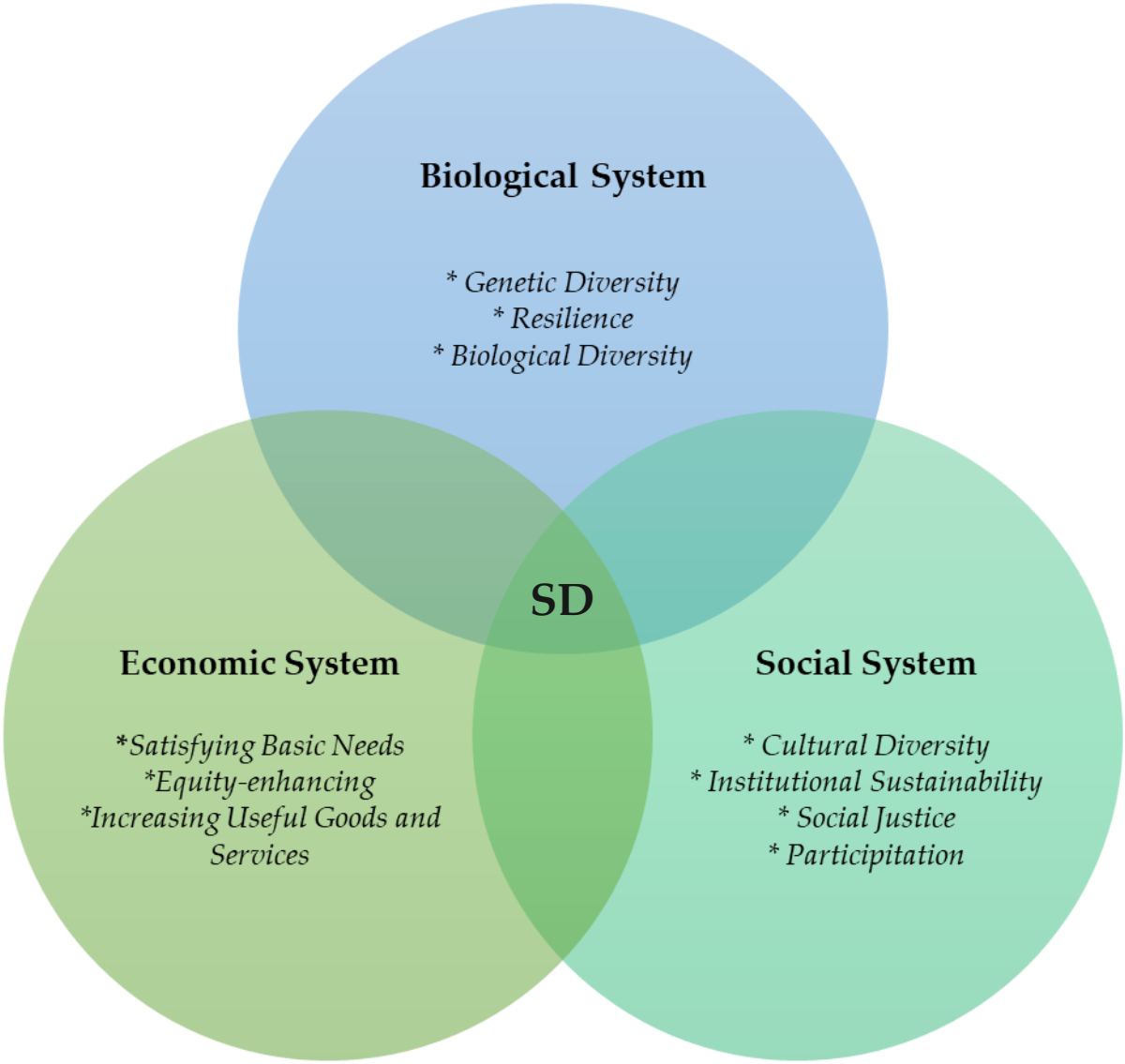


Figure 1.2. The formation of sustainable economic development (Barbier, 1987)

1.2.3. Current Perspective on Sustainable Goals

In its most current form, sustainable development grounds on three pillars; *economic, social and environmental sustainability*. In this context, economic models aim to accumulate and utilize natural and financial capital in a sustainable manner, while environmental models focus on preserving biodiversity and ecological integrity, and social models, on the other hand, seek to enhance political, cultural, religious, health

and educational systems, among others, to continuously promote human dignity and well-being (Acemoğlu & Robinson, 2012; Evers, 2018). In detail, e*conomic sustainability* refers to a production system that meets current consumption demands while ensuring the ability to satisfy future needs. When considered not being indefinite of natural resources, and being replenished or renewable for all, economic system should be reformed. Additionally, natural resources available are not capable of meeting the requirements of other triggers including the population growth and the rise in human needs such as food, housing and clothing. From another perspective, while the primary focus is often on economic growth, critical cost factors such as the effects of resource depletion and pollution are frequently overlooked (Retchless and Brewer, 2016). *Social sustainability* involves promoting the development of individuals, communities, and cultures to achieve a meaningful life, supported by adequate healthcare, education, gender equality, and global peace and stability (Saith, 2006). Because the concept 'social' is complex and multifaceted, the social elements consisting of the sustainable development are highly intangible and modelled difficultly. *Environmental sustainability* is defined as being "about the natural environment and how it remains productive and resilient to support human life", by Mensah (2019). It necessitates the sustainable use of natural capital both as a source of economic inputs and as a repository for waste (Goodland & Daly, 1996). Environmental sustainability has gained much more significance, especially in recent times when we have started to experience the impacts of climate change more intensively. In fact, climate change has a profound impact on production, which is the first stage of the economic cycle, by reducing biodiversity and crop yields, altering product physiology, and depleting natural resources.

Seventeen sustainable development goals determined in the context of economic, environmental and social sustainability are shown in Table 1.2.

Table 1.2. Explanations of 17 sustainable development goals

SDG 1	No Poverty	End poverty in all its forms, everywhere
SDG 2	Zero Hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
SDG 3	Good Health and Well Being	Ensure healthy lives and promote well-being for all at all ages

SDG 4	Quality Education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
SDG 5	Gender Equality	Achieve gender equality and empower all women and girls
SDG 6	Clean Water and Sanitation	Ensure available and sustainable management of water and sanitation for all
SDG 7	Affordable and Clean Energy	Ensure access to affordable, reliable, sustainable, and modern energy for all
SDG 8	Good Jobs and Economic Growth	Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all
SDG 9	Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
SDG 10	Reduced Inequalities	Reduce inequality within and among countries
SDG 11	Sustainable Cities and Communities	Make cities and human settlements inclusive, safe, resilient, and sustainable
SDG 12	Responsible Consumption and Production	Ensure sustainable consumption and production patterns
SDG 13	Climate Action	Take urgent action to combat climate change and its impacts
SDG 14	Life Below Water	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development
SDG 15	Life on Land	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
SDG 16	Peace, Justice and Strong Institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels
SDG 17	Partnership for the Goals	A successful sustainable development agenda requires partnerships between governments, the private sector, and civil society. These inclusive partnerships built upon principles and values, a shared vision, and shared goals that place people and the planet at the center, are needed at the global, regional, national, and local level

Source: Authors own creation. The goals and their explanations compiled from UN (2015b)

When looking into the scope of the goals, it is possible to classify them according to the system it serves. While ‘no poverty’ (SDG 1), ‘zero hunger’ (SDG 2), ‘good health and well-being’ (SDG 3), clean water and sanitation’ (SDG 6), ‘affordable and clean energy’ (SDG 7), ‘good jobs and economic growth’ (SDG 8), ‘industry, innovation and

infrastructure' (SDG 9) represent the *economic sustainability*; 'quality education' (SDG 4), 'gender equality' (SDG 5), 'reduced inequalities' (SDG 10), 'peace, justice and strong institutions' (SDG 16), and 'partnerships for the goals' (SDG 17) are for the *social sustainability*. The remaining ones including 'sustainable cities and communities' (SDG 11), 'responsible consumption and production' (SDG 12), 'climate action' (SDG 13), 'life below water' (SDG 14), and 'life on land' (SDG 15) belong to the *environmental sustainability*. The explanations of these objectives are given in detail in Table 1.2.

These elements are very important and good instruments for sustainable development and there are many indicators and index to measure them as given in the report by UN (2015c). The analysis and measurement of sustainable development is possible through a compact indicator which is technically robust, operationally feasible and informative for governments and others stakeholders (UN, 2015c). These indicators are strong tools to forecast the country development, develop the strategy and allocate resources accordingly. Additionally, they, serving as a report card, ensure the accountability of all stakeholders for attainment of SDGs (UN, 2015c). However, within this context, there is a prevalent concern is that the SDGs were designed primarily as a framework for guiding development efforts, rather than as a tool for monitoring and measuring actual progress (Barbier and Burgess, 2021).

1.3. FOOD INSECURITY

Shaw's (2007) citation of Boyd Orr and Lubbock (1953) and Boyd Orr (1966) reveals that 'in the early 1930s, Yugoslavia proposed that in view of the importance of food for health, the Health Division of the League of Nations should disseminate information about the food position in representative countries of the world. Its report was the first introduction of the world food problem into the international political arena'. A survey conducted by the Health Division of the League of Nations led to the publication of a report on 'Nutrition and Public Health' in 1935. This report is of great significance as it was the first comprehensive document to present the issues of hunger and malnutrition on a global scale, revealing the severe food shortages in impoverished countries (Simon, 2012). Similar to the evolution of the concept of sustainable development, the concept of food security has also undergone changes over time. In earlier periods, the focus of

this concept was primarily on food availability and production; however, over time, food accessibility and utilization have also been incorporated into its scope (Berry et al., 2015). The global food crises (The Global Food Crisis (1972-1974), The Bangladesh Famine (1974), The Ethiopian Famine (1984-1985), The Asian Food Crisis (1997-1998), The Global Food Crisis (2007-2008), The Horn of Africa Famine (2010-2011), The East Africa Famine (2011-2012), The COVID-19 Pandemic Food Crisis (2020-2022), The Russia-Ukraine War Food Crisis (2022)) have further highlighted the concepts of food supply and food security. The international community gathered at the 1974 World Food Conference and took a resolution regarding food security which emphasizes 'the urgent need to ensure availability at all times of adequate world supplies of basic food-stuffs, particularly so as to avoid acute food shortages in the event of widespread crop failure, natural or other disasters, to sustain a steady expansion of food consumption in countries with low levels of per capita intake and to offset fluctuations in production and prices' (UN, 1975). The humanitarian perspective of A. Sen has provided a different outlook on this concept by highlighting the lack of access to food as a fundamental right or the absence of effective demand. The next development came in 1986 when the World Bank published its critical report "*Poverty and World Hunger"* (World Bank, 1986). This report introduced a time scale for food security by distinguishing between chronic food insecurity, linked to poverty-related issues, and acute, transient food insecurity, caused by natural or human-made disasters (Berry et al., 2015). The 1994 Human Development Report published by the United Nations Development Programme (UNDP, 1994) also highlighted that food security, along with health, personal, economic, community, political and environmental security, represents one of the greatest threats to human security. It asserts that food security needs that individuals must have reliable access to food, meaning they have an "entitlement" to accessibility, either through personal production, purchasing, or utilizing a public food distribution system. In the report published in 2002 by the FAO, the concept of food security was further broadened and defined as 'food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and life'. More recently, in 2009, this concept became one of the institutional strategic goals of the FAO. The latest revision was made at the 2009

World Food Security Summit, where a ‘constancy’ dimension was added to the concept of food security, incorporating it as a short-term indicator that measures resilience to natural or human-made shocks (FAO, 2009a). When considered in conjunction with the concept of sustainability, the significant role of sustainability in food security becomes clearly evident. Because of the undeniable impact of climate on food production, the availability of natural resources, food availability and the preservation of biodiversity, the role of economic sustainability in food access, and the influence of social sustainability on the utilization of food, and all are crucial for achieving the goals of this concept. At the same time, this relationship is bilateral, as food security also provides a foundation for sustainability.

1.3.1. Factors Influencing Food Insecurity

Numerous studies have examined and analyzed diverse determinants causing food insecurity in the past. These studies cover demographic information (age, gender, marital status, employment status, education, race, the income and size of household head) (Sekhampu, 2013; Santos et al., 2022; Dunga, 2020; Bimerew and Beyene, 2014; Sisay and Edriss, 2012); climate change (Frona, 2020; Agidew and Singh, 2018); insecurity, lack of job opportunities, huge influx of refugee, unsustainable livelihoods, landlessness in rural areas, low wage (Ahmedzai and Akbay, 2020); food expenses per person (Santos et al., 2022); the shortage of farm land, land degradation (Agidew and Singh, 2018); use of improved variety (Bimerew and Beyene, 2014); ownership of bank account (Sisay and Edriss, 2012); livestock possession, participation in off-farm activities, soil conservation practices, per capita consumption expenditure (Abafita and Kim, 2014). These factors collectively play a crucial role in understanding and addressing food insecurity. This chapter categorizes these factors into more general themes such as demographic characteristics, climate change, lack of production and changes in consumption pattern, logistics and food inflation.

1.3.1.1. Demographic Characteristics

While the topic may seem somewhat interesting, the literature underscores the significant impact of demographic characteristics on food security. Some researches reveal that larger household sizes correlate with a higher probability of food insecurity (Sisay and Edriss, 2012; Sekhampu, 2013). This relationship may stem from increased

food expenditure to meet the needs of larger households, and the competition for limited resources. Moreover, these pressures lead to push education and healthcare into the background, potentially worsening future outcomes. Similarly, households with lower incomes tend to experience higher levels of food insecurity due to their financial constraints.

The gender of household heads is as crucial as household size. While numerous studies argue that male-headed households generally exhibit greater food security compared to female-headed households (Agide and Singh, 2018; Santos et al., 2022), there are also studies suggesting advantages for female-headed households (Sekhampu, 2013).

Furthermore, disparities in food security outcomes have been observed even among households of the same gender but different racial backgrounds. According to Dunga's analysis (2020), white female-headed households tend to experience better food security, likely attributed to higher income levels. This situation shows that food security may vary by gender, and even when individuals share the same gender, the existence of colorism[1] may be also evident in this regard.

Education is highlighted as another critical factor for food security in the literature. This is because education facilitates the adoption and understanding of new agricultural technologies and practices more efficiently and rapidly (Sisay and Edriss, 2012; Bimerew and Beyene, 2014; Santos et al., 2022). The contribution of the education on information acquisition, accessibility to the new and improved technologies, efficient decision-making process, systematic and creative thinking for innovative decisions plays a great role in the rise in productivity, the diffusion of innovations, and shaping of behaviors (Nelson and Phelps, 1966; Wozniak, 1984; Norris and Batie, 1987; Cotlear, 1990). All these impacts hold considerable importance for food security.

1.3.1.2. Climate Change

Climate change, exacerbated by global warming, is a significant determinant of agricultural production due to its sensitivity to fluctuations in temperature and precipitation. This phenomenon not only alters the characteristics and physiology of

[1] Colorism is defined as “chiefly U.S. Prejudice or discrimination against individuals who have a dark skin tone, esp. among people of the same ethnic or racial bakcground” (Oxford English Dictionary, 2025).

crops but also affects crucial growth processes such as photosynthesis, transpiration, and maturation in diverse ways (Mahato, 2014). Changes in climate inevitably affect agricultural productivity, often resulting in negative effects, in spite of occasional positive extraordinary outcomes (Belloumi, 2014). Elevated temperatures above average levels can lead to reductions in grain weight, protein content, taste, nutritional value, and overall crop quality (Kim and UN.ESCAP, 2012). Moreover, climate-driven extremes such as intense rainfall, storms, and floods can significantly reduce potential production by deteriorating crops, infrastructure, and community assets (Habib-ur-Rahman et al., 2022; Squires and Gaur, 2020).

The decline in agricultural production exacerbates two ongoing agenda items: food inflation and food security, prompting governments to increase investments and expenditures to meet essential societal needs. Nelson et al. (2009) provide insight into this issue, highlighting the necessity for approximately $7 billion in agricultural productivity investments to mitigate the adverse effects of climate change on children's health and well-being. In this regard, while climate change has an enormous effect on food insecurity, it also imposes a substantial burden on economies and disrupts sustainable development efforts.

1.3.1.3. Lack of Production and Changes in Consumption Pattern

As it was mentioned before, the level of agricultural production depends on several fundamental determinants, including climate change, depletion of water resources, land degradation, crises and related issues, and a decline in agricultural labor force. The decrease in agricultural production has diminished both current and future production by reducing farmers' income and their investment in agricultural products in the following terms. This situation exacerbates food insecurity, which already faces challenges related to availability, accessibility, utilization, and stability.

From another perspective, agricultural workers constitute one of the cornerstones of sustainable development due to their crucial role in sustainable agriculture and rural development. However, despite their significant contribution to sustainable development, the number of agricultural workers has notably declined in several middle- and high-income countries (Christiaensen et al., 2020). However, this situation

is not specific to these country groups but all countries regardless of their development levels because the decline in agricultural workers can be attributed to several factors, including challenging farming conditions, the evolving societal perception of farming, rising input costs, significant urbanization trends and the decline in agricultural support levels. In addition to these factors, there is a very important issue on the agenda especially in the recent times, and which affects many factors including agricultural employment: technological improvements (Schuh et al., 2019). These improvements including high-tech agricultural machines and systems increase the agricultural productivity using less labor, this progress may also unbare the reality of the decline in agricultural employment (Pesce et al., 2019; Schuh et al., 2019). Even the non-standardised tasks such as selective weeding and crop sensing can be performed by the robots and artificial intelligence and substitute the human workers (Marinaoudi et al., 2019). Additionally, the rise in the farm size and the fall in the number of farms need more adoption of technology-intensive farming, the capability of these larger farms on adoption sparks the decline in labor amount (European Commission, 2017, 2018; Knierim et al., 2018). Profit rate in terms of trade constitutes another critical dimension, as insufficient earnings in agricultural production can lead to withdrawal from the sector and this outcome represents a significant barrier to sustainable agricultural production and development (Ak, 2020).

Urbanization, in particular, has been recognized as a major driving factor behind migration. Factors contributing to internal migration among agricultural laborers include economic uncertainties, low wages, insecure employment conditions, job losses due to agricultural modernization and technological advancements, better job prospects in non-agricultural sectors, inadequate rural infrastructure, the impact of climate change on agriculture, and limited access to education, healthcare, and social protection in rural areas (Selod and Shilpi, 2021; Güreşçi, 2022). The dependency on temporary or migrant workers exacerbates challenges for producers—and consequently for consumers-- and disturbs food supply chain (Koç, 2020; Tansey, 2020).

According to FAO (2023), urbanization is expected to increase in the future, potentially exacerbating food insecurity. Simultaneously, shifting dietary preferences towards cheaper and fast-food options contribute to malnutrition and hinder meeting daily

nutritional requirements. This dual impact underscores the existing challenge of negative consumption behaviors influenced by food insecurity, which has profound implications for nutrition and health (Smith et al., 2022; Turnbull et al., 2021; Kendall et al., 1996).

1.3.1.4. Logistics

Logistics plays a crucial role in ensuring accessibility and availability of food, thereby contributing significantly to food security. The empirical study by Subramaniam et al. (2022) implies a positive relationship between enhanced logistics performance and food security. Furthermore, efficient logistics not only supports food security but also accelerates improvements in other sectors, thereby fostering economic development and growth (Sanchez et al., 2014). In support of this perspective, Li and Chen (2021) have found that the logistics industry contributes approximately 40% to economic growth, with an additional 36% spillover effect on the economic growth of surrounding areas. Similarly, Sezer and Abasiz (2017) underscore the multifaceted impact of logistics on economic growth, including job creation, national income generation, and attracting foreign investment at the macro level, as well as enhancing corporate competitiveness and benefiting other industries at the micro level. Furthermore, the role of logistics in driving economic growth extends to bolstering international trade, as highlighted by Katrakylidis and Madas (2019).

The COVID-19 pandemic has underscored the growing significance of logistics in recent times. During the pandemic, countries and economies faced unprecedented challenges, necessitating numerous regulations and restrictions. These changes had a profound impact on the logistics sector, affecting it negatively through phenomena like the bullwhip effect[2], reduced carrying capacity, fluctuations in the volume of international trade, and increased costs (Özkanlısoy, 2021). The COVID-19 pandemic has severely impacted both land and air transport in a negative way (Xu et al. (2022)). This new scenario exacerbates existing challenges in food security, particularly issues related to accessibility due to infrastructural and distributive problems. According to an alternative view, containment measures such as additional inspections and quarantines

[2] The “bullwhip effect” is a phenomenon in supply chains where small fluctuations in consumer demand at the retail level lead to increasingly significant fluctuations in demand at the levels of wholesalers, distributors, manufacturers, and raw material suppliers.

have hindered food production workers and disrupted the supply chain process, furthermore, this situation has led to losses of perishable goods and delays in goods reaching markets (OECD, 2020; UNCTAD, 2020). The reduced accessibility of food, coupled with increased food inflation resulting from supply shortages, further exacerbates the issue of food insecurity.

The impact of inflation extends beyond affecting goods directly; it also significantly affects the inputs of logistics, thereby disrupting logistics and food security. Among these inputs, the price of oil stands out as a crucial factor. In this context, Taghizadeh-Hesary et al. (2019) present significant findings indicating that 64.17% of changes in food prices can be attributed to oil prices, highlighting how volatility in oil prices and inflation pose threats to food security. Other studies have also demonstrated the strong correlation and vulnerability of food inflation to shocks in oil prices (Esmaeili and Shokoohi, 2011; Neff et al., 2011; Dillon and Barret, 2016; Meyer et al., 2018; Taghizadeh-Hesary et al., 2018; Kırıkkaleli and Darbaz, 2021).

1.3.1.5. Food Inflation

Rising prices, particularly highlighted after the acute and consecutive events experienced recently, can be identified as a core driver of food insecurity. However, it is important to note that there are other underlying factors contributing to price increases and significantly impacting food security, such as climate change and shifts in agricultural production as mentioned before as mentioned before. Beside the impacts of climate change on production, the literature identifies several drivers contributing to declines in agricultural production and increases in food inflation. These include rural-to-urban migration, decrease in the number of agricultural workers, rising production costs (especially fluctuations in oil prices), shifts in consumption and dietary preferences, increasing purchasing power, population growth, and changes in supply-demand equilibrium.

Regardless of the reasons behind these trends, the consequences often lead to rising food prices and highlight the harsh reality and severity of food insecurity. Numerous studies emphasize that these impacts disproportionately affect poor populations (Myers et al., 2017; FAO, 2008), as food expenditures constitute a significant part of their

budgets. Therefore, any volatility in food prices has the potential to push these vulnerable groups further into hunger and poverty. The Asian Development Bank (ADB, 2011) supports this notion with findings indicating that a 10% increase in domestic food prices results in more than 60 million people in developing Asia being pushed into poverty. Beyond exacerbating poverty, such price increases unfortunately contribute to escalated inequality and social unrest (Jha and Rhee, 2012).

The impact of recent global crises and unforeseen events such as the COVID-19 pandemic and the Russia-Ukraine war introduces another layer to food inflation, exacerbating challenges in sustainable development and food security. These crises disrupt logistics, supply chains, and the agricultural food value chain, leading to unpredictable spikes in food inflation (Laborde et al., 2020; Agyei et al., 2021; Afesorgbor and Lim, 2023). Moreover, increasing volatility in prices are anticipated to heighten political and social instability in developing countries (National Intelligence Council, 2013). On a contrasting viewpoint, Gustafson (2013) presents a positive outlook, suggesting that food inflation can lead to increased real income and wages for farmers, thereby contributing to the development of rural economies and investment.

Headey and Martin (2016) agree with Gustafson's view by supporting the benefits of higher food prices for the rural poor, highlighting positive impacts on labor supply, wages, and global poverty reduction efforts. Consequently, rising prices often direct governments to implement policies such as improving social safety nets and providing subsidies. However, regardless of the reasons behind such measures, they sap government budgets (Woertz et al., 2014), potentially delaying primary goals or reducing investments in other areas, thereby hindering sustainable growth processes.

1.3.2. The Major Outcomes of Food Insecurity

Food insecurity extends beyond its impacts on health; it is a fundamental human need that affects everyone regardless of social status or welfare level. Even individuals who can access food easily may be affected by food insecurity, as evidenced by increased crime rates, for instance. Therefore, addressing food security involves considerations beyond health, encompassing education and social stability as well.

1.3.2.1. Health

Malnutrition or poor diet has a detrimental impact on health in various ways, as evidenced by previous studies. These include negative effects on depressive symptoms, lower self-reported health status, and engagement in HIV-risk behaviors (Al Abosy et al., 2022); increased risk of asthma (Gundersen and Ziliak, 2015); higher likelihood of cardiovascular disease, cardiovascular disease mortality, and type 2 diabetes (Thomas et al., 2021); chronic diseases (Gregory and Coleman-Jensen, 2017); hypertension, hyperlipidemia, and diabetes (Seligman et al., 2010); higher body mass index and obesity (Olson, 1999); infant mortality (Beyene, 2023).

Furthermore, it may be seen not only the unidirectional links but bidirectional links as well between food insecurity and health issues. For instance, studies by Weiser et al. (2011) emphasize this bidirectional linkage between food insecurity and HIV/AIDS. It is asserted that the food insecurity which is effective on the nutritional, mental health and behavioral pathways may lead to HIV acquisition, and likewise HIV/AIDS being more related to the morbidity and mortality increases being susceptible to the food insecurity because the income-lowering and cost-increasing impact of illnesses (Weiser, 2011). Johnson's study (2021) focusing on the relationship between food insecurity and healthcare spending clearly shows the interrelated cycle. According to this cycle, while poor health is a cause of the rise in healthcare expenditure, this increase leads to the fall in household income/competing demands, and these causes food insecurity which will set ground for poor health. The findings of Olson (1999) and Beyene (2023), supportively, indicate the association of food insecurity with compromised psychosocial functioning and reduced life expectancy. These negative health effects not only affect sustainable development but also underscore poverty as a significant underlying cause. This situation highlights that while the negative impact of food insecurity on health is straightforward, various health problems can, in turn, adversely affect food security because its detrimental effect on earning income and the ability of being worked.

These direct and indirect factors impose a greater economic burden than often perceived. Although the source of the issue is single, food insecurity impacts are multifaceted, resulting in high costs for economies. These costs, driven by problems related to food insecurity, lead to reduced investment in other fields and amplify their adverse effects.

The median annual health care cost is found as $687,041,000 associated with food insecurity in the study of Berkowitz et al. (2019). Considering social assistance payments, social security, health insurance coverage, and other welfare benefits, which contribute to a well-educated population and lower crime rates, the burden of indirect costs are more striking.

1.3.2.2. Education

The prevalence of food insecurity and its consequences for health also influence education, as inadequate food security affects physical growth, intellectual capacity, and social skills. Its adverse effects are evident in poor developmental trajectories in children (Jyoti et al., 2005), school absenteeism (Belachew et al., 2011; Tamiru et al., 2017; Tamiru and Belachew, 2017), academic performance and overall health of college students (Loofbourrow and Scherr, 2023), as well as poor academic achievement, particularly in reading and mathematics (Faught et al., 2017). Additionally, challenges with academics, careers, and procrastination are also associated with food insecurity (DeBate et al., 2021).

Furthermore, Mutisya et al. (2016) showed that a one-unit increase in average years of schooling reduces food insecurity by 0.019 units. Education plays a crucial role not only in economic growth and development, as educated individuals contribute significantly to these aspects, but also in achieving sustainable reductions in hunger and poverty. FAO, IFAD, and WFP (2013) emphasize that sustainable growth and poverty alleviation must be broadly shared to be effective. Fairly distributed opportunities can profoundly promote rural development.

1.3.2.3. Crime & Social Unrest

While food insecurity initially brings to mind concerns related to nutrition and health, extensive literature underscores its strong correlation with crime. Numerous studies reveal significant positive associations between food insecurity and various types of crime, including murder, rape, and robbery (Finnerty, 2023); firearm injuries (Ali et al., 2022); gunshot injuries (Smith et al., 2020); exposure to child abuse, neglect, and rape (Chilton et al., 2014); low self-control and early delinquency (Jackson et al., 2018); as well as violent arrests (Schuck et al., 2021). Supportively, findings from Caughron

(2016) indicate that a 1% increase in food insecurity correlates with an approximate 12% increase in the violent crime rate. Additionally, Brinkman and Hendrix (2011) emphasize the crucial role of stabilizing food prices, particularly for vulnerable households, in preventing violent conflict.

1.4. THE RELATIONSHIP BETWEEN FOOD INSECURITY AND SUSTAINABLE DEVELOPMENT

As mentioned before, the consensus on the definition of a sustainable economy varies between economists, it generally encompasses sustainable economic growth and development that ensures autonomy and equity, maintains competitive markets, and stable currency values (Ikerd, 2012). Additionally, a sustainable economy aims to reduce resource use and environmental degradation, diversify economies, and improve institutions (UN, 2024). The 17 goals of the 2030 Agenda for Sustainable Development, adopted by UN member states to promote global peace and prosperity, are foundational to the concept of a sustainable economy. These goals are specified as shown in Figure 1.3.;

Figure 1.3. Sustainable development goals by United Nations

Achieving these goals represents a significant advancement in economic growth and development. Therefore, understanding the underlying reasons and challenges associated with these goals becomes crucial for countries striving to make progress.

Focusing on these goals in detail reveals an often overlooked reality: food security is the backbone supporting many of these goals, as they are directly or indirectly related to food security/insecurity. At this juncture, it is crucial to mention the "green revolution" to enhance our understanding of sustainability in relation to food security. The "green revolution[3]", aimed at improving the efficiency and productivity of agricultural production to meet food demand (Ameen and Raza, 2017), stands as a milestone in enhancing incomes, food supplies, and thereby food security (Pinstrup-Andersen and Hazell, 1985). However, over time, it has become evident that the innovations and new agricultural practices associated with the green revolution also have disadvantages and long-term consequences. Some of these include a decline in diet quality leading to vitamin deficiencies, increased unemployment and social inequalities due to mechanization and unequal access to opportunities, degradation of water quality and marine life, loss of biodiversity from extensive pesticide use, and an increase in certain diseases such as cancer (Ameen and Raza, 2017). Therefore, at this juncture, it is crucial to distinguish between simply increasing agricultural production and achieving sustainable food security without compromising the environment, human health, the agricultural sector, and ecosystems. In essence, prioritizing sustainable agriculture, rather than solely focusing on increasing production, is a basis as a first link in the virtuous cycle for food security and sustainable development.

[3] By the mid-1960s, widespread hunger and malnutrition, especially in Asia, and successive droughts in India exacerbated the food problem. A 1967 report by the President's Committee of Advisors on Science concluded that "the scale, severity, and duration of the world food problem are so great that a major, long-term, innovative effort is required, without precedent in human history." In response, the Rockefeller and Ford Foundations took the lead in establishing an international agricultural research system, making their first investments in research on two major food crops, rice and wheat. The breeding of improved varieties, combined with the expanded use of fertilizers, other chemical inputs, and irrigation, significantly increased yields in Asia and Latin America by the late 1960s. This period of significant agricultural growth was described in 1968 by William S. Gaud, Administrator of the United States Agency for International Development (USAID), as the "Green Revolution." High-yielding varieties (HYVs) were later also developed for other important food crops such as sorghum, millet, maize, cassava, and beans, for developing countries. By 1970, about 20% of wheat and 30% of rice areas in developing countries were planted to HYVs. The yields of these crops nearly doubled. This increased agricultural production, reduced the prices of the products, increased overall demand, stimulated the non-farm economy and creating new income and employment (International Food Policy Research Institute, 2002).

The relationship between food security and SDGs can be understood as a vicious circle, where a factor can serve as both a primary cause and a trigger or outcome, as illustrated in Appendix 1. For instance, while food inflation is cause of poverty, inequality, and social unrest, it is also an adverse outcome of economic crises. Additionally, certain factors can act as both the cause and consequence of a determinant, such as reduced agricultural production due to climate change. These intricate interconnections highlight the telescopic spectrum of factors that play pivotal roles in food insecurity, underscoring the necessity of addressing multiple determinants that both cause and conclude it for sustainable development. As a matter of fact, initiating action on any of these factors can break the cycle and represent a crucial step towards reducing food insecurity and promoting sustainable development. Therefore, beginning with sustainable agriculture serves as the initial crucial step in addressing this issue comprehensively.

1.4.1. The Importance of Sustainable Agriculture

FAO (1989) defines the sustainable agriculture and rural development as "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Rural development and sustainable agriculture defined in this way conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable". As inferred from this definition, sustainable agriculture is a crucial factors for achieving both food security and sustainable development. Upon closer examination of the definition, their interconnectedness becomes evident.

1.4.1.1. Efficient Use of Natural Resources

With the increasing consumption frenzy and demand, the natural resource has been rapidly depleted and degraded. Although the efficient resource use is always on agenda, the growing food insecurity problem underscores the critical importance of addressing this issue. On one hand, problems like land degradation, groundwater depletion, salinity, and waterlogging exacerbate natural resource degradation, while climate change adds to these challenges. On the other hand, all of these challenges force small farmers, in particular, to abandon their work.

Policies and supports implemented for farmers can prevent them from leaving agricultural employment and significantly contribute to the effective use of natural resources. For example, Kumar (2003) argues that government-managed water supply management and its intersectoral allocation not only enhance the equity and accessibility of water but also promote efficient resource use.

Moreover, implementing volumetric pricing of water and unit pricing of electricity in the farm sector is suggested to be highly beneficial for ensuring equal income-earning opportunities and promoting the efficient use of natural resources.

1.4.1.2. Resource Degradation

Although well-implemented policies can provide equal opportunities and allocation, another crucial aspect is understanding how resources are effectively and appropriately utilized. This knowledge is essential to hamper degradation.

Appropriate and proper resource use is indeed crucial for mitigating degradation. Teaching farmers about good farming practices, new technologies, improved farm implements, installation of irrigation systems, and postharvest processing and storage can significantly enhance the production of existing crops and reduce resource degradation. Beyond increasing efficiency, these practices contribute significantly to sustainable agricultural practices that conserve natural resources for future generations.

Apart from these, supporting farmers to improve their capabilities in making informed decisions about external inputs and cropping patterns is crucial. When farmers have the knowledge and capacity to choose appropriate crops and manage their production processes effectively, it helps to prevent both excessive and incorrect use of resources, thereby reducing resource degradation (Umesha et al., 2018).

1.4.1.3. Equity / Policy and equal allocation / Water Management

Efficient utilization of natural resources and equitable opportunities for farmers in agriculture significantly enhance economic efficiency. The principle of equity motivates farmers to engage more actively in the agricultural sector, thereby boosting productivity. Furthermore, the proper allocation of tradable private property rights can ensure equitable access across different rural classes, thereby enhancing income

generation from farming (Kumar, 2003). Increased income derived from agriculture not only stimulates investment in the sector but also fosters sustainable agricultural development.

1.4.1.4. Technology Adoption

Another crucial aspect of sustainable agriculture is undoubtedly the adoption of new technologies, which has a superior power on productivity and efficiency. The initial hurdle lies in farmers' acceptance and integration of new technologies. Several determinants affect this adoption process, including labor intensity, farmers' age, experience, education levels, literacy rates, engagement with extension services or farmer-related associations, managerial and analytical skills, awareness levels, participation in governmental or non-governmental programs and field days, investment behavior, risk management, land tenure rights, economic incentives, institutional affiliations, networks, and collective actions (Lee, 2005). Access to many of these factors necessitates financial possibility, highlighting the pivotal role of subsidies and support schemes in enabling farmers to achieve sustainable agricultural objectives.

1.4.1.5. Subsidies for Farmers

There exists a wide array of instruments and policies designed to support the financial stability of farmers. These measures encompass field-specific supports, agricultural insurance provisions, credit facilities, deficiency payments, and rural development initiatives (Tandoğan, 2022). Furthermore, supports can be provided through different channels. As it could be directly in the form of income subsidies or payments linked to outputs and input usage, and their costs, it could be indirectly through macro-level investments like infrastructure development and research, subsidies towards producers such as production volume, or export performance as well.

In addition to the various subsidies available, the crucial task lies in identifying the specific areas where farmers require support and ensuring targeted financial assistance. Effective governmental policies can stimulate farmers to invest in agricultural technologies, machinery, and farm improvements through subsidies and supports. This approach not only enhances agricultural productivity but also promotes sustainable agriculture and development.

1.5. SDGs AND THEIR IMPORTANCE ON FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

As evident from the requisites of sustainable agriculture, many factors crucial to sustainability also align with goals related to food security and sustainable development, given agriculture's foundational role in sustainable development, as previously mentioned. When comparing the Sustainable Development Goals (SDGs), which predominantly reflect economic development, with the determinants of food insecurity, their interconnectedness becomes more apparent. From the related ones;

SDG 1) No poverty

Undoubtedly, agricultural production, a significant contributor to food security, has been widely documented to alleviate poverty in numerous studies (ILO, 2008; Hazell and Haddad, 2001; Irz et al., 2001; Anowor et al., 2013; Devkota and Upadhyay, 2013; Ogundipe et al., 2017; Warr and Suphannachart, 2020). This impact can be likened to a butterfly effect[4] on economies by generating employment, stimulating other sectors, lowering food prices, and improving welfare by reducing costs and fostering rural non-farm multiplier effects[5]. Consequently, increased productivity in agriculture has a dual effect on sustainable development by simultaneously reducing food insecurity and alleviating poverty.

SDG 2) Zero hunger

The reasons causing food insecurity have a great impact also on food inflation and soaring prices great share in poverty. The correlation between poverty and hunger or malnutrition is robust and direct: as incomes decline and food prices rise, access to a healthy and balanced diet diminishes (Turrell et al., 2002; Blössner and de Onis, 2005; Appelhans et al., 2012; Pechey and Monsivais, 2016; French et al., 2019). Hunger not only affects nutrition but also deteriorates economic growth and development (Wang and Taniguchi, 2002), leading to increased mortality and morbidity, decreased academic performance, and reduced efficiency (Martinez and Fernandez, 2008).

[4] The “butterfly effect” states the smallest change could leave drastic ripple effects.
[5] The “multiplier effect” can be explained as a change in a particular input lead to a larger change in an output.

Certain studies emphasize the detrimental effects of hunger, particularly on women and children, as noted in education and health sectors. In accordance with this acceptance, demographic shapes the future of the economy, and its impediment to sustainable development is inevitable.

SDG 3) Good health and well-being

Financial incapability and malnutrition inevitably lead to health problems because they prevent access to basic needs such as a daily healthy diet and necessary medical treatment in case of illness. Furthermore, they cause some serious diseases such as diabetes, obesity, and infant mortality, as discussed in the health effects section. These conditions significantly undermine well-being, quality of life, and consequently, sustainable economic growth.

SDG 4) Quality education

Achieving the goal of education requires both educators and students to have adequate conditions, as any shortcomings experienced by these individuals can lead to inadequate teaching and learning outcomes. At this juncture, numerous studies explore the relationship between education, health, and food security, highlighting the positive impact of improved health and enhanced food security on educational outcomes (Suhrcke and de Paz Nieves, 2011; Anisef et al., 2017; Correa, 2017). Education plays a crucial role in both academic success and overall well-being. The relationship between education and health is reciprocal: improved education enhances health outcomes by promoting preventative care, reducing tendencies toward addictions and obesity, and lowering morbidity rates (Feinstein et al., 2006; Groot and van den Brink, 2006; Cutler and Lleras-Muney, 2007; Raghupathi and Raghupathi, 2020; Brunello et al., 2011). This interplay plays a crucial role in sustainable development because healthy individuals, and the positive impacts on education and academic success, contribute to a more educated population in the future. Furthermore, these educated masses enhance productivity and play a significant role in fostering strong economies.

SDG 8) *Decent work and economic growth*

Several factors contribute to economic growth, with individuals occupying a central role among them. Productive individuals are particularly pivotal, as productivity serves as a crucial determinant of economic growth, characterized by the rise in national income and per-capita income. At this point, it is essential to highlight the butterfly effect, symbolizing the intricate and causal relationship between food security, health, and education as discussed earlier.

Production represents the next phase of this effect, where any improvement in this process not only increases production levels but also contributes significantly to economic growth (Bloom et al., 2003; Kim et al., 2016; Ivic, 2015). According to the report of FAO, IFAD, and WFP (2015), economic growth is a key factor in reducing undernourishment, highlighting a bilateral and cyclical relationship in this context as well.

SDG 9) *Industry, innovation and infrastructure*

While the goals of industry, innovation, and infrastructure may initially appear less directly related to food security, their contributions are more significant than commonly perceived. Issues in production and logistics are one of the major contributors to food insecurity. Enhancements in these three areas are critical because robust infrastructure significantly alleviates logistical challenges (Senquiz-Diaz, 2021; Hayaloğlu, 2015), while advancements in industry and innovation accelerate production processes (Fayomi et al., 2019; Fazlıoğlu et al., 2016; Polder et al., 2009). Economically, these improvements stimulate internal trade, enhance countries' integration into the global economy, increase international trade, bolster exports, promote employment, and enhance competitiveness. Collectively, these factors expedite progress towards sustainable development.

SDG 10) Reduced inequalities

The concept of "inequality" is frequently associated with food insecurity. Numerous studies indicate that a significant portion of this issue occurs in developing countries (Staatz et al., 2009; Smith et al., 2000). Furthermore, a substantial body of research

underscores that poverty within communities, largely stemming from income inequalities, is a major contributing factor (Debebe and Zekarias, 2020; Rosen and Shapouri, 2001; Holleman and Conti, 2020). Additionally, studies highlight that women face considerable discrimination and are disproportionately affected by food insecurity (Botreau and Cohen, 2020; FAO et al., 2020; Akter, 2021). Pollard and Booth (2019) assess the issue of food insecurity and propose a solution that involves government leadership and effective engagement with other sectors. They advocate for coordinated, collaborative, and cooperative efforts as essential elements of the solution. Moreover, as noted by Doyle and Stiglitz (2014), higher inequalities not only reduce aggregate demand and investment in public goods such as education and infrastructure, but also lead to slower economic efficiency and growth, and increase unemployment. This ripple effect not only limits educational opportunities and future earnings potential for disadvantaged children but also impedes future investments (Cingano, 2014). Undoubtedly, this domino effect affects income levels, income distribution equality, and economic freedom (De Gregorio and Lee, 2002; Stryzhak, 2020), posing significant obstacles to sustainable development.

SDG 11) Responsible consumption and production

With shifting consumption preferences and desires in today's world, the prevalence of food insecurity compels changes in consumption and production habits. As noted earlier, food insecurity drives individuals towards increased consumption of fast-food and unhealthy foods (Huet et al., 2017; Turnbull et al., 2021). Therefore, their consumer behaviors have changed out of necessity rather than a sense of responsibility. However, in terms of both consumption and production, decisions and actions should be more informed, especially considering the effects of climate change and the finite nature of natural resources.

Unconscious production and consumption impose irreparable costs on society. They not only harm the environment through waste but also burden economies with excessive resource use. However, an effective government-led control program and planning can achieve dual objectives by ensuring balanced sourcing and equitable distribution. Such actions alleviate economic burdens and address food insecurity issues simultaneously.

SDG 13) Climate action

It is obviously clear that climate change holds significant importance alongside food insecurity, as both pose threats to the future of the world. Climate change, often perceived as "global warming" in recent times, profoundly impacts agricultural production and efficiency, thereby influencing food prices. Decreased supply and increased prices adversely affect food accessibility and human health, leading to what is described as "cascading impacts" (Gitz et al., 2016). It is projected that the risks of hunger and malnutrition could increase by approximately 20% by 2050 compared to a scenario without climate change (WFP et al., 2009). Indeed, the measures taken for climate change affects food insecurity as well as it's one of the reasons of food security as illustrated in Appendix 1. However, to a large extent, its impacts have been observed on diseases and economies. Actions aimed at mitigating climate change have positive effects on reducing disease prevalence and minimizing economic losses. Therefore, countries must act swiftly and decisively to promote sustainable development.

SDG 15) Life on land

In recent times, experiencing a consumption frenzy, protecting natural resources, terrestrial ecosystems, and biodiversity are not only challenging but also imperative for human survival. Ecosystem and land degradation threaten essential life-supporting elements such as oxygen and food. Sustainable development necessitates proactive measures that anticipate future needs and mitigate risks.

In this regard, raising social awareness about sustainable agricultural practices, promoting efficient resource utilization instead of overexploitation, and implementing measures to mitigate environmental degradation are crucial steps towards sustainable development. These actions bring significant benefits, particularly in agriculture and more broadly in preserving natural ecosystems. They also play a vital role in addressing the agricultural aspects of food insecurity exacerbated by climate change.

SDG 16) Peace, justice and strong institutions

Peace and justice thrive in countries where issues like food insecurity, inequality, discrimination, and poverty are effectively addressed. These challenges not only create

social unrest and economic instability but also erode trust in government institutions. When societies lose faith in their systems, it becomes difficult to mobilize collective efforts towards national interests. This situation not only triggers internal disturbances but also hampers economic growth (Cingano, 2014; Selmonaj et al., 2020; Breunig and Majeed, 2020). Moreover, sustainable development becomes unattainable under these conditions, highlighting the imperative to eradicate problems such as food insecurity.

1.6. CONCLUSION

The threat of food insecurity to human life becomes increasingly evident as its impacts are strongly perceived within economies. While countries and governments often prioritize economic indicators that indicate growth and development, awareness of the profound effects of food security on overall development and growth remains insufficient.

Given the Sustainable Development Goals articulated in the UN's 2030 Agenda for Sustainable Development, it is essential to assess food security within the context of economic growth and development is crucial. Accordingly, Therefore, this paper emphasizes the critical importance of food security (or insecurity) in realizing the sustainable development objectives established forth by UN member states.

The established framework reveals a bilateral and strong relationship between food insecurity and sustainable development. Food insecurity adversely affects sustainable development, while positive changes in sustainable development have a beneficial impact on food security. This interconnectedness can be viewed as a vicious circle that has the potential to transform into a virtuous circle through timely intervention. Within this cycle, the primary causes of food insecurity include demographic characteristics, food inflation, crises, climate change, and inadequate agricultural production. The increase in food insecurity, exacerbated by these contributing factors, correlates with higher crime rates and challenges in education and health. These issues not only hinder sustainable development but also disrupt the developmental process itself. Fundamentally, sustainable development hinges on healthy, educated, and well-being individuals and societies who can actively contribute to national interests and strive

towards a better world. Food security plays a pivotal role as a cornerstone of all these factors, ensuring the foundation for sustainable development.

Considering the pivotal role of sustainable agriculture on sustainable development, it is one of the most important backbones for reaching the global aims. The existence of sustainable agriculture means the efficient and proper use of natural resources, equal allocation and good management, appropriate subsidies and solutions, and the continued satisfaction of human needs for present and future generations. These substructures contain the solutions for the most of the problems and obstacles in food insecurity because they apply for the eco- and bio- friendly implementations and, therefore, extend the lifespan of our planet in one hand, they increase the food accessibility, availability and security by making a substantial contribution for production and productivity, and ensure the survival of individuals and improves the living conditions of the people in disadvantaged conditions on the other hand.

Initiating action on these interconnected factors can trigger a butterfly effect within the vicious circle of food insecurity, potentially transforming it into a virtuous circle. These changes not only address food insecurity but also elevate sustainable development to a higher level. By tackling the underlying causes and fostering positive outcomes in health, education, and well-being, societies can foster a cycle of improvement and progress towards sustainable development goals.

Taking into account of all these provides insight us into what should be primarily done for attainment of 2030 Sustainable Development Goals aiming the global peace and prosperity. Although there are many determinants on these goals, handling primarily the food security/insecurity in connection with the sustainable agriculture will create a multidimensional and high-powered impact than considered because it constitutes the cause and/or solution of most goals.

CHAPTER 2

BEYOND AVAILABILITY: STRUCTURAL DRIVERS AND EXTERNAL SHOCKS IN GLOBAL FOOD INSECURITY

2.1. INTRODUCTION

Although the world agenda has recently focused on the sustainable development adopted by the UN (2015b) for global peace and prosperity, there is a major challenge which threatens human life, it is "food security". "Zero hunger" as a second goal has been addressed in Sustainable Development Goals (SDGs) however reaching this aim means more than achieving just one objective because of its multifaceted impact on the other goals such as good health and well-being.

Especially, as a fundamental human right, food security is an issue that should be prioritized and resolved in the fastest possible manner. According to the World Food Programme (WFP) (2025a), while 44.4 million people are in an emergency or worse levels of hunger, a substantial amount shows 20 percent of households facing extreme food shortages and 30 percent of children suffering from acute malnutrition. Finding a comprehensive and permanent solution has become more vital in our world, where the population declines by 9 million people every year due to hunger (WFP, 2025b).

Food security needs multidimensional system improvement because it should provide *availability, accessibility, utilization* and *stability,* which are seen as four dimensions of food security (FAO, 2006). Ensuring sufficient food (*availability*) is not adequate by itself without economic and physical access to food (*accessibility*), sufficient food intake and utilization (*utilization*), and being resilient and stable against any possible external circumstances or volatility (*stability*). In addition, numerous factors influence food insecurity such as demographic characteristics (education, income etc.) (Dunga, 2020; Santos et al., 2022; Sekhampu, 2013), land availability (Agidew and Singh, 2018), climate change (Agidew and Singh, 2018; Frona, 2020), production- and consumption-related issues (Christiaensen et al., 2020) and pricing matters (Myers et

al., 2017). Therefore, both meeting the four conditions and having control over the factors make the issue more complex. However, one fact remains that although unexpected situations such as the Russia-Ukraine war and the COVID-19 pandemic in recent times exacerbate the issue, it has unbarred the importance of food security and the deficiencies of the countries and the systems as well. These effective situations on a global scale have caused dwelling on some topics including logistics, import dependency, and self-sufficiency in detail because they have hampered the supply chain (Aday and Aday, 2020; Barman et al., 2021; Dyson et al., 2023; European Parliamentary Research Service (EPRS), 2022).

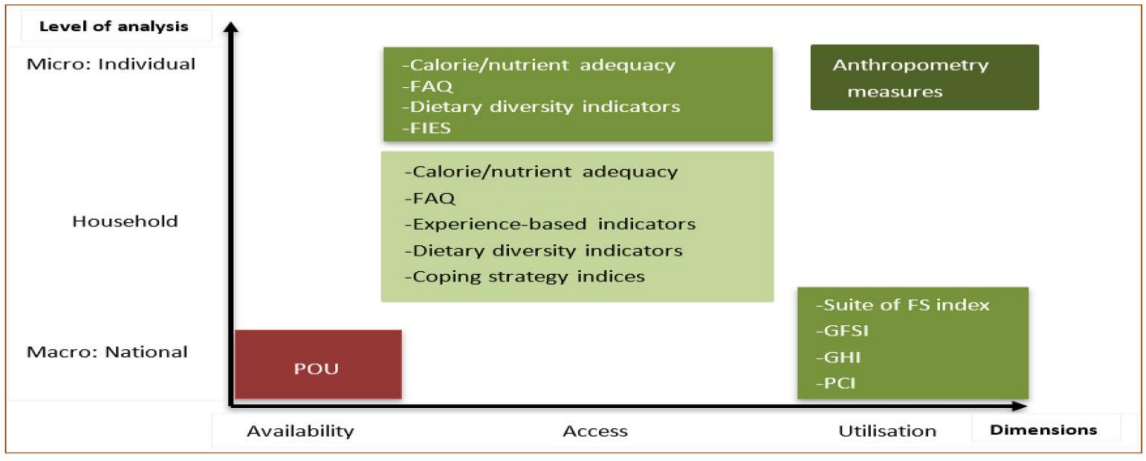
The number of undernourished people (NUP) is an important indicator revealing the change of food security over time. It represents the population whose habitual food consumption is inadequate to meet the necessary dietary energy levels needed to sustain an active and healthy life. While it was 575 million in 2011, it is recorded as 733.4 million in 2023 (FAO, 2025), which means that approximately 158 million joined the ranks of people suffering from food insecurity. This incredible rise stimulated by extreme situations influences on all parts of life because it may cause social unrest, an increase in crime rate, a decrease in public health, a substantial burden on economies and hence economic slowdown.

In this direction, the current paper aims to analyze the internal factors influencing the number of undernourished people (representing food insecurity) and the impact of an external factor which is handled as COVID-19 pandemic, which has a global impact and is a breaking point in this issue. Our analysis based on the period from 2004 to 2022 covers 138 countries and employs eight variables representing six main factors, along with an external shock as an exogenous factor. Differently from the other studies, this paper focuses on and provides insight into the impact of an extreme issue/shock.

The remainder of this paper is organized as follows. Section 2 presents the literature review on food security. Section 3 indicates the data and methods used for analyses. Section 4 and Section 5 present the results of the analyses and the discussion respectively. Finally, conclusions and future recommendations are summarized in the last section.

2.2. LITERATURE REVIEW

There are numerous studies focusing on food (in)security in the literature and different methods to measure, analyze and monitor food (in)security. Among them, the frequently used indicators are the ones set by international agencies such as the *Food Consumption Score (FCS)* by World Food Programme (WFP), *Household Food Insecurity Access Scale (HFIAS)* by United States Agency for International Development (USAID), *Prevalence of Undernourishment (PoU)* and *Food Insecurity Experience Scale (FIES)* by Food and Agriculture Organization of the United States (FAO) and *Global Food Security Index (GFSI)* by Economic Intelligence Unit (EIU). However, there is no consensus about the best indicator of food (in)security because all represent the different dimensions of food (in)security rather than capturing all four dimensions which are *availability, accessibility, utilization* and *stability.* Most of the indicators focus on *food accessibility* at the household level and few ones handle the dimension of *utilization* (Manikas et al., 2023). Indeed, this also depends on the analysis type because the focal issue has changed based on the components, levels and methods of the study, and the data structure as can be seen in Figure 2.1. Food security indicators may be identified in five types as i) experience-based food insecurity measurement scales, ii) national-level indicators, iii) dietary intake and diversity indicators; iv) income and expenditure-based indicators, and iv) indicators reflecting coping strategies and anthropometry measures (Perez-Escamilla and Segall-Corea, 2008; Manikas et al., 2023).



Note Indicators capturing higher level of food security dimension at higher (micro) level of analysis are preferred (i.e. clusters of food security indicators located in the right and upper parts of the figure are better measures of FS).
FAQ, Food Adequacy Questionnaire; FIES, Food Insecurity Experience Scale; POU, Prevalence of Undernourishment; food security, Food Security; GFSI, Global Food Security Index; GHI, Global Hunger Index; PCI, Proteus Composite Index.

Figure 2.1. Summary of the retrieved indicators according to the level of analysis and food security dimensions (Manikas et al., 2023)

For national-level estimates of food (in)security, the main highlight is given on *food availability.* The measurements and the analysis of Sustainable Development Goals (SDGs) are evaluated based on these indicators which are yardsticks for cross-national comparisons and monitoring the differences in macro-level trends (Jones et al., 2013). In this direction, there are three important and frequently used indicators; the *Prevalence of Undernourishment*, the *Global Hunger Index* (developed by the International Food Policy Research Institute (IFPRI)), and the *Global Food Security Index. Prevalence of Undernourishment* measures the population whose habitual food consumption is inadequate to meet the necessary dietary energy levels needed to sustain an active and healthy life. *Global Hunger Index* handles hunger in three dimensions including insufficient availability of food, shortfalls in the nutritional status of children and child mortality (World Health Organization (WHO), 2025) and the index score reveals the severity scale of hunger. *Global Food Security Index* uses 28 unique indicators measuring the factors of food (in)security through the three food security domains; affordability, availability, and quality and safety (United Nations Convention to Combat Desertification (UNNCD), 2025).

The existing literature indicates that the most commonly used one among these is the prevalence of undernourishment (*PoU*) representing food (in)security, as can be seen in Table 2.1. Based on *PoU* data, comparative studies at the macro-level have obtained striking results about the differences in countries or regions, and the drivers of prevalence of undernourishment. Even if it varies depending on the focal point, the most common factors evaluated in these kinds of analyses are GDP, inflation, population and production. Besides, the findings of prior literature reveal that there are other numerous various factors influencing food security. These can be mainly categorized as;

- ***Economic factors*** — trade openness, GDP, inflation, tariffs, credit accessibility (Dithmer and Abdulai, 2017; Abdullah et al., 2020; Cancino and Cancino-Escalante, 2023),

- ***Dietary intake or diversity factors*** — kilocalorie supply, calorie intake (Dithmer and Abdulai, 2017; Azimi and Rahman, 2024),

- ***Environmental factors*** — natural disasters, climate change (Dithmer and Abdulai, 2017; Rehman et al., 2024),

- ***Demographical factors*** — population, literacy, education, income, marital status, household size (Abdullah et al., 2020; Nafti, 2021; Cassimon et al., 2022; Amao et al., 2023, Adesete et al., 2023),

- ***Governmental and political factors*** — policy/trade openness, government/political stability, internal and external conflicts, military in politics, democratic accountability, bureaucracy quality, religious/ethnic tensions, regulatory quality, corruption control (Dithmer and Abdulai, 2017; Abdullah et al., 2020; Cassimon et al., 2022; Nugroho et al., 2022; Mulyo et al., 2023; Bopushev et al., 2024)

- ***Agricultural factors*** — agricultural revenue, arable land, land size, land area equipped with irrigation, number of agricultural workers, agricultural credit (Dithmer and Abdulai, 2017; Amao et al., 2023; Abdullah et al., 2020; Mulyo et al., 2023; Mohamed et al., 2024; Rehman et al., 2024)

Table 2.1. Studies about the drivers of food (in)security or the relationship between the relevant variable(s) and food (in)security

Reference	Region	Method	Variables	Period
Dithmer and Abdulai (2017)	151 countries	* System GMM	*** Dietary energy consumption** * Trade openness (+) * GDP per capita * GDP growth * Armed conflict * Arable land * Agricultural productivity * Rural population * Natural disasters * Inflation * Landlocked * Population living in geographical tropics * Policy openness * Tariffs * Globalization * Sachs-Werner openness * Dietary energy supply adequacy * Dietary diversity * Protein consumption	1980-2007

Abdullah et al. (2020)	124 countries	* System GMM	*** Dietary energy supply** * Population growth (-) * Arable land (+) * GDP (+) * Trade openness (+) * Government stability (+) * Socioeconomic condition (-) * Investment profile (+) * Internal conflict (-) * External conflict (-) * Corruption (-) * Military in politics (-) * Religious tensions (-) * Law and order (+) * Ethnic tensions (-) * Democratic accountability (+) * Bureaucracy quality (-)	1984-2018
Bogmans et al. (2021)	142 countries	* First difference instrumental variables (FD-IV) estimation approach	*** Prevalence of undernourishment** * GDP per capita * Social protection expenditure * Food inflation * Share of energy from cereals, roots and tubers	2001-2018
Nafti (2021)	26 Developing Countries	* GMM	*** Prevalence of undernourishment** *** Average intensity of food deprivation of undernourished people** * GDP per capita * Share of health expenditure in GDP * Adult literacy rate * Access to improved water source	1990-2018
Cassimon et al. (2022)	25 Sub-Saharan African countries	* Difference GMM * System GMM	*** Average value of food production** *** Average dietary energy supply adequacy** *** Prevalence of undernourishment** * Control of corruption * Political stability * Rule of law * Voice and accountability * Regulatory quality * Composite governance index * Foreign direct investment	1996-2018

			* Portfolio equity * Official development assistance * Remittances * Capital flows * Share of agriculture in GDP * Population growth * Inflation * Secondary school enrollment	
Nugroho et al. (2022)	57 Developing Countries	* One-step GMM * Two-step GMM	*** Number of unnourished people** * Food production index (+) * Cereal import dependency ratio (-) * GDP per capita * Unemployment * Economic globalization index * Corruption control * Human capital index	2002-2008
Adesete et al. (2023)	30 countries in Sub-Saharan Africa	* One-step GMM * Two-step GMM	*** Prevalence of malnourishment** * Income * Population growth * Food supply * Food price (+) * Climate change (+)	2000-2019
Amao et al. (2023)	Nigeria	* Ordinary least squares * Poisson regression * Instrumental variables (IV) poisson regression	* Sex of the household's head * Age of household's head * Agricultural revenue * Asset ownership * Household size * Education *Use of firewood *Access to credit * Food expenditure * Land size * Non-food expenditure *Marital status	2012-2013
Cancino and Cancino-Escalante (2023)	Colombia	* Time series multiple regression analysis	*** Prevalence of undernourishment** * GDP per capita (-) * Unemployment (+) * Inflation rates (+)	2000-2021
Mulyo et al. (2023)	83 Developing Countries	* System GMM	*** Prevalence of undernourishment** * Gross cereal production index * Cereal import dependency ratio * Consumer price index (CPI)	2002-2020

			* General government final consumption expenditure * Unemployment to total population * Human capital index * Land area equipped for irrigation * Individuals using the Internet (-) * Economic globalization index * Political stability and absence of violence/terrorism (-)	
Azimi and Rahman (2024)	South Asia	* Generalized Autoregressive Conditional Heteroskedasticity Model (GARCH)	*** Life expectancy at birth** *** Infant mortality rates** * Prevalence of undernourishment * Per capita kilocalorie supply * Per capita calorie intake * School enrollment rate * Per capita GDP growth *Per capita health expenditure * Per capita CO2 emissions * Inflation uncertainty * Composite institutional quality index	2000-2021
Bopushev et al. (2024)	4 Central Asian countries	* Fixed-effects regression analysis	*** Prevalence of undernourishment** * Personal remittances (-) * Food production index * GDP per capita * Unemployment * Inflation * Political stability and absence violence/terrorism **(-)**	2002-2021
Mohamed et al. (2024)	Maghreb countries	* Time lapse data models	***Agricultural productivity** * Per capita product variable (-) * Rural population (-) * Arable area (-) * Number of workers in the agricultural sector (-) * Agricultural exports (-) * Food exports * Agricultural imports * Food imports	2003-2018
Rehman et al. (2024)	South Asian countries	* Dynamic common correlated technique	*** Food production index** * Climate change * Renewable energy * Agricultural credit *Population	1990-2021

Shang et al. (2024)	Sub-Saharan Africa	* Two-step System GMM	*** Food production index** *** GDP per capita** * Innovation * Globalization	2001-2021

In addition to these, there is another factor that we have not foreseen and taken precautions: crises and pandemics. Such unforeseen extreme events underscore the inherent volatility of food security and expose the structural deficiencies and weaknesses within the system. The COVID-19 pandemic among the most profound and far-reaching events in recent history provides insight into the impact of this extreme event on food security through the movement restrictions of workers, the imposed restrictions on food trade policies, different consumption tendencies of consumers, the fall in food production facilities, and financial pressures in the food supply chain (Aday and Aday, 2020). These volatilities in the food system caused a huge food loss and waste (Fleetwood, 2020), and aggravated the food insecurity problem, malnutrition and poverty, especially for vulnerable groups (Kakaei et al., 2022).

2.3. DATA AND METHODOLOGY

2.3.1. Data

The data used in the study covers 138 countries in total over the period 2004-2022. Of these countries, there are 35 developed, 14 in transition and 89 developing countries, as defined by the United Nations (United Nations, 2023) and shown in Appendix 2. As this data consists of approximately 94 percent of the world population (see Figure 2.2.), the results obtained capture well the core of the issue.

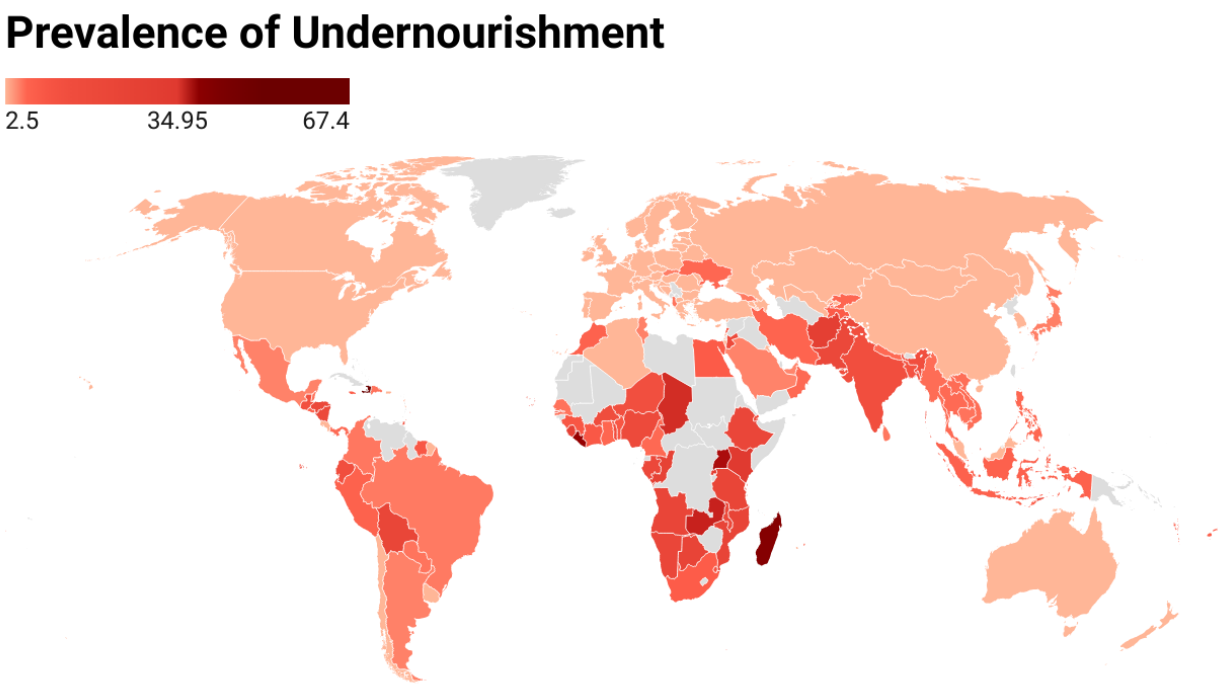


Figure 2.2. The amount of prevalence undernourished people (million)

We meticulously compiled a comprehensive set of variables based on an extensive literature review. For our analysis, we designate the prevalence of undernourishment data (*PoU*) as the dependent variable to assess food (in)security. This selection aligns with established literature (Bogmans et al. (2021), Adesete et al. (2023), Mulyo et al. (2023)) where the number of undernourished people represents the severity of the issue.

As the independent variables, we preferred using gross domestic product (*LNGDP*), food price inflation (*INF*), domestic general government health expenditure (*EXP*), food production index (*PROD*), political stability and absence of violence/terrorism *(POLST),* rural population (*RURPOP*), cereal import dependency ratio (*IMPDEP*) and total greenhouse gas emissions (*CLIMATE*) as can be seen in Table 2.2. Furthermore, the dummy variable, which is determined as the COVID-19 pandemic *(COVID)* which had led to a global destructive effect and alterations in various systems and structures, has been utilized as a proxy to capture the influence of unexpected and unpredictable events on food (in)security. Analyzing this dummy variable is crucial to assess how and to what degree extreme and unpredictable events affect the existing system.

Table 2.2. Data variables, representative factors and sources

Symbol	Variable	Representative Factor	Expected Sign	Source
		Dependent Variable		
PoU	Prevalence of Undernourishment (% of Population)	Food (In)Security	+	FAO (2025a)
		Independent Variables		
LNGDP	Gross Domestic Product per Capita (current US$)	Economic Factor	-	WorldBank (2025a)
INF	Food Price Inflation (%)	Economic Factor	+	FAO (2025a)
EXP	Domestic General Government Health Expenditure (% of GDP)	Governmental Factor	-	WorldBank (2025a)
PROD	Food Production Index	Agricultural Factor	-	WorldBank (2025a)
POLST	Political Stability and Absence of Violence/Terrorism (Percentile rank)	Political Factor	-	WorldBank (2025a)
RURPOP	Rural Population (% of total population)	Demographical Factor	-	WorldBank (2025a)
IMPDEP	Cereal Import Dependency Ratio (percent)	Economic Factor	+	FAO (2025a)
CLIMATE	Total Greenhouse Gas Emission (Mt CO2e)	Environmental Factor	+	WorldBank (2025a)
		Dummy Variable		
COVID	COVID-19 Pandemic	External Factor/Shock	+	-

2.3.2. Methodology

We apply the System GMM estimation procedure to implement this study by using balanced panel data. System GMM, which was developed by Arellano & Bover (1995) and Blundell & Bond (1998), gives more reliable results than GMM in terms of controlling time-invariant country-specific effects; correcting endogeneity by

introducing more instruments to dramatically improve efficiency and transforming the instruments to make them uncorrelated with the fixed effects; building a system of two equations which are the original equation and the transformed one; using orthogonal deviations which means minimizing data loss; and combining information on cross-country variation in levels with within-country variation in changes (Fukase, 2010). As can be seen in Table 2.1., there are many methods used to measure the impacts of different determinants on food (in)security. However, we preferred to use System-GMM because of the advantages of this method, explained above. Following the implementation of the System GMM, we compare its results with other methods, including POLS (Pooled Ordinary Least Squares), FE (Fixed Effects) or RE (Random Effects) according to the result of the Hausman test, and DIF-GMM (difference Generalized Method of Moments). The Wald chi-square statistic is employed to assess the significance of the model coefficients, thereby evaluating the overall significance of the model. A statistically significant Wald chi^2 value indicates that the model, as a whole, explains a significant proportion of the variation in the dependent variable, suggesting that at least one of the independent variables contributes meaningfully to the explanation of the outcome. Its null hypothesis is that all slope coefficients, except the intercept, are equal to zero. The alternative one represents that at least one coefficient is not equal to zero. Arellano-Bond test for testing autocorrelation and Hansen Test for overidentifying restrictions which are important for the validity of instruments are also applied in the analysis. For the Arellona-Bond test, being significant of AR(1) means the existence of a dynamic panel data model for the data. If the result of AR(2) is not significant, the null hypothesis is accepted hence there is no second-order autocorrelation. The existence of both results means no evidence of misspecification. For the Hansen test, the null hypothesis is being valid of overidentifying restrictions and thus accepting it means that all instruments are valid. Hausman test is used to differentiate between the fixed effects model and the random effects model in our paper. The test has a null hypothesis that the random effects model is consistent. If the p-value is statistically 0, we can reject the null and it means the fixed effects model is more consistent.

2.3.2.1. Static Model

Pooled OLS and fixed effect models are static models we have used in our analysis. The impacts of our variables can be estimated through the Equation (1):

$$\ln(PoU)_{it} = \beta_0 + \beta_1 LNGDP_{it} + \beta_2 INF_{it} + \beta_3 EXP_{it} + \beta_4 PROD_{it} + \beta_5 POLST_{it} + \beta_6 RURPOP_{it} + \beta_7 IMPDEP_{it} + \beta_8 CLIMATE_{it} + \beta_9 COVID_{it} + \varepsilon_{it} \quad (1)$$

where i represents the country, t denotes the time period. β_0 and β_i are constant and the coefficient of the related variable respectively. ε_{it} is the error term.

2.3.2.2. Dynamic Model

GMM models are dynamic models and we used Equation (2) to observe the impact of selected variables.

$$Ln(PoU)_{it} = \beta_0 + \beta_1 (PoU)_{it-1} + \beta_2 LNGDP_{it} + \beta_3 INF_{it} + \beta_4 EXP_{it} + \beta_5 PROD_{it} + \beta_6 POLST_{it} + \beta_7 RURPOP_{it} + \beta_8 IMPDEP_{it} + \beta_9 CLIMATE_{it} + \beta_{10} COVID_{it} + \varepsilon_{it} \quad (2)$$

This equation is a dynamic model where i represents the country, t denotes the time period. β_0 and β_i are constant and the coefficient of the related variable respectively.

2.4. RESULTS

In this paper, we focus on the factors influencing the number of undernourished people representing food insecurity over the period 2004-2022 for 138 countries. Panel data analysis was preferred in this study and four models were implemented: POLS (Pooled Ordinary Least Squares), FE (Fixed Effects) or RE (Random Effects) according to the result of the Hausman test, DIF-GMM (difference Generalized Method of Moments) and SYS-GMM (System Generalized Method of Moments). Before proceeding to the empirical analysis, it is essential to provide a general overview of the data used in the study. This includes presenting descriptive statistics, shown in Table 2.3, to better understand the characteristics and distribution of the variables.

Table 2.3. Descriptive statistics

	N	Mean	Minimum	Maximum	Std. Dev.
PoU	3036	10.350	2.5	67.4	10.367
LNGDP	3036	8.476	4.697	11.803	1.509
INF	3031	7.213	-39.148	438.655	14.570
EXP	2903	3.336	0.084	10.693	2.209
PROD	3036	93.163	30.85	183.45	18.510
POLST	2898	45.734	0.472	100	26.255
RURPOP	3036	41.675	0	86.053	21.649
IMPDEP	2892	23.040	-507.7	100	62.764
CLIMATE	3036	309.784	0.518	15175.62	1172.891
COVID	3036	0.091	0	1	0.288

Following the descriptive analysis, unit root tests are performed to examine the stationarity properties of the variables. This step is crucial to determine the appropriate econometric methodology, especially in the context of time-series or panel data analysis. Given the panel nature of the dataset, both cross-sectional and time-series dimensions are considered. Prior to implementing advanced econometric models such as the System GMM, the stationarity of the variables is tested to ensure robust and unbiased estimations. Accordingly, we primarily performed the Fisher-ADF (Augmented Dickey-Fuller) unit root test to determine the stationarity of the data. This test enables to accommodate heterogeneity across cross-sectional units by allowing individual unit root tests and then combining their p-values, and increases the power of the test in panels with a moderate number of time periods and cross-sections. The results of the unit root test are given in Table 2.4.

Table 2.4. Fisher-ADF unit root test result for all variables in the model.

Variables	At Level
PoU	758.62***
LNGDP	406.27***
INF	437.07***
EXP	319.13***
PROD	378.22***
POLST	466.82***
IMPDEP	454.51***
CLIMATE	381.50***
COVID	189.35***

Significancy code: *** significant at 0.01 level

The results of our analysis, as shown in Table 2.5., indicate that the significant and persistent impacts of lagged values for SYS-GMM models are clearly seen when looking into the coefficients of *PoU(t-1)*, it is 0.9348 for the two-step SYS-GMM model. While the coefficients of *GDP, POLST* and *CLIMATE* are significant only for static models (POLS and FE), the *INF* variable has been found as significant only for dynamic models (SYS-GMMs). The *PROD* and *IMPDEP* are the only variables which has been found as significant on all models. One unit increase in *PROD* and *IMPDEP* is associated with an average 0.0074 and 0.0012 unit increase respectively in the prevalence of undernourishment. The significance of other variables chosen has changed depending on the model however the SYS-GMM models taken as a basis in our study indicate that *PoU(t-1), INF, PROD, RURPOP, IMPDEP* and *COVID* among independent variables are significant on both SYS-GMM models. Even if the impact of *INF, PROD* and *IMPDEP* are relatively small, they have an exacerbating impact on food insecurity. One unit increase in inflation, production and import dependency is associated with an average 0.0035, 0.0074 and 0.0012 unit increase respectively in the prevalence of undernourishment. Unlike the others, despite having a negligible coefficient, *RURPOP* has a positive effect on food security. These findings demonstrate how significantly the prevalence of past undernourishment and the COVID-19 pandemic have influenced food security. The prevalence of undernourishment in previous year has 0.94 impact on the current year. The devastating impact of the *COVID* pandemic as a shock and an external factor has been clearly proven following the results, it serves as a catalyst and increases the issue by 37%. The other independent variables are not significant and hence cannot be evaluated.

Table 2.5. Results of the estimation based on POLS, FE, DIF-GMM and SYS-GMM

Results of the Estimation based on POLS, FE, DIF-GMM and SYS-GMM						
Independent variables	**POLS**	**FE**	**One-Step DIF-GMM**	**Two-Step DIF-GMM**	**One-Step SYS-GMM**	**Two-Step SYS-GMM**
PoU(t-1)			0.9364***	0.9364***	0.9349***	0.9348***
LNGDP	-5.2450***	-4.2070***	-0.1938	-0.1939	-0.2091	-0.2101
INF	0.0103	0.0031	0.0038***	0.0038***	0.0035***	0.0035***
EXP	0.2381**	-0.0498	0.0080	0.0076	0.0111	0.0109
PROD	0.0396***	-0.0758***	0.0076**	0.0076**	0.0075**	0.0074**
POLST	0.0510***	-0.0328***	0.0026	0.0026	0.0029	0.0029
RURPOP	-3.18e-06***	-0.0000	-1.32e-07	-1.31e-07	-1.38e-07*	-1.37e-07*

IMPDEP	0.0192***	-0.0054**	0.0011*	0.0011*	0.0012*	0.0012*
CLIMATE	-0.0002*	0.0007**	-0.0000	-0.0000	-0.0000	-0.0000
COVID	0.5296	1.0875***	0.4078***	0.4073***	0.3686***	0.3683***
C	54.9641***	54.7682***	1.0968	1.0945	1.2355	1.2442
R^2	0.51	0.39				
F-statistic	281.99***	131.47***				
Wald chi^2			23311.21***	23180.58***	23127.75***	23011.30***
Arellano-Bond test for AR(1)			1.40	1.50	1.42	1.53
Arellano-Bond test for AR(2)			0.18	0.18	0.18	0.19
overid.restrictions						
Hansen test			137.12	137.12	136.90	136.90
Difference-in-Hansen tests						
Hansen test-GMM			137.11	137.11	136.33	136.33
Hansen test-IV			133.63	133.63	136.25	136.25

Note: *** Significant at 0.01, **Significant at 0.05, *Significant at 0.1

The validity of the findings has been proved by the tests specified in the lower part of the table. Because the result of Wald chi^2 is significant, we reject the null hypothesis, thereby meaning that our model has a statistically significant explanatory capacity. The presence of autocorrelation was investigated through the Arellano-Bond test. According to this test, if the result of AR(1) is significant but AR(2) is not, this is an expected situation and proves that there is evidence of first-order autocorrelation however it is solved in second-order autocorrelation, thereby the model is statistically valid for our analysis. The validity of instruments has been also proved by Hansen test results failing to show statistical significance. This consistency is also approved by Difference-in-Hansen test results.

Figure 2.3. visually demonstrates the magnitude of the effects. As it can be clearly understood that the most important and influential factors on the prevalence of undernourished people are the lagged values, COVID-19 pandemic, production, inflation, import dependency and rural population, respectively.

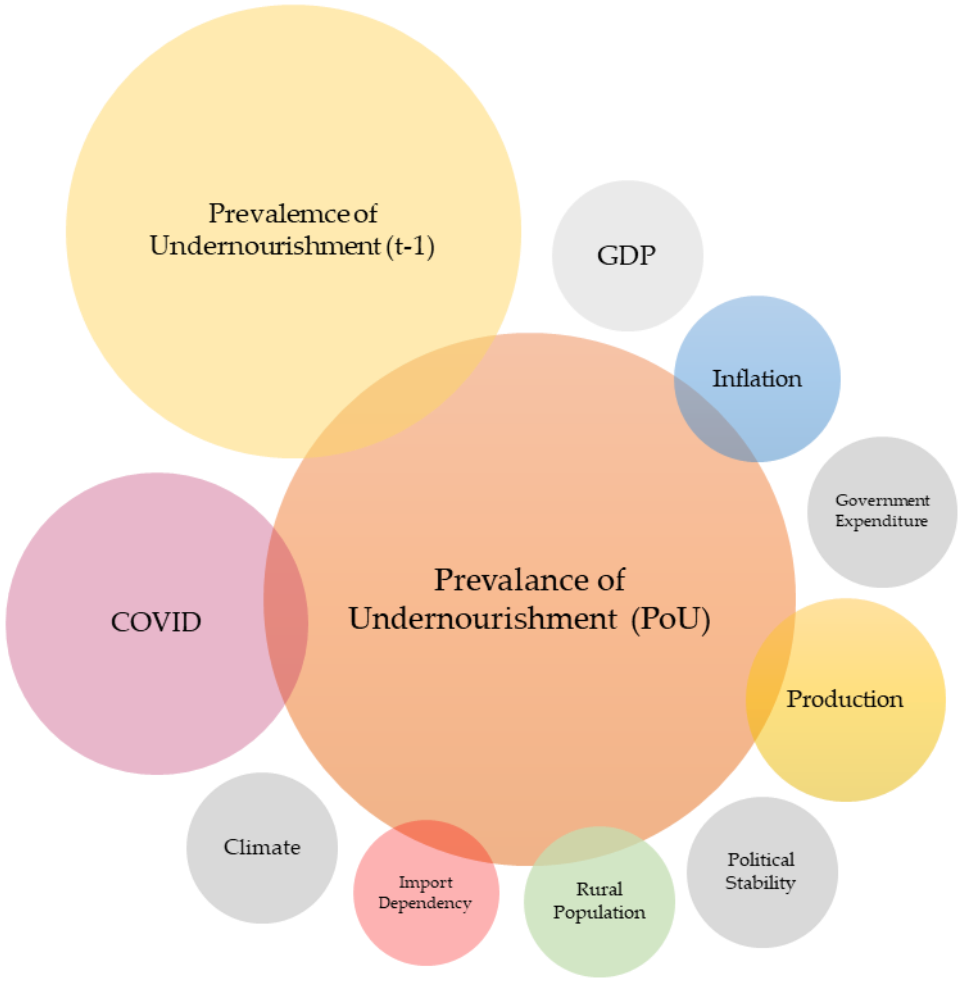


Figure 2.3. Illustration for the magnitude of effects

2.5. DISCUSSION

This investigation focusing on the drivers of the prevalence of undernourishment, representing food insecurity, addresses the issue in a multidimensional manner, including economic, governmental, agricultural, political, demographical, environmental factors and a shock representing an external factor. By adopting a multidimensional approach, the study provides a comprehensive framework to assess the relative impact of diverse factors affecting food insecurity.

In light of the findings, it has been clearly seen that the lagged value of PoU *(PoU(t-1))* is the most influential factor on the prevalence of undernourishment. As can be supported by the literature (Abdullah et al., 2020; Cassimon et al., 2022; Nugroho et al., 2022; Adesete et al., 2023), the value of PoU in the previous year is a very important factor in food (in)security. Structural deficiencies stemming from the production, distribution, income level, infrastructure, and policies implemented could potentially explain this outcome. This implies that any action taken today to address the issue can have a substantial mitigating effect on the problems that may arise in the near future. If any extreme event or crisis occurred in the previous year and its effects have not yet been mitigated, this may also contribute to the persistence of food insecurity in the following year.

Because many elements such as purchasing power, living standards, consumption preferences, health conditions tend to evolve in parallel with GDP (Kakwani, 1993; Diacon and Maha, 2015; Erçelik, 2018; Behera and Dash, 2017), it is anticipated to make a contribution of GDP growth to the rise in production and the fall in inflation through increasing production; social aid for poor and undernourished people; infrastructure development strengthening logistical operations that will improve both food access and food quality as well. All these contributions, therefore, play a significant decreasing role in the number of undernourished people. However, contrary to our expectations, the impact of *LNGDP* is not significant in our analysis so cannot be evaluated. Although the finding may initially appear counterintuitive, existing literature offers plausible explanations. Nugroho (2022) finds that GDP per capita does not make a substantial difference on number of undernourished people. This outcome is attributed to the possibility that, despite increases in income levels, individuals may refrain from traveling to access or purchase adequate food due to prevailing such conflicts. Secondly, Headey (2016) argues that GDP may be a misleading indicator of the purchasing power of poor or vulnerable households within a country, as it does not capture income inequality. He contends that the price index used to calculate real GDP per capita (i.e., the GDP deflator) may not accurately reflect the consumption patterns of populations experiencing food insecurity. Consequently, it remains unclear whether changes in GDP adequately capture trends in the purchasing power of the poor. From a different perspective, the study of Eini-Zinab et al. (2020) divided countries into three groups

based on their GDP levels, it was found that the trend in the reduction of undernutrition rates did not show a significant difference among these groups. It was suggested that this lack of association may be due to income inequalities. In contrast, when countries were grouped and evaluated according to their Gini coefficient, this coefficient was found to be a significant variable in predicting the trend of decreasing undernutrition rates. It was observed that countries with lower Gini coefficients experienced a more rapid decline in undernutrition, indicating that income distribution plays a critical role in reducing food insecurity.

Inflation (*INF)* which has a very strong power on the purchasing power undoubtedly influences food insecurity to a great extent. There are various driving factors influencing agricultural inflation (Tandoğan Aktepe and Kayral, 2024). Among these, the main factors can be cited as the role of exchange rate (Norazman et al., 2018; Köse and Ünal, 2022; Davidson et al., 2012), changes in input prices including crude oil, fertilizer etc. (von Braun and Pachauri, 2006; Wang et al., 2014; Baffes, 2007), supply-side factors such as trade restrictions (Giordani et al., 2014), international prices and volatilities (Kornher and Kalkuhl, 2013; Lee and Park, 2013; Dawe et al., 2015). All these changes tend to exert upward pressure on prices, resulting in a general inflationary trend. Under such circumstances, the already existing food access issue is likely to be aggravated, thereby increasing the prevalence of undernutrition.

Although some analyses reach the negative impact of government expenditures *(EXP)* on the prevalence of undernourishment and food insecurity (Nafti, 2021), the coefficient of *EXP* is not significant in our study hence we cannot make any interpretation.

The most striking result in our study is the impact of production *(PROD)* because its impact on *PoU* is positive contrary to our expectations. Predictably, a wide range of scholarly research reveals the importance and contribution of agricultural production and productivity on food security (World Bank, 2025b, FAO, 2025b, Mozumdar, 2012, Adesete, 2023, Bopushev et al., 2024, Mulyo et al., 2023). However, our findings, despite its small impact, surprisingly uncover a distinct facet of the matter. This, in turn, highlights a more compelling truth about the issue — that improving food security necessitates not merely increasing production, but also guaranteeing fair and effective access to that production. Despite increases in production, inequitable distribution —

which may result from logistical problems or inadequate social policies — along with rising prices and export-oriented production, can lead to negative outcomes for food security. Furthermore, agricultural practices focused on monoculture, while boosting production, may diminish crop diversity, resulting in limited access to essential nutrients and contributing adversely to food insecurity. Nugroho et al. (2022) having similar result to our paper assert that the cause of this unexpected result is poorly shaped food distribution channel, population growth exceeding production growth, social conflicts and wars influencing internal economies, and the rise in demand for biofuels globally which may lead producers to change food crops to energy crop production, for their sample chosen.

As previously stated, ensuring food accessibility represents a core element of achieving food security, and this is closely linked to political stability. The ongoing Russia-Ukraine conflict serves as a pertinent example, given that both nations are significant actors in global agricultural production and major providers of basic agro-commodities including wheat and maize (European Parliamentary Research Service (EPRS), 2022). Additionally, while political and security stability has a decreasing impact on the prevalence of undernourishment, the related issues with political instability such as internal and external conflicts, military in politics, religious and ethnicity tensions worsen food security (Abdullah et al., 2020, Cassimon et al., 2022, Mulyo et al., 2023, Bopushev et al., 2024). For our study, because the coefficient of political stability *(POLST)* is not significant, we cannot provide any result about it.

Urbanization and the fall in agricultural population remain a consistently prominent issue when it comes to agricultural production and food security. As these changes exert a non-negligible influence on agricultural production and the food supply chain, their mitigating role on food security outcomes is particularly significant (Dithmer and Abdulai, 2017, Mohamed et al., 2024). Our findings reveal the positive impact of *RURPOP*, despite its very small coefficient, on food security.

The recent COVID-19 pandemic and the Russia-Ukraine crisis have once again underscored the critical role of import dependency in food security. Indeed, some international disruptions and unforeseen crises such as pandemics and natural disasters have revealed its different dimension. The finding from our study (*IMPDEP*) indicates

its aggravating effect on the prevalence of undernourished people. This may be attributed to the price volatility, disruptions in supply chains and thereby supply assurance risk, fall in domestic production, exchange rate risk and foreign currency dependency, increasing vulnerability during external shocks. Although import dependency may contribute to greater food availability and diversity in the short run, it represents a structural vulnerability that threatens long-term food security. In line with this reasoning, our empirical findings, compatible with the studies by Nugroho et al. (2022) and Mulyo et al. (2023), substantiate the claim that import dependency poses a risk to long-term food security.

As a long-standing topic of global concern, climate change (*CLIMATE*) representing environmental factor is incorporated into our analysis given its substantial and well-documented effects on agricultural production. Its negative impacts on food systems including production, access, utilization, nutrition and thereby rural livelihoods and food security have been demonstrated in numerous studies (FAO, 2015; UNWFP, 2012). Adesete et al. (2023) empirically demonstrated the adverse impact of climate change on food security. However, in the present paper, it is not possible to derive a conclusive result due to the insignificance of the coefficients.

The findings related to COVID-19 *(COVID)* represent one of the most striking aspects of our study. The magnitude of COVID-19's impact is underscored by the staggering death toll, which has surpassed millions globally. Nevertheless, our findings reveal that, aside from the tragic loss of life, the pandemic has served as a profound test and experience of humanity's ability to access essential goods and services (Bene et al., 2021; Alam and Khatun, 2021). This is an expected result because of the adverse impacts of the COVID-19 pandemic on food security through the movement restrictions of workers, the imposed restrictions on food trade policies, different consumption tendencies of consumers, the fall in food production facilities, and financial pressures in the food supply chain (Aday and Aday, 2020). All these changes in the food system caused huge food loss and waste (Fleetwood, 2020), and aggravated the food insecurity problem, malnutrition and poverty, especially for vulnerable groups (Kakaei et al., 2022). These adverse conditions are reflected in our findings, which indicate that the pandemic had a negative impact on food security of approximately 38%.

2.6. CONCLUSION

Food security, which forms the foundation of many Sustainable Development Goals (SDGs) including no poverty, good health and well-being, reduced inequalities etc. and has gained increasing prominence in the context of accelerating global warming, has become an even more critical issue in light of recent extreme events and the COVID-19 pandemic. These developments underscore the urgent need to examine food security more closely and comprehensively. In the analysis of food security, the prevalence of undernourishment is widely regarded as a key indicator which may reveal the change of food security in time and represent the population whose habitual food consumption is inadequate to meet the necessary dietary energy levels needed to sustain an active and healthy life.

The present paper, accordingly, delves into the internal factors influencing the number of undernourished people (representing food insecurity) and the impact of an external factor which is handled as the COVID-19 pandemic, which has a global impact and is a breaking point in this issue. In this context, we focused on the 2004-2022 period by using 138 countries and the impact of an extreme issue/shock as well, unlike many previous studies. The data chosen consists of approximately 94 percent of the world population, thereby the results obtained capture well the core of the issue. Our primary focus is on the prevalence of undernourished people as the dependent variable, while we consider various independent variables including gross domestic product (*LNGDP*), food price inflation (*INF*), domestic general government health expenditure (*EXP*), food production index (*PROD*), political stability and absence of violence/terrorism *(POLST),* rural population (*RURPO*P), cereal import dependency ratio (*IMPDEP*) and total greenhouse gas emissions (*CLIMATE*) and a dummy variable which is determined as COVID-19 pandemic *(COVID)* as a proxy to capture the influence of unexpected and unpredictable events on food (in)security. We employed the System GMM estimation procedure to ensure the reliability of our findings.

The findings we obtained suggest that the lagged value of the prevalence of undernourished people variable, inflation, food production, rural population, import dependency and *COVID* have been identified as significant factors influencing food security. Among them, the variables including the lagged value of *PoU*, COVID-19

pandemic, food production, inflation and cereal import dependency, from the most to the least influential, are triggering and aggravating factors on the prevalence of undernourished people. Rural population is the only decreasing factor in our analysis.

Therefore, beyond immediate responses, long-term structural reforms are essential to ensure lasting resilience and decrease the prevalence of undernourished people in the years ahead. These can be exemplified as providing agricultural subsidies, modern and climate-resilient agricultural practices, investment in R&D and agricultural innovations for the rise in *better production*; improving logistics networks, supporting cooperatives and local marketing networks and making regulations on reducing food waste for *better distribution*; creating employment opportunities and implementing necessary income regulations that can improve the living standards, or increasing social assistance programs that can be used to support low-income groups for *better income level;* investing on agricultural infrastructure, irrigation systems and storage facilities for *better infrastructure;* and addressing policy inadequacies requires the formulation of inclusive, evidence-based strategies with strong implementation and monitoring mechanisms for *better policies.* Implementing these measures and developing relevant policies could contribute to increased production and GDP, while also helping to lower food prices and enhance food accessibility. An increase in domestic production could, in turn, contribute to a reduction in import dependency and it is imperative for countries to implement policies that both mitigate reliance on external sources and promote the resilience of domestic agricultural systems. Such policy interventions contribute to the strengthening of national food systems while increasing their resilience to external shocks like COVID-19 pandemics and reducing the severity of their negative consequences.

As food security is inherently a complex, multi-factorial, and multi-dimensional issue, future research may benefit from exploring additional variables not covered in the current study, particularly by examining the implications of the Russia-Ukraine conflict, which has substantial implications for food security and resilience, and provide a comprehensive assessment of crisis impacts.

CHAPTER 3

UNRAVELING THE MAJOR DETERMINANTS BEHIND PRICE CHANGES IN FOUR SELECTED REPRESENTATIVE AGRICULTURAL PRODUCTS

3.1. INTRODUCTION

Food supply and security discussions have remained at the forefront as a panhuman issue across the board. Although their popularity has increased with the COVID-19 pandemic, it is a longstanding issue that becomes more visible during crisis periods. Particularly, after the COVID-19 pandemic, this problem has been triggered and it has become a more complex issue with global stockpiling and speculative news. In addition to unsettling societies, it stimulates a preexisting and deeper food inflation problem. Although mostly seen and evaluated as a macroeconomic issue, it is more of a basic need because extreme price movements endanger food security and increase poverty (Anoruo and Elike, 2009; Headey and Ruel, 2023; Birhane et al., 2014). As a new phenomenon in the changing world, sustainable development goals (SDGs) defined as a 'universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity' by the UNDP (2024), focus on this issue. Hence being able to analyze its drivers plays a crucial role in human life rather than simply reducing prices for economic indicators. A substantial body of research has examined the factors driving food inflation from different perspectives. According to these studies, the determinants can be categorized mostly as climatic conditions (Bandara and Cai, 2014; Mavejje, 2016; Çevik and Tovar Halles, 2023), supply- and demand-side factors (Trostle, 2008; Tadesse et al., 2014; Aday and Aday, 2020), changes in input prices (Lee, 2002; Işık and Özbuğday, 2021), external factors such as crises (Espitia et al., 2020; Mead et al., 2020; Bairagi et al., 2022), and macroeconomic factors (Apergis and Rezitis, 2011; Ur Rehman and Khan, 2015).

Undoubtedly, any change in these factors exerts either a positive or negative influence on agricultural production, consequently impacting food inflation. Climate change

attributed to global warming both changes crop physiology and affects growth processes such as photosynthesis, transpiration, and maturation (Mahato, 2014). Extreme temperatures also contribute to loss in grain weight, nutrition value, and protein inclusion, impairing overall crop quality (Kim, 2012). Moreover, climate-driven extremes like floods and intense rainfall decrease the potential production yield (Habib-ur-Rahman et al., 2022) by damaging the crops and agricultural community assets (Squires and Gaur, 2020). Agricultural production is heavily influenced by the prices of inputs. Increases in the prices of fertilizers, energy, and other inputs cause an incremental cost resulting in low production levels (Alexander et al., 2022; Soliman et al., 2023) and decreased crop yield below potential (Brunelle et al., 2015). Energy prices, in particular, have attracted attention in recent times due to supply constraints and their susceptibility to political and geopolitical conditions, which often dictate price fluctuations (Shahbaz et al., 2023). In addition to these mentioned factors, in an interlinked and globalized world, international prices affect domestic prices and volatility (Kornher and Kalkuhl, 2013; Lee and Park, 2013; Dawe et al., 2015). This volatile structure shows its power and redound on prices. Also, external factors such as wars and pandemics spark this volatility, leading to price spikes as disruptions in production, supply chains, and logistics processes ensue (Özkanlısoy, 2021; Janzen and Zulauf, 2023). Given the importance of policymaking aimed at increasing production and decreasing prices, changes in macroeconomic variables such as interest rates, exchange rates and money supply wield considerable influence over the price analyses (Awokuse, 2005; Kadir and Tunggal, 2015; Oluwatoyese et al., 2016).

As a country where the relative importance of the agricultural sector is still quite high, Türkiye exhibits notable contributions from the food and non-alcoholic beverages group to inflation dynamics, with their weights in the 2003 based inflation basket and annual contribution to overall change standing at 24.98% and 18.51% respectively (TurkStat, 2024a). However, this is not a recent concern for Türkiye when considering previous periods. Given Türkiye's geopolitical and the various influencing factors, there are different determinants affecting prices. Besides all these factors, food inflation is still relatively higher in Türkiye compared to the European Union in terms of both level and volatility (Erol, 2017). Additionally, while the consumer food price index based on 2015 increased by 141.6 percent in 2023 for world, Türkiye experienced a rate of 913.7

percent (FAO, 2024). Many reasons including exchange rate, country risk arising in economic and political areas, interest rates (Akyol Özcan, 2023; Ertuğrul and Seven, 2023; Kartal and Depren, 2023) can be attributed for this discrepancy. The World Bank report (World Bank, 2020) underscores inefficiencies in Turkish agricultural markets, and the negative impacts of short-term policies rather than broader policies strategy focusing on the increased productivity and improved market linkages, for this upward trajectory.

With the crises experienced, this issue has become more complicated. Among the crises having the most penetrating impact on prices of agricultural products, the Asian crisis (1997–1999), Turkish economic crisis (2001), the overlapping period of the global financial crisis and the global food crisis (2008–2009), Russia– Türkiye aircraft crisis (2015–2016), and COVID-19 pandemic (2019–2021) can be cited for the recent years. Although each crisis stems from different reasons, all have an impact on price fluctuations.

The Asian crisis, mostly grounded in excess foreign borrowing, inadequate audit of banking systems, and massive exchange rate devaluation, increased prices in different ways depending on the fiscal and monetary policy responses of the crisis countries. Knowles et al. (1999) reveal that agriculture was profoundly affected because of the rise in input prices and livestock input prices being connected with the high exchange rate. While the increase in farm input prices is 15–100 percent, it is approximately 100 percent for the price of animal feeds and farm labor in the Philippines (Reyes et al., 1999). In Indonesia, the depreciation of the exchange rate and the increase in CPI for food was 80 percent and more than 50 percent respectively, in this crisis period (Atinc and Walton, 1998).

The reasons for the 2001 Turkish economic crisis can be attributed to internal debates within the government, resulting in the depreciation of the Turkish lira. This led to a significant shift towards foreign currency, pulling the withdrawal of foreign investors from the market, overnight interest rates in interbank markets exceeding 1000 percent, and a decline in the reserves of the Central Bank (Turan, 2011). Moreover, while inflation was approximately 30 percent, it exceeded 70 percent in the post-crisis period (Turan, 2011; Temiz ve Gokmen, 2009).

The overlapping period of the global financial crisis and the global food crisis (2008-2009) can be defined as the periods during which the most impactful crises on price fluctuations. Food commodity prices and the index for all commodities increased by 98 percent and 286 percent, respectively (Trostle, 2008), during this crisis which stemmed from various factors including a decline in agricultural production growth and global grain stocks, higher production costs due to energy prices, and increased demand from emerging economies, etc. (Mittal, 2009).

While the impact of Russia–Türkiye aircraft crisis on price movements cannot be clearly observed, this crisis, which erupted from the downing of a Russian bomber aircraft by a Turkish fighter jet due to airspace violation, notably affected the most imported and exported agricultural products. For instance, prices of tomatoes, eggplant, squash, oranges, and grapefruits, among the most exported agricultural products by Türkiye, decreased by approximately 29%, 26%, 46%, 29%, and 25%, respectively, in the post-crisis period (Oğuz, 2016). The Borsa Istanbul (BIST) food and beverage index was also negatively affected (Şahin et al., 2017).

Although the COVID-19 pandemic is primarily considered a health crisis, its impacts have reverberated across the globe, affecting all sectors due to disruptions in workflow, production systems, logistic sectors, and supply processes. Restrictions, leading to a sharp decline in the supply side of agricultural production in countries regarding entry and exit, have significantly driven prices up for the long term. While the prices of perishable goods and basic food items have been strongly affected and increased due to the pandemic (Mead et al., 2020; Bairagi et al., 2022), the prices of cotton have decreased due to a decline in demand in the textile and apparel sector (WTO, 2021).

In this study, we analyze the drivers of price changes for four selected representative agricultural products within the context of crises. Factors considered in accordance with the existing literature are categorized into four subgroups: governmental effects, agricultural inputs, macroeconomic indicators, and climatic conditions. We evaluate the impacts on four goods: wheat, maize, olive oil, and cotton. These goods are chosen for two reasons. Firstly, they effectively represent price movements owing to their important shares in both global agricultural production and Turkish exports, as depicted

in Table 3.1. Secondly, the two of them (wheat and maize) represent the subsistence goods while the others (olive oil and cotton) represent the industrial goods (cash crops).

According to data from the Turkish Statistical Institute (TurkStat) (2024b), cereal exports constitute approximately one-quarter of Turkish total exports. Among cereals, wheat and maize have the largest shares, accounting for 28.1% and 12.1%, respectively, in 2023. Türkiye hold a significant position in cotton, contributing 3% to global cotton production and ranking 7th (USDA, 2024). Similarly, Türkiye ranks 4th in the world for olive oil production for the 2021–2022 period (International Olive Council, 2024).

The present study comprehensively addresses the issue of price development across different dimensions, making its results highly significant for the literature and serving as a guide for policymakers. With this purpose, this paper focuses on identifying the factors influencing price changes during the period of 2002–2021, taking into account three distinct crises. The study analyzing four variables categorizes them into four sub-groups: governmental effects, inputs, macroeconomic indicators, and climatic conditions. Compared to the literature mostly focusing on the impacts of agricultural inputs and macroeconomic variables on agricultural commodity prices, this paper presents a more comprehensive analysis by including both overlooked factors and crises of different causes. Hence, the findings are expected to contribute to the gap in the literature to a great extent.

Table 3.1. Top countries having the largest shares in the production of chosen products in the world production

Wheat		**Maize**		**Olive Oil**		**Cotton**	
Top Countries	**Share in the World**	**Top Countries**	**Share in the World**	**Top Countries**	**Share in the World**	**Top Countries**	**Share in the World**
1. China	17.3%	1. US	31.6%	1. Spain	42.0%	1. China	24.4%
2. EU	17.0%	2. China	23.4%	2. Italy	10.2%	2. India	22.6%
3. India	14.1%	3. Brazil	9,9%	3. Tunisia	7.7%	3. Brazil	12.9%
4. Russia	11.6%	4. EU	5.0%	**4. Türkiye**	**7.4%**	4. US	10.7%
5. US	6.2%	5. Argentina	4.0%	5. Greece	7.3%	5. Pakistan	5.9%
6. Canada	4.1%	6. India	3.1%	6. Morocco	6.5%	6. Australia	4.3%
7. Pakistan	3.6%	7. Ukraine	2.6%	7. Portugal	3.9%	**7. Türkiye**	**2.8%**
8. Australia	3.3%	8. Mexico	1.9%	8. Algeria	3.2%	8. Uzbekistan	2.6%
9. Ukraine	3.0%	…	…	9. Argentina	1.0%	9. Argentina	1.4%

10. Türkiye	**2.5%**	**16. Türkiye**	**0.7%**	10. Egypt	0.7%	10. Mali	1.2%

Source: USDA (2024) for wheat, maize, and cotton; International Olive Council (2024) for olive oil.

3.2. LITERATURE REVIEW

3.2.1 Literature in the World

Although the factors influencing price changes vary across countries, there are common determinants that affect countries universally, as illustrated in Table 3.2. This table, which presents studies analyzing various periods and countries or groups of countries, highlights the consistent drivers of inflation. Regardless of the sample and timeframe, variables such as CPI, GDP, exchange rates, oil price, and money supply are frequently used to examine this relationship. Although many studies affirm the significant role of exchange rates in driving inflation (Norazman et al., 2018; Köse and Ünal, 2022; Davidson et al., 2012), there is no consensus about the impact of money supply on food inflation. While some studies assert its positive correlation with food inflation (Kuma and Gata, 2023; Samal et al., 2022), others contest this assertion (Qayyum and Sultana, 2018). Additionally, the impact of crude oil price on production costs contributes to a decline in agricultural supply, and this is seen as another additive effect on prices (Von Braun and Pachauri, 2006; Wang et al., 2014; Baffes, 2007). Supply-side factors, including trade restrictions, declining in agricultural productivity, and inadequate reserves, along with demand-side factors like population growth, shifting consumption patterns, and urbanization also significantly stimulate inflation pressures (Tadesse et al., 2014; Obadi and Korcek, 2014; Demirtaş et al., 2023). Table 3.2. summarizes a comprehensive overview of the literature by presenting studies using different periods, methodologies, and variables.

Table 3.2. Some studies on the determinants of food price inflation in the world

Reference	Title	Years	Period	Region	Method	Variable
Baek and Koo (2010)	Analyzing Factors Affecting U.S. Food Price Inflation	1989–2008	Monthly	US	* Johansen cointegration analysis * VEC model	* US food prices *Agricultural commodity prices * Energy prices * Ethanol production * Exchange rates
Davidson et al. (2012)	Explaining UK Food Price Inflation	1990-2010	Annually	UK	* Co-integrated vector autoregressive (C-VAR)	* UK retail food price index * Domestic producer prices * World commodity prices * Dollar price of oil * Exchange rate * Labour costs

						* Unemployment rate
Huh and Park (2013)	Examining the Determinants of Food Prices in Developing Asia	1995-2011	Quarterly	11 Developing Asian Countries	* Vector autoregression	* Oil price * World GDP * World food price * Food price future * Asian GDP * Asian food price * US exchange rates * Real GDP * Money supply * Individual food prices
Irz et al. (2013)	Determinants of food price inflation in Finland—The role of energy	1995-2010	Monthly	Finland	* Vector error-correction model (VEC)	* Farm Price * Food Price * Energy Price * Wage
Lee et al. (2013)	Food Prices and Population Health in Developing Countries: An Investigation of the Effects of the Food Crisis Using a Panel Analysis	2001-2010	Annually	Developing Countries	* Panel analysis	* Government Health Expenditure per capita * GDP per capita * Political score * Armed conflict dummy * Youth population share * Improved sanitation facilities * Value-added agriculture
Ahmed and Singla (2014)	An Analysis of Major Determinants of Food Inflation in India	2006-2013	Monthly	India	* Johansen cointegration technique * Error correction model	* Food price index * Oil price index * World food price index * Rainfall * Broad money * Interest rate on the short-term loan * Nominal effective exchange rate
Bhattacharya and Sen Gupta (2017)	Drivers and Impact of Food Inflation in India	2006-2013	Monthly	India	* Structural vector autoregression (SVAR) * Structural vector error correction model (SVECM)	* Global food prices * Fuel prices * Agricultural wages * Demand for food products
Ismaya and Anugrah (2018)	Determinant of Food Inflation the Case of Indonesia	2008-2017	Quarterly	Indonesia	* GMM estimator	* GDP agriculture * GDP consumption * Domestic retail fuel price * Food imports * Narrow money * Credit agriculture * M1 to GDP consumption ratio
Norazman et al. (2018)	Food Inflation: A Study on Key Determinants and Price Transmission Processes for Malaysia	1991-2013	Monthly	Malaysia	* Vector error-correction model (VECM)	* Malaysian food price index * World food price index * Labor cost * Real effective exchange rate * World oil price
Qayyum and Sultana (2018)	Factors of Food Inflation: Evidence from Time Series of Pakistan	1970-2017	Annually	Pakistan	* Regression analysis	* CPI * GDP in GDP growth * Food export * Food imports * Money supply * Taxes
Caklovica and Efendic (2020)	Determinants of Inflation in Europe: A Dynamic Panel Analysis	2005-2015	Yearly	28 European countries	* Dynamic panel analysis	* Economic openness * Unemployment rate * Real wage growth *Institutional effects * Prices of food * Oil prices * Growth of real GDP per capita * Income growth per

						capita * Growth rate of monetary aggregate * Change in real exchange rate * Policy framework * Inflation * Fiscal balance/GDP * Terms of trade * Political stability * Exchange rate regime * Central bank independence * EBRD index of structural and institutional reforms * Food prices * EU membership * Domestic credit to private sector * Western Balkan regime * CIS group * General government expenditures * Current account balance * Share of agriculture * Population growth * Territory area * Index of economic freedom * Nominal or real exchange rate index
Adjemian et al. (2024)	Factors Affecting Recent Food Price Inflation in the United States	2004-2022	Monthly	United States	* Structural vector autoregressive models – SVAR	* Core prices * M2 money supply * Per capita income * Wage * Energy price * GSCI * Transport price * Farm product price * Food price
Köse and Ünal (2022)	The effects of the oil price and temperature on food inflation in Latin America	2003-2020	Monthly	Latin America	* Structural vector autoregression (SVAR) * Panel granger causality test	* Temperature change * Oil price * Nominal exchange rate * Wages in the agricultural industry * Food price
Kohlscheen (2022)	Understanding the Food Component of Inflation	1990-2020	Annually	35 Countries	* Local projection method	* CPI inflation * Expected inflation * Output gap * Domestic crop growth * Food exports growth * Food imports growth * Oil price change * Global food price inflation
Samal et al. (2022)	The Impact of Macroeconomic Factors on Food Price Inflation: An Evidence from India	2006-2019	Monthly	India	* ARDL bounds test	* Per capita GDP * Real exchange rate * Money supply * Global food price index * Per capita net availability of food grain * Agricultural wages * Combined price index-industrial workers for food indices
Kuma and Gata (2023)	Factors Affecting Food Price Inflation in Ethiopia: An Autoregressive Distributed Lag	1990-2021	Annually	Ethiopia	* ARDL	* Food Price Index * Real GDP * World food price * Rainfall amount * Population number * Money supply

Approach	* Exchange rate * Interest rate

3.2.2. Literature on Türkiye

Among the studies on inflation in Türkiye, their focuses can be categorized as determinants of inflation in a general context, the impact of specific variables on prices, the analysis of macroeconomic indicators' impact, the examination of other relevant factors, and the relationship analysis with prices.

The determinants in a general context are mostly identified as the exchange rate, consumer price index (CPI) or food price index, GDP, and money supply (Tay Bayramoğlu and Koç Yurtkur, 2015; Erol, 2017; Alev, 2019; Aytekin and Hatırlı, 2021; Şahin Kutlu, 2021; Demirkılıç et al., 2022). On the other hand, findings obtained by Tay Bayramoğlu and Koç Yurtkur (2015) show that the dollar and euro exchange rate are the most important international factors affecting food industry prices in the short term. Despite their limited impacts, oil prices, international food prices, and agricultural producer prices are found to be effective on food prices in the long term. Similarly, Şahin Kutlu (2021) and Demirkılıç et al. (2022) highlight the significance of the exchange rate on food prices. Alev (2019) asserts that while inflation is positively affected by the money supply, interest rate applied to loans and deposits in the long run, it is positively affected only by the money supply and budget deficit (balance) variables in the short run. Aytekin and Hatırlı (2021) emphasize the significance of the import unit variable of food production on unprocessed food inflation. In addition to these studies, some studies analyze the factors affecting the prices of specific products. In this sense, while Mat et al. (2021) examine the factors of raw milk price, Bayramoğlu et al. (2020) analyze tomato prices.

From the studies focusing on the impacts of specific inputs on prices, Altıntaş (2016) prefers oil prices as a variable and concludes that while a negative change in oil prices has a negative impact on food prices, positive change also has a positive impact. However, the effect of positive changes in oil prices is greater on prices than negative changes. Gökçe's study (2021), which evaluates the exchange rate in addition to oil prices, reaches the same result as Altıntaş (2016) in terms of the relationship direction,

emphasizing that their relationship with food prices is asymmetric. Başkaya et al. (2008) focus on global warming, globalization, and food crisis rather than the impacts of inputs. The findings indicate that supply-side factors are more determinant in the high rise of processed food prices. Among these factors, drought precedes supply-side shocks and a high rise in international food prices stemming from the drought. Similarly, Bayramoğlu et al. (2021) handle the issue by adding ecological factors to economic factors to estimate their impacts on wheat prices. The results obtained present that the most effective factor in wheat prices is precipitation. Güloğlu and Nazlıoğlu (2013) directly analyze the impact of inflation on agricultural prices and assert that inflation has a positive impact on the prices in the low-inflation regime and a negative impact in the high-inflation regime. Specifically, Özaytürk (2023) examines the impact of energy inflation and presents its positive impact on agricultural products' inflation. Because prices are influenced by many factors, as mentioned in the literature above, some studies explore the relationship among those factors. Of them, İcen et al. (2022) aimed to study the relationship among food prices, the exchange rate and oil prices in Türkiye. The findings reveal that positive changes in the long-term trend of oil prices and the exchange rate have a greater impact on food prices than negative changes. The same relationship was also analyzed by Güngör and Erer (2022). The paper finds that the real exchange rate effect on food inflation increased during the COVID-19 pandemic period. Karacan (2022) specifically examined the prices of grains, crude oil, and real effective exchange rates as examples. It is revealed that there is a unidirectional causality from REER to crude oil, wheat, corn, and rye prices, and from wheat, barley, and rice prices to Brent oil prices. Moreover, bidirectional causality is found between REER and barley, rice, and durum wheat prices.

3.3. DATA AND METHODOLOGY

3.3.1. Data

The data set used in this paper comprises annual data for Türkiye, spanning from 2002 to 2021. The preceding years were not be incorporated into the analysis because of the outbreak of the 2001 Turkish economic crisis. Including this crisis in the analysis could have led to potentially misleading results. In order to mitigate this risk, earlier data should have been included; however, regrettably, the absence of such data necessitated

the exclusion of the period before 2002. Although many papers focusing on the agricultural issues utilize quarterly or monthly data, our goal was to evaluate less-examined variables and more interrelated factors. Hence, we chose to use annual data, following the approach of numerous other studies (Işık and Özbuğday, 2021; Kuma and Gata, 2023; Samal et al., 2022; Dumrul and Kılıçarslan, 2017).

The dependent variables chosen to measure price developments are the price of wheat (*Wheat*) and the price of maize (*Maize*), representing subsistence goods, as well as the price of olive oil (*OliveOil*) and the price of cotton (*Cotton*), representing industrial goods (cash crops). The independent variables, as can be seen in Figure 3.1., are categorized into four groups: governmental effects, agricultural inputs, macroeconomic indicators, and climatic conditions, allowing for evaluation based on the specific fields. These categories have been named Group I, Group II, Group III and Group IV, respectively, for evaluation purposes. Compared to the existing literature, variables under Group III are most frequently used for analyzing price changes (Kuma and Gata, 2023; Samal et al., 2022; Qayyum and Sultana, 2018; Huh and Park, 2013; Ismaya and Anugrah, 2018). Input-related variables, especially oil prices, under Group II, are also often examined (Norazman et al., 2018; Bhattacharya and Sen Gupta, 2017; Kohlscheen, 2022). However, studies focusing on the impact of Group I and Group II are relatively scarcer than those examining other groups. Although there are some analyses on political stability (Lee et al., 2013; Caklovica and Efendic, 2020) and climatic conditions (Köse and Ünal, 2022; Ahmed and Singla, 2014), they are very limited in scope. Thus, our study gains significance in terms of bridging this gap, particularly as these issues have become more pressing in recent times with the escalation of climate change and the increasing complexity of governmental effects.

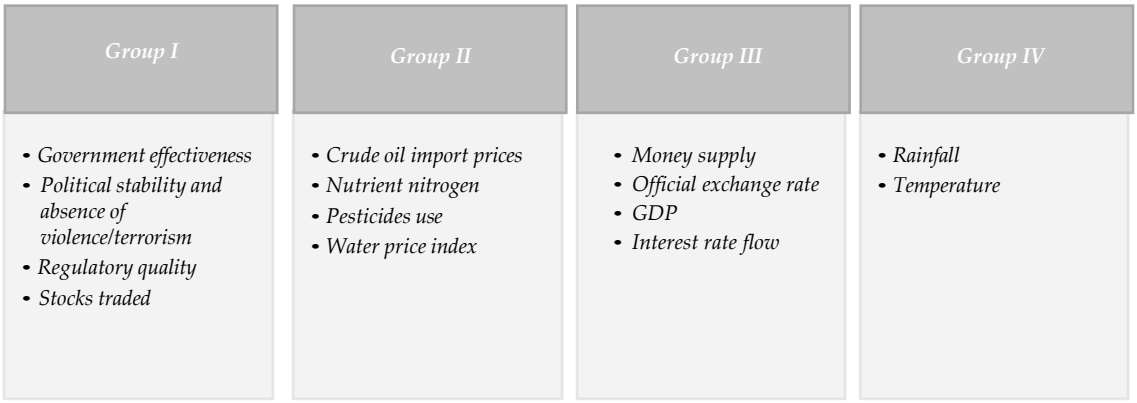


Figure 3.1. Independent variables

Among them, the governmental effect includes government effectiveness (*GovEff*), political stability and absence of violence/terrorism (*PolS*), regulatory quality (*Reg*) and stocks traded (*Stocks*). The inputs cover crude oil import prices (*Oil*), nutrient nitrogen (*Nitr*), pesticide use (*Pest*) and the water price index (*WPI*). The macroeconomic indicators consist of money supply (*M1*), official exchange rate (*Exc*), GDP (*GDP*) and interest rate flow (*Int*). The climatic conditions are represented by the impact of rainfall (*Rain*) and temperature (*Temp*). Detailed explanations and sources of the variables are shown in Table 3.3.

Table 3.3. The explanations of the variables

Variables	***Explanations***
Wheat	Price of wheat (USD 1000) (FAO, 2024)
Maize	Price of maize (USD 1000) (FAO, 2024)
OliveOil	Price of olive oil (USD 1000) (FAO, 2024)
Cotton	Price of cotton (USD 1000) (FAO, 2024)
GovEff	Government effectiveness: The quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (World Bank, 2024)
PolS	Political stability: The perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism (World Bank, 2024)
Reg	Regulatory quality: The ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development (World Bank, 2024)
Stocks	Stocks traded: The value of shares traded is the total number of shares traded, both domestic and foreign, multiplied by their respective matching prices (World Bank, 2024)
Oil	Crude oil import prices (USD/barrel) (OECD, 2024)
Nitr	Nutrient nitrogen used in agriculture (FAO, 2024)
Pest	Pesticide use, including the major pesticide groups (insecticides, herbicides, fungicides, plant growth regulators, and rodenticides) and relevant chemical families, in agriculture (FAO, 2024)
WPI	Water supply price in the context of CPI (TurkStat, 2024a)

M1	M1 money supply including money in circulation and current deposit (FAO, 2024)
Exc	Official exchange rate: the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (World Bank, 2024)
GDP	Gross domestic product: the sum of the value added by all of its producers (USD) (World Bank, 2024)
Int	Interest rate flow: The weighted average interest rates of deposits calculated for each deposit (stock) and maturity segment (The Central Bank of the Republic of Türkiye, 2024)
Rain	Average annual rainfall (Turkish State Meteorological Service, 2024)
Temp	Average annual temperature (Turkish State Meteorological Service, 2024)

Note: The explanations of *GovEff*, *PolS*, *Reg*, *Stocks*, *Pest*, *Exc* and *GDP* are given as defined in the source from which the data were taken.

To measure the impact of crises, three crises of distinct causes are included in the equations as dummies. These include the overlapping period of the global financial crisis and the global food crisis (2008–2009) which is addressed as the global food crisis in this paper since our research focuses on the food dimension, the Russia–Türkiye aircraft crisis (2015–2016), and the COVID-19 pandemic (2019–2021). These crises are incorporated into all equations to observe their effects, represented as *GFC*, *Aircraft* and *COVID* in the equations and analysis. Except for the independent variables under the category of governmental effects, all the series are converted into logarithmic form. Data are sourced from the databanks of World Bank, FAO, OECD, the Turkish Statistical Institute, and the Central Bank. EViews 12 software package is used for the analysis. Descriptive statistics related to the data are given in Appendix 3.

3.3.2. Methodology

In the context of this paper, the ARDL model proposed by Pesaran et al. (2001) is preferred for analyzing the short-term and long-term relationships between price changes' inputs and crises. The ARDL approach outperforms other possible models in several aspects: It facilitates cointegration analysis across different orders of stationarity, yields better results with limited data, obtains more reliable results compared to the Engle– Granger causality test when data are scarce, and enables the estimation of whether the model has an autocorrelation problem or not through the Breusch–Godfrey LM test (Narayan and Narayan, 2004). A general form of ARDL model is given below:

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{i=0}^{p} \alpha_{2i} x_{t-i} + \varepsilon_t \quad (3)$$

where y and x represent the dependent and independent variables, respectively, α_0 is a constant term, p denotes the autoregressive order of the ARDL, α_i and α_{2i} are coefficients associated with a linear trend, and ε_t is the error term.

The error correction model showing how long the shocks occurred for in a short period reaching the equilibrium point over the long period is formulated as follows:

$$\Delta y_t = \alpha_0 + \alpha_1 EC_{t-1} \sum_{i=1}^{p} \alpha_{2i} \Delta y_{t-i} + \sum_{i=0}^{p} \alpha_{3i} \Delta x_{t-i} + \varepsilon_t \quad (4)$$

where α_i represents the spread of adjustment of the parameter and EC is a residual from the equation.

Because the existence of the differences between the number of observations and the number of variables is important in terms of preventing biased results, a new model is estimated for each group of variables. The equation used for the analysis can be essentially shown as follows:

For *Group I*;

$$\begin{aligned} lnFI_t = \; & \alpha_1 + \alpha_{GE} GovEff_t + \alpha_{PS} PolS_t + \alpha_R Reg_t + \alpha_S lnStocks_t + \alpha_A Aircraft_t \\ & + \alpha_C COVID_t + \alpha_{GF} GFC_t + \sum_{h=1}^{m_1} \beta_h lnFI_{t-h} + \sum_{i=0}^{n_1} \beta_i GovEff_{t-i} \\ & + \sum_{j=0}^{o_1} \beta_j PolSt_{t-j} + \sum_{k=0}^{p_1} \beta_k Reg_{t-k} + \sum_{l=0}^{q_1} \beta_l lnStocks_{t-l} \\ & + \sum_{m=0}^{r_1} \beta_m Aircraft_{t-m} + \sum_{n=0}^{s_1} \beta_n COVID_{t-n} + \sum_{o=0}^{t_1} \beta_o GFC_{t-o} + \varepsilon_{1t} \end{aligned} \quad (5)$$

For *Group II*;

$$\begin{aligned} ln\mathrm{FI}_t = {} & \alpha_2 + \alpha_{CO} lnOil_t + \alpha_N lnNitr_t + \alpha_{PU} lnPest_t + \alpha_{WP} lnWPI_t + \alpha_A Aircraft_t \\ & + \alpha_C COVID_t + \alpha_{GF} GFC_t + \sum_{h=1}^{m_2} \beta_h ln\mathrm{FI}_{t-h} + \sum_{i=0}^{n_2} \beta_i lnOil_{t-i} \\ & + \sum_{j=0}^{o_2} \beta_j lnNitr_{t-j} + \sum_{k=0}^{p_2} \beta_k lnPest_{t-k} + \sum_{l=0}^{q_2} \beta_l lnWPI_{t-l} \\ & + \sum_{m=0}^{r_2} \beta_m Aircraft_{t-m} + \sum_{n=0}^{s_2} \beta_n COVID_{t-n} + \sum_{o=0}^{t_2} \beta_o GFC_{t-o} + \varepsilon_{2t} \end{aligned} \tag{6}$$

For *Group III*;

$$\begin{aligned} ln\mathrm{FI}_t = {} & \alpha_3 + \alpha_{CP} lnM1_t + \alpha_{ER} lnExc_t + \alpha_{GD} lnGDP_t + \alpha_{IR} lnInt_t + \alpha_A Aircraft_t \\ & + \alpha_C COVID_t \\ & + \alpha_{GF} GFC_t + \sum_{h=1}^{m_3} \beta_h ln\mathrm{FI}_{t-h} + \sum_{i=0}^{n_3} \beta_i lnM1_{t-i} + \sum_{j=0}^{o_3} \beta_j lnExc_{t-j} + \sum_{k=0}^{p_3} \beta_k lnGDP_{t-k} \\ & + \sum_{l=0}^{q_3} \beta_l lnInt_{t-l} + \sum_{m=0}^{r_3} \beta_m Aircraft_{t-m} + \sum_{n=0}^{s_3} \beta_n COVID_{t-n} \\ & + \sum_{o=0}^{t_3} \beta_o GFC_{t-o} + \varepsilon_{3t} \end{aligned} \tag{7}$$

For *Group IV*;

$$\begin{aligned} ln\mathrm{FI}_t = {} & \alpha_4 + \alpha_{RF} lnRain_t + \alpha_T lnTemp_t + \alpha_A lnAircraft_t + \alpha_C lnCOVID_t + \alpha_{GF} GFC_t \\ & + \sum_{h=1}^{m_4} \beta_h ln\mathrm{FI}_{t-h} + \sum_{i=0}^{n_4} \beta_i lnRain_{t-i} + \sum_{j=0}^{o_4} \beta_j lnTemp_{t-j} + \sum_{k=0}^{p_4} \beta_k Aircraft_{t-k} \\ & + \sum_{l=0}^{q_4} \beta_l COVID_{t-l} + \sum_{m=0}^{r_4} \beta_m GFC_{t-m} + \varepsilon_{4t} \end{aligned} \tag{8}$$

where FI_t represents the price of the chosen dependent variable; α_1, α_2, α_3 and α_4 are the constant; other α_x terms and β_x show the long-run and short-run coefficients respectively; ε_t terms are the error terms.

3.4. RESULTS

3.4.1. Unit Root Tests

To be able to implement the ARDL model, the order of stationarity is one of the preconditions. By contrast with the conditions in traditional cointegration tests such as Engle Granger (1987) and Johansen (1988) cointegration tests which conditions being stationary in I(0), the ARDL model enables the cointegration analysis even if they are stationary at different levels such as I(0) and I(1). Hence, this paper examines the stationarity of the dependent variables at I(0) and I(1) level by using Augmented Dickey Fuller (ADF) unit root test (1981) and Phillips-Perron (PP) unit root test (1988) as can be seen in Table 3.4.

Table 3.4. Unit root tests for dependent variables

Unit Root Tests	***ADF***				***PP***			
Variables	***I(0)***		***I(1)***		*I(0)*		*I(1)*	
	Intercept	***Trend and Intercept***	***Intercept***	***Trend and Intercept***	***Intercept***	***Trend and Intercept***	***Intercept***	***Trend and Intercept***
lnWheat	-5.3438***	-5.8411***	-5.0456***	-4.8031***	-3.3695**	-4.9201***	-7.0292***	-7.3019***
lnMaize	-0.1160	-4.1266**	-4.9221***	-4.8584***	-2.9655*	-4.5816***	-10.7074***	-10.2056***
lnOliveOil	-0.9164	-2.1474	-1.6802	-6.5761***	-0.9402	-2.4228	-6.1610***	-6.1148***
lnCotton	-2.2449	-2.8796	-6.4637***	-3.8689**	-2.2449	-2.8796	-7.0035***	-19.6503***
GovEff	-1.5624	-1.1898	-4.2080***	-4.9308***	-1.0086	-1.1632	-4.2427***	-4.9376***
PolS	-1.4927	-2.1918	-3.8467**	-3.7696**	-1.4651	-1.8906	-3.9347***	-4.4314**
Reg	0.1164	-0.2221	-3.1681**	-3.2829	-0.9522	-0.8728	-2.8771*	-3.8570**
lnStocks	-1.9534	-2.7419	-3.6538**	-3.2984*	-1.9388	-2.7045	-3.6538**	-3.2173
lnOil	-2.4841	-2.1538	-3.6217**	-3.6960**	-2.4920	-2.0841	-3.5450**	-3.5195
lnNitr	0.5177	-4.3684**	-7.9176***	-4.6653**	-2.3281	-4.5360***	-8.7712***	-9.5052***
lnPest	-1.0697	-5.7521***	-10.5544***	-2.7557	-2.4430	-5.6881***	-14.6800***	-14.0909***
lnWPI	0.1799	-3.0950	-3.9285**	-4.2392**	0.4070	-2.6237	-3.1263**	-2.8059
lnM1	0.4509	-1.4952	-2.8855*	-2.7739	0.0339	-1.7746	-2.8929*	-2.7040
lnExc	-0.2578	-0.4408	-0.8061	-6.4791***	4.2022	0.2932	-2.0353	-13.7321***
lnGDP	-5.1657***	-2.8848	-3.0221*	-3.8424**	-6.5906***	-6.0155***	-2.9778*	-3.7552**
lnInt	-3.1495**	-1.1006	-3.2240**	-5.4897***	-3.3270**	-2.5539	-3.0890**	-6.1067***
lnRain	-4.4481***	-4.6459***	-5.1711***	-5.0400***	-4.4630***	-4.7290***	-17.4911***	-18.3060***
lnTemp	-3.2700**	-5.9474***	-4.6999***	-4.4940**	-3.2676**	-7.0547***	-23.7940***	-22.8425***

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The findings present that all the variables are stationary at first difference according to ADF and PP unit root tests.

The stationarity of crises is separately analyzed by using Breakpoint Unit Root Tests (Dickey-Fuller min-t) because they represent the breakdown in the series. Their results are given in Table 3.5.

Table 3.5. Breakpoint unit root tests for dummy variables

Breakpoint Unit Root Tests (Dickey-Fuller min-t)	***I(0)***		***I(1)***	
Variables	***Intercept***	***Trend and Intercept***	***Intercept***	***Trend and Intercept***
GFC	-4.4159*	-4.3721	-6.3687***	-7.8612***
Aircraft	-7.0000***	-5.4222***	-6.9282***	-6.0250***
COVID	-1.50E+080***	-2.6488	-2.51E+08***	-4.6668*

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The results of the breakpoint unit root test show being stationary of all crises at both levels. The differences in stationary levels observed in all unit root tests indicate being ARDL model appropriate for the analysis.

3.4.2. Lag Length Criteria and Bounds Test

The optimal lag length is chosen based on the Akaike Information Criteria (AIC). For the measurement of long-term relationship and cointegration, the F-bounds test is applied as can be seen in Table 3.6.

Table 3.6. F-Bounds test

F-Bounds Test							
Dependent Variable: lnWheat		***Dependent Variable: lnMaize***		***Dependent Variable: lnOliveOil***		***Dependent Variable: lnCotton***	
Variable Group	***F-Stat***	***Variable Group***	***F-Stat***	***Variable Group***	***F-Stat***	***Variable Group***	***F-Stat***
Group I	7.0492***	***Group I***	33.5497***	***Group I***	26.3861***	***Group I***	10.9923***
Group II	4.2257*	***Group II***	3.6251*	***Group II***	1.7744	***Group II***	21.7804***
Group III	6.7250***	***Group III***	5.1116**	***Group III***	6.6230***	***Group III***	21.1098***
Group IV	2.8097	***Group IV***	1.8711	***Group IV***	3.9751*	***Group IV***	6.2298**

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The findings indicate that the null hypothesis (H_0), which asserts no cointegration, is rejected for Group I and Group III across all selected goods. Although a long-term relationship is found for all variables concerning cotton, it is observed across all groups

except for Group IV for wheat and maize. Regarding olive oil, the long-run relationship is established in all groups except for Group II. Notably, the results for Group IV concerning the price of wheat and maize lead to the rejection of the alternative hypothesis (H_1) referring to the presence of a long-term relationship.

3.4.3. ARDL Model

Based on the results of the bounds test, the ARDL model is evaluated for both short and long-term analysis with the lowest AIC value, as detailed in Appendix 4. The Breusch–Godfrey LM test shows that the null hypothesis meaning no serial correlation cannot be rejected for wheat, maize, and olive oil at the 5% significance level. However, for cotton, it can only be rejected for inputs at a 5% significance level, indicating the existence of autocorrelation. The Ramsey Reset test findings prove no specification problem in the model except for Group III specific to the price of cotton, where all other probabilities are greater than 0.05. The Breusch–Pagan–Godfrey (BPG) heteroskedasticity test reveals no heteroskedasticity problem for any of the variables, except for Group II specific to the price of olive oil.

3.4.4. Long-Run Relationship

Upon analyzing the price movements of the selected variables as outlined in Appendix 5, it is observed that the price fluctuations of maize and wheat show similarities. However, while maize prices have followed a fluctuating trajectory thus far, wheat prices have shown a moderate course, albeit not as stable as the cotton price. In the course of cotton prices, volatilities have remained range-bound for an extended period but have had a tendency to increase in recent years. Although olive oil has followed a fluctuating course for the years, it shows more stability in recent years. Starting from this point, it can be evaluated that subsistence goods tend to follow a more volatile trajectory compared to industrial goods.

However, these observations are not explanatory in themselves and do not help to unravel the underlying causes behind price changes in selected agricultural products. Hence, empirical studies and findings are essential to understand this phenomenon.

As given in Table 3.7., regarding the results of wheat, we can evaluate all groups except Group IV without encountering a lack of cointegration problem. In Group II, while

crude oil and nitrogen use exhibit positive relationships with the rate of wheat price increasing by 5.32% and 29%, respectively, the WPI shows a negative relationship, decreasing by 10.29%. Group III propounds striking results about the impact of macroeconomic indicators on price. Contrary to the strong positive impact of money supply by 18.93%, the exchange rate and GDP show a negative impact of 22.44% and 26.15%, respectively. Additionally, the Russia–Türkiye aircraft crisis and COVID-19 contributed to price declines of 2.66% and 8.82%, respectively.

Table 3.7. Long-run relationship

ARDL Long Term Results							
Dependent Variable: lnWheat							
Group I		***Group II***		***Group III***		***Group IV***	
Variable	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***
GovEff	-34.4375	***lnOil***	5.3207**	***lnM1***	18.9344***	***lnRain***	4.0944
PolS	-3.0724	***lnNitr***	28.9994*	***lnExc***	-22.4379***	***lnTemp***	23.2546
Reg	41.1295	***lnPest***	12.2228	***lnGDP***	-26.1514**	***Aircraft***	-0.3166
lnStocks	-1.8230	***lnWPI***	-10.2934*	***lnInt***	2.8473	***COVID***	-0.4555
Aircraft	-4.3567	***Aircraft***	2.0609	***Aircraft***	-2.6552*	***GFC***	0.3209
COVID	6.3222	***COVID***	-0.2128	***COVID***	-8.8226*		
GFC	4.4976	***GFC***	2.3200	***GFC***	-0.7226		
Dependent Variable: lnMaize							
Group I		***Group II***		***Group III***		***Group IV***	
Variable	**Coefficient**	***Variable***	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***
GovEff	-19.8404**	***lnOil***	1.3259	***lnM1***	8.5622*	***lnRain***	-15.5487
PolS	-1.8595	***lnNitr***	19.4751**	***lnExc***	-8.0163	***lnTemp***	-4.9602
Reg	23.6453**	***lnPest***	2.9215	***lnGDP***	-20.0751*	***Aircraft***	0.7598
lnStocks	-0.4553	***lnWPI***	-3.5376	***lnInt***	-3.6687	***COVID***	0.8749
Aircraft	-1.7212	***Aircraft***	-0.5512	***Aircraft***	-1.2464	***GFC***	0.8134
COVID	1.3076	***COVID***	-0.2192	***COVID***	-6.0654		
GFC	2.0874**	***GFC***	1.7946	***GFC***	0.2351		
Dependent Variable: lnOliveOil							
Group I		***Group II***		***Group III***		***Group IV***	
Variable	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***
GovEff	-2.8344***	***lnOil***	0.1105	***lnM1***	0.8338**	***lnRain***	1.8026*
PolS	-0.3995***	***lnNitr***	2.4800	***lnExc***	-0.4630	***lnTemp***	8.7144***
Reg	1.5979***	***lnPest***	2.1943	***lnGDP***	-0.7345	***Aircraft***	0.4494**
lnStocks	0.4748***	***lnWPI***	-0.6098	***lnInt***	0.5713**	***COVID***	0.7157***
Aircraft	-0.4118**	***Aircraft***	0.9730	***Aircraft***	0.0386	***GFC***	-0.5962*
COVID	-0.3338**	***COVID***	1.1510	***COVID***	-0.1270		
GFC	0.3095***	***GFC***	0.8835	***GFC***	-0.0703		
Dependent Variable: lnCotton							
Group I		***Group II***		***Group III***		***Group IV***	

Variable	*Coefficient*	*Variable*	*Coefficient*	*Variable*	*Coefficient*	*Variable*	*Coefficient*
GovEff	-3.7489**	***lnOil***	-0.4495***	***lnM1***	0.2465	***lnRain***	0.8302
PolS	-0.9168**	***lnNitr***	0.4447	***lnExc***	0.3137	***lnTemp***	2.0535
Reg	2.3037	***lnPest***	0.3524**	***lnGDP***	-0.6133	***Aircraft***	0.1416
lnStocks	-0.3591	***lnWPI***	0.1684	***lnInt***	0.2420	***COVID***	0.6713***
Aircraft	-1.5058**	***Aircraft***	-0.6418***	***Aircraft***	-0.0562	***GFC***	-0.5460*
COVID	1.2283**	***COVID***	-0.0002	***COVID***	0.1996		
GFC	0.2053	***GFC***	-0.4091***	***GFC***	-0.1326		

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

Similar to the findings for wheat, the positive effects of nitrogen and money supply, along with the negative effect of GDP, are observed in the impacts on maize prices. A unit increase in nitrogen use and money supply leads to an incremental impact of 19.48% and 8.56%. GDP shows a strong negative impact again, with a rate of 20.08%, as in its impact on wheat prices. Unlike wheat, however, government effectiveness and regulatory quality are found to be significant for maize prices, with substantial impacts. While a unit increase in government effectiveness decreases maize prices by 19.84%, an increase in regulatory quality has a similar effect, reducing prices by 23.65%. Moreover, the impact of the GFC, in this category, is positively related to inflation. These rates are noteworthy due to their impacts on maize prices. Variables under Group IV cannot be evaluated due to the autocorrelation problem.

Except for Group II, having heteroskedasticity and autocorrelation problems, the validity tests of olive oil prices show that they meet all the model's preconditions, enabling the evaluation of all variables. The values of all factors in Group I and Group IV are significant. In Group I, government effectiveness and political stability negatively affect the price of olive oil by 2.83% and 0.40%, while regulatory quality and stocks have positive effects, with rates of 1.60% and 0.48%, respectively. Among the crises, the aircraft crisis and COVID-19 led to a decrease in inflation, while the GFC caused an increase. In Group III, the only significant and positively effective variables are money supply and the interest rate, with impact ratios of 0.83% and 0.57%, respectively, on olive oil inflation. In Group IV, the impacts of rainfall and temperature are observed as positive, with rates of 1.80% and 8.71%, respectively. However, the signs of the crises show exact opposition compared to Group I.

The findings regarding the drivers of cotton inflation reveal that a unit increase in government effectiveness and political stability slow down the rate of price increase by 3.75% and 0.92%, respectively, in Group I. Among the crises within this group, the aircraft crisis has a negative impact, while COVID-19 has a positive effect. However, the other variables cannot be evaluated because of the serial correlation problem in Group II and the specification problem on Group III. In Group IV, where only COVID-19 and GFC are significant, they have an impact on the price increase of olive oil by 0.67% and −0.55%, respectively.

3.4.5. Short-Run Relationship

A short-run relationship analysis is conducted using the error correction model. As can be seen in Table 3.8., the coefficient sign of CointEq(-1) is negative and significant, meaning that deviations from the long-run equilibrium in the selected agricultural product prices can be restored in the short-run, stabilizing the standard deviation and mitigating the shocks. Compared to the long-term results, the short-term values are notably promising, as all coefficients are significant except for a few variables.

In detail, a unit increase in the government effectiveness and stocks leads to a reduction in wheat inflation by 17.01% and 6.28%, while political stability and regulatory quality have increasing impacts with rates of 5.22% and 25.45%, respectively. The impact of COVID-19 is observed as positive on Group II with a rate of 2.36%. In Group II, except for the WPI, which shows a negative sign with a rate of 22%, the signs of all of the other significant variables are positive. A unit increase in crude oil has a positive impact on wheat inflation of 4.81%, while the impact of nitrogen use (20.64%) on wheat inflation is remarkable among the other variables in this group. The only effective crisis found is the aircraft crisis, with a rate of 5.87%. We also encounter noteworthy results in Group III. A unit increase in money supply rises wheat inflation by 17.20%, while an increase in GDP reduces it by 28.12%. Additionally, COVID-19 has a negative impact of 4.94%.

For maize, all variables are significant in Group I. Among them, the most striking results are the negative impact of government effectiveness (21.42%) and the positive impact of regulatory quality (20.77%). In Group I, all crises are positively related. In

Group II, three significant and strong effective factors are nitrogen use, WPI, and aircraft crisis. A unit increase in nitrogen use leads to a 14.11% increase in the rate of change in maize price, while a unit increase in the WPI results in a decrease by 18.73%. The Russia–Türkiye aircraft crisis is also positively related, with a rate of 1.78%. In Group III, the only significant and positive variable is the GFC, with its impact on maize inflation being 2.71%.

Table 3.8. Error correction models

Error Correction Model Results							
Dependent Variable: lnWheat							
Group 1		***Group II***		***Group III***		***Group IV***	
Variable	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***	***Variable***	***Coefficient***
D(GovEff)	-17.0136**	***D(Oil)***	4.8049**	***D(lnM1)***	17.1996***	***CointEq(-1)***	-0.9174***
D(PolS)	5.2184***	***D(lnNitr)***	20.6407***	***D(lnGDP)***	-28.1222***		
D(Reg)	25.4486**	***D(lnPest)***	5.9568**	***D(lnInt)***	-1.1334		
D(lnStocks)	-6.2819**	***D(lnWPI)***	-22.0011**	***D(Aircraft)***	-0.5280		
D(COVID)	2.3551*	***D(Aircraft)***	5.8689***	***D(COVID)***	-4.9441***		
D(GFC)	-1.1958	***D(GFC)***	-0.9675	***CointEq(-1)***	-1.4030***		
CointEq(-1)	-1.3732***	***CointEq(-1)***	-1.3579***				
Dependent Variable: lnMaize							
Group 1		***Group II***		***Group III***		***Group IV***	
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**
D(GovEff)	-21.4179***	***D(lnOil)***	0.0257	***D(COVID)***	0.2715	***D(lnRain)***	-8.1191**
D(PolS)	1.0241**	***D(lnNitr)***	14.1047***	***D(GFC)***	2.7121***	***D(COVID)***	3.8056***
D(Reg)	20.7717***	***D(lnPest)***	0.4266	***CointEq(-1)***	-0.8082***	***D(GFC)***	-2.9221*
D(lnStocks)	2.2542***	***D(lnWPI)***	-18.7280***			***CointEq(-1)***	-1.1820***
D(AirCraft)	0.4709*	***D(Aircraft)***	1.7760**				
D(COVID)	5.3984***	***CointEq(-1)***	-1.4066***				
D(GFC)	1.7996***						
CointEq(-1)	-1.7125***						
Dependent Variable: lnOliveOil							
Group 1		***Group II***		***Group III***		***Group IV***	
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**
D(GovEff)	-2.1325***	***D(lnOil)***	-0.1998*	***D(lnExc)***	-2.1728***	***D(lnTemp)***	3.4734***
D(Reg)	0.2437*	***D(lnNitr)***	-0.5906**	***D(lnGDP)***	-2.0659***	***D(Aircraft)***	-0.0089
D(lnStocks)	-0.1512***	***D(lnWPI)***	-2.8356***	***D(COVID)***	-0.2550***	***D(COVID)***	-0.0064
D(Aircraft)	-0.1912***	***D(COVID)***	-0.2369*	***CointEq(-1)***	-0.8120***	***D(GFC)***	0.2218**

D(COVID)	0.0592*	***CointEq(-1)***	-0.2262***			***CointEq(-1)***	-0.5740***
D(GFC)	0.3914***						
CointEq(-1)	-1.2652***						
Dependent Variable: lnCotton							
Group 1		***Group II***		***Group III***		***Group IV***	
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**
D(GovEff)	-0.7206	***D(lnOil)***	-0.0999	***D(lnM1)***	-0.6299***	***D(Aircraft)***	-0.1676
D(PolS)	-2.0945***	***D(lnNitr)***	3.2767***	***D(lnExc)***	-2.6147***	***D(GFC)***	0.4147**
D(Reg)	-0.2369	***D(lnWPI)***	8.3946***	***D(lnGDP)***	-2.0736***	***CointEq(-1)***	-1.2936***
D(lnStocks)	-1.5762***	***D(Aircraft)***	-0.7021***	***D(GFC)***	0.3538***		
D(Aircraft)	-0.9610***	***D(COVID)***	1.6962***	***CointEq(-1)***	-1.5292***		
D(COVID)	-0.2254	***D(GFC)***	0.3125***				
CointEq(-1)	-1.489***	***CointEq(-1)***	-2.0997***				

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

The majority of the results obtained for olive oil are significant and hence valuable for the literature. In Group I, a unit increase in government effectiveness and stocks leads to a fall in the rate of olive oil inflation by 2.13% and 0.15%, respectively, whereas regulatory quality has a positive impact of 0.24%. Among the crises, only the Russia–Türkiye aircraft crisis is negatively related to the price of a given good. In Group III, all of the significant variables, which are the exchange rate, GDP, and COVID-19, show negativity. Contrarily, in Group IV, all of the significant variables are positively related to olive oil inflation. While the impact of temperature is 3.47%, the GFC affects it by 0.22%.

The findings regarding cotton inflation present negative impacts of political stability, stocks, and the Russia–Türkiye aircraft crisis, with rates of 2.10%, 1.58%, and 0.96%, respectively. In Group IV, the only variable with a positive sign is the GFC, with an impact of 0.42%.

3.5. DISCUSSION

Upon examining all of the results, it becomes clear that the findings propound striking contributions to the literature and enhance analyses regarding the determinants behind price changes in chosen agricultural products. In the general context, the effective factors on inflation have been observed among both subsistence goods (wheat, maize)

and industrial goods (olive oil, cotton). When evaluating the common results, the role of government effectiveness, political stability, and regulatory quality as macroeconomic indicators on the inflation of the chosen agricultural products is quite obvious. However, there are some important points of distinctions among them. Firstly, although the impact of political stability may not be high, the other factors have a sizeable effect on inflation. Secondly, political stability is positively related to wheat and maize inflation but negatively related to olive oil and cotton inflation. Although this positive result may seem unexpected, findings from Lee et al. (2013) support this variability, as suggested in their study about food prices and population health in developing countries. They assert that there is an inconsistency in its impacts because while a high level of democracy is found to be negatively related to infant and child mortality, a political score is positively related to the prevalence of undernourishment. Thirdly, the government effectiveness of all of the variables shows a negative impact, while regulatory quality is found to be positively related to all goods except for cotton, which has insignificant values. Laborde et al. (2019) explain that during price plunges, government encouragement of more exports and global supply leads to a decrease in prices. Similarly, the impact of stocks varies depending on both agricultural products and the terms. However, the considerable values among them prove its negative precedence over its expected positivity. This impact is consistent with the literature (FAO, 2009b; Hathaway, 1974), which asserts that high stock levels are very important to depress price inflation. In terms of inputs, we have obtained two impressive results for the inflation of wheat and maize. Nitrogen use has affected wheat inflation by more than 20% and maize inflation by an average of 17%, positively influencing both short- and long-term scenarios. This is not a surprising result because as the input price increases, costs and, correspondingly, prices will also increase. However, the WPI has a strong negative impact on the inflation of goods mentioned with at least a 10.29% decrease. Contrary to these results, the negativity of WPI on price movements is unexpected. However, it should be noted that we used accessible tap water data. Unfortunately, the data may have misled the results because of the existence and high usage of external water sources without tap water.

Examining the macroeconomic indicators, the impacts of money supply and GDP have attracted attention regarding wheat and maize inflation. The positive impact of money

supply on wheat inflation in both the short and long terms, as well as for maize in the long term, has been distinguished. Additionally, the impact rates indicate quite an impressive impact of money supply on wheat and maize inflation. With some exceptional studies indicating a negative impact of money supply such as Qayyum and Sultana (2018), most of the literature presents that an increase in money supply tends to lead to an increase food inflation (Huh and Park, 2013; Adjemian et al., 2024), especially in the long run (Samal et al., 2022; Ahmed and Singla, 2014). GDP has been found to have a decreasing impact on the inflation of wheat, maize, and olive oil. Its impact is very strong on wheat and maize despite being comparatively slightly effective on olive oil inflation. Even if there is no consensus about the impact of GDP on food inflation, our findings are consistent with the majority of the literature (Ur Rehman and Khan, 2015; Ismaya and Anugrah, 2018; Alev, 2019). Although its sizeable impact is found only on wheat inflation in the long term, the exchange rate is a crucial driver for the analysis of food inflation. Its negative impact on food inflation, observed as 22.44%, is also supported by the literature (Davidson et al., 2012; Baek and Koo, 2010; Huh and Park, 2013). However, there is no consensus about its impacts, as some studies assert its positive effect on food inflation, while others claim the opposite. Among them, besides the study by Norazman et al. (2018) which found its impact to be negative in both terms, many papers present its positive impacts on food inflation (Kuma and Gata, 2023; Şahin Kutlu, 2021; Akçağlayan, 2021). In addition to them, some papers observe a positive relationship only in the long run (Ahmed and Singla, 2014) or the short run (Samal et al., 2022). The reason for the positive impact is explained as the rise in costs, especially for importing countries and, correspondingly, the rise in domestic demand.

Except for its impact on olive oil inflation, climatic conditions have not been found to be highly correlated with inflation. For olive oil alone, the positive impact of temperature is remarkable and the impact of rainfall is partially effective in line with the literature supporting the increasing impact of temperature and rainfall on food inflation (Köse and Ünal, 2022; Kuma and Gata, 2023; Ahmed and Singla, 2014). This does not mean that they do not have any impact on agricultural product prices, but they can be evaluated as the less effective factors.

Based on the categories, the impacts of the crises on the prices of the chosen products have varied. While it is challenging to draw a common inference, these differences can be understood. In general, during periods of crises, investments in agriculture decrease, demand for agricultural products declines, and public intervention increases, leading to a negative influence on productivity growth (Swinnen an van Herck, 2009). In this respect, less productivity growth may induce inflation. From another perspective, reduced demand for goods and services, problems in credit availability, and rising protectionism stemming from the financial crisis may cause a fall in prices (Massa, 2012).

3.6. CONCLUSIONS

As is commonly known, the importance of agriculture and agricultural production has become increasingly evident over time. Periods of crises are pretty instructive for economies and countries regarding the deficiencies in this field. The impacts of crises vary depending on the resilience and structure of countries. Understanding the drivers of agriculture production and the effects of crises on agriculture is more important than ever.

Moreover, the analyses of the factors influencing agricultural production and agricultural commodity prices have gained increasing importance due to inflation and food security problems. It is tough to explain the exact factors because of many external factors, such as political issues, climatic conditions, various crises and governmental effects, etc., alongside main inputs like agriculture and labor which play a role. Even if these factors are interrelated, and identifying the main effective factors is complex, each analysis aiming to understand the framework plays a crucial role in producing solutions to overcome these problems.

For this purpose, the current paper endeavors to shed light on the drivers behind the price changes of agricultural products for the annual period from 2002 to 2021. During this period, three different crises are also taken into consideration to analyze their impact on prices. These crises include the global food crisis (2008–2009), the Russia–Türkiye aircraft crisis (2015–2016), and the COVID-19 pandemic (2019–2021). The analysis is implemented by taking four representative agricultural products: wheat,

maize, olive oil, and cotton, as a base. Fourteen possible factors categorized into four groups, titled as governmental effectiveness, inputs, macroeconomic indicators, and climatic conditions and labeled as Group I, Group II, Group III, and Group IV, have been examined within the scope of the study.

Depending on the findings obtained, the present paper first proves the power of governmental effects and regulatory quality on price developments. The negative impacts of governmental effects on prices are an expected result because the quality of public services and its independence from political pressures increase the production and trading activities and decreases the prices. This principle also applies to the regulatory quality of the government. For instance, Mittal (2009) asserts that one factor contributing to the decline in investment in agricultural production is the reduced regulatory quality in agricultural production by the state. However, the key point mentioned here is that appropriate policies can benefit production and decrease inflation. From another perspective, the positive impact of regulatory quality on prices may be interpreted as a response to the increasing value of the goods due to regulations. Regulations mostly require meeting specific conditions and rules, which may increase costs and induce inflation.

Secondly, the impact of inputs on price movements is evident according to the findings. The incremental effect of nitrogen use and the decremental effect of the WPI should be carefully evaluated by the government, and the target-oriented regulations should be implemented to enhance their positive impacts and advantages for the goods while prevent their disadvantages. Because their impacts are not negligible, switching over their disadvantages to advantages can significantly contribute to production levels and prices more than anticipated. Moreover, careful and decisive policymaking is imperative, especially concerning nitrogen use. While nitrogen fertilizers contribute to soils, water ecosystems, oceans, and environmental degradation, decreasing their use with inappropriate implementation could lead to a 13% decrease in agricultural production and a 26% increase in prices until 2050 (Baldock et al., 2023). Hence, governments should ameliorate nitrogen-use efficiency through initiatives via manure recycling, sewage treatment and recycling, falling harvest loss and food waste, etc. (Baldock et al., 2023). Similarly, addressing water pricing requires efforts to prove

efficient and equitable water use, incentivize investment expenditure recovery rates, and allocate more resources to prevent water losses stemming from the irrigation infrastructure (Çakmak, 2010).

Money supply, exchange rate, and GDP comprise the strongest elements of food inflation, within the category of macroeconomic factors. Therefore, providing stability and sustainability in economies are crucial prerequisites for maintaining agricultural commodity prices at optimum levels.

All of these results emphasize a notion crucial for the sustainability and resilience of economies in the future, known as the SDGs (Sustainable Development Goals) in the agenda. A major part of the findings obtained is closely connected with the goals outlined in these SDGs. A thorough analysis of the components of price changes is not only beneficial to maintaining price stability but also crucial for increasing welfare, equity, and quality of life. It consists of the first link in the life cycle chain, because proper nourishment is the most essential requirement for human beings. Therefore, increasing agricultural production, providing essential support, and keeping agricultural prices remain accessible level to anyone can make a huge difference on Earth. Considered in parallel with the SDGs, these efforts may directly or indirectly contribute to the following goals:

- (SDG 1) Preventing the fall into poverty, through employment opportunities provided by support for agricultural production and the agriculture sector;

- (SDG 2) Alleviating starvation by reducing prices and increasing food accessibility, thus enhancing food security;

- (SDG 3 and SDG 4) Increasing good health and well-being, as well as the quality of education, through adequate and balanced nutrition;

- (SDG 6 and SDG 15) Providing clean water, sanitation, and sustainable land use through well-planned and controlled input use.

Considering the limitations of the study, because of incomplete data and it only being possible to take the period up to 2021, the impact of COVID-19 could not be thoroughly

investigated. Hence, including data from periods after the COVID-19 pandemic may yield better results regarding its impact. Similarly, the lack of data hindered us from analyzing a larger period, which could have included other important crises such as the Asian crisis and the Turkish economic crisis, both of which have had a sizeable impact on price movements.

Additionally, because there are many other potential factors influencing price changes in agricultural products, these factors may be included and analyzed for a better understanding of the components of price changes. For instance, among them, world demand, environmental rules, changing consumption habits and their impacts on production, land degradation, and crop characteristics would greatly contribute to insight into the issue.

Furthermore, considering external issues such as the impact of the Russia–Ukraine war would be beneficial to take a step further on the issue. If we could have, our analysis would have provided more detailed and comprehensive perspectives on the impact of drivers. In this sense, future studies may widen the scope of this study by taking a longer period and possible factors to pave the way for achieving SDGs and improving the standard of living for human beings through optimal pricing strategies.

CONCLUSION

“Sustainable development” has become more important for the whole humanity, especially in recent times, because its impacts have begun to be seriously felt by everyone irrespective of financial standing or social status. Tough and unexpected issues which may be cited as increasing consumption frenzy and demand, rapidly depleted and degraded natural resources, climate change, crises and related issues have brought the term “sustainability” to the agenda as a hot topic. Because those critical issues threaten our future to a great extent, understanding the essentials of sustainable development is very crucial.

This dissertation handles that issue through the lens of food security, which are the essential requirements of humanity and constitutes one of the most essential pillars of sustainable development. This issue has become even more important in recent years with unexpected shocks such as the COVID-19 pandemic and long-lasting political wars such as the Russia-Ukraine war that have had a serious impact on food security. In this context, the study adopts a general to specific approach, and discusses the role of food security in sustainable development, the factors affecting food security, and the dynamics of food prices, which have a significant impact on food security. The aim of these issues addressed is to reveal important findings about the underlying causes of food insecurity and the relationship between food security and sustainable development, and to make serious progress in terms of sustainable development with the suggestions presented in this direction.

In this respect, our first analysis focuses on the role of food security in sustainable development and asserts that at least 11 goals of Sustainable Development Goals adopted by UN member states, which set 17 goals aimed at promoting global peace and prosperity, are directly or indirectly linked to food security. Therefore, ensuring food security plays a crucial role in economies and influences various dynamics such as economic growth, poverty, employment, and social justice conditions of these countries. This multidimensional and effective factor is not only important for measuring hunger but improving sustainable development as well. At this point, it should be emphasized that there is a bilateral relationship between food security and sustainable development.

While food insecurity adversely affects sustainable development, positive changes in sustainable development have a beneficial impact on food security. Hence, transforming this vicious cycle into a virtuous circle is possible and very advantageous for the countries to reach prosperity and sustainable economies. Our analysis on this issue reveals that food insecurity mostly stemming from some demographic characteristics, climate change, lack of production and changes in consumption patterns, logistics problems, food inflation has a great impact on health, education, crime and social unrest, which are the major factors constituting the backbones of the sound and productive economies. Therefore, the repercussions of sustainable agriculture and food security on sustainable development are more than thought, and this dissertation provides extensive insight into this issue.

Although various indicators and variables are used to demonstrate the severity or degree of food (in)security, one of the most commonly utilized among them is the prevalence of undernourishment. In the second focal point of our study, we aimed to identify structural drivers of food (in)security with the COVID-19 period, during which food (in)security emerged as a prominent global concern. This study, conducted on the six key factors (economic, governmental, agricultural, political, demographical and environmental) and one external shock (COVID-19 pandemic), provided a general picture of the topic and yielded striking findings about food (in)security. The findings we obtained reveal the importance of the lagged value of the prevalence of undernourishment, inflation, food production, rural population, cereal import dependency and COVID-19 pandemic, while the remaining ones which are gdp, domestic general government health expenditure, political stability and absence of violence/terrorism, and climate change have been not found as significant on food (in)security. Among them, the variables including the lagged value of *PoU*, COVID-19 pandemic, food production, inflation and cereal import dependency from the most to the least influential have been determined as triggering and aggravating factors on the food insecurity. The rural population appears the only positive influence on food security in our analysis. Taking this as a starting point, some measures and improvements grounded on better production, distribution, income level, infrastructure and policies may exhibit considerable potential on production growth, stronger national food systems and thus reducing the severity of food insecurity.

Food prices are undoubtedly among the most critical factors influencing food accessibility and availability. In this capitalist system, the adverse conditions with the other causes also play a big role in the inflation. Considering all factors into consideration provides us the broad scanning in terms of getting the drift of the issue. Hence, our recent study is on the identification of the factors influencing agricultural price changes by taking three distinct crises into account. For the analysis, many potential drivers have been examined in groups. These groups are governmental effect covering the government effectiveness, political stability and absence of violence/terrorism, regulatory quality and stocks traded; agricultural inputs representing crude oil import prices, nutrient nitrogen, pesticides use and water price index; macroeconomic indicators including money supply, official exchange rate, GDP, interest rate flow; and climatic conditions consisted of rainfall and temperature. The striking results obtained reveal the importance of government effectiveness, regulatory quality, political stability, nitrogen use, money supply, exchange rate and GDP on inflation. Especially the governmental effects and macroeconomic indicators among these factors, are related to the resilience of the economies. Furthermore, this interconnectedness creates a broader repercussion and adds another element called as "food security" to the circle.

Considering the three analyses conducted in this study, it becomes evident that food security constitutes a far more critical pillar of sustainable development than commonly assumed and importantly this relationship is reciprocal and deeply intertwined. Within the general-to-specific framework adopted in this study, although various factors influencing food security—such as governmental influences, agricultural inputs, macroeconomic variables, and climatic conditions—are identified, our analysis presents a particularly noteworthy finding. While agricultural production is indeed essential in ensuring the "availability" dimension of food security, the research reveals that when individuals are unable to access these food resources—i.e., when the "accessibility" component is not met—the positive impact of production on food security becomes negligible. In this respect, ensuring that food reaches food-insecure populations and regions and enhancing access proves to be of even greater importance for achieving food security. Therefore, the policies and measures to be implemented in this regard are of critical significance.

As discussed in this study and strongly experienced during the COVID-19 pandemic, one of the most crucial components in enhancing food security is undoubtedly ensuring access to food. Accordingly, rather than relying on temporary interventions, governments must develop sound and comprehensive policies based on structural reforms and institutional arrangements. These may be outlined as follows:

- ✓ Increasing public **investment in infrastructure** to ensure timely, safe, and cost-effective delivery of food from production sites to consumers, especially in disadvantaged regions,
- ✓ Establishing **advanced storage systems**—including cold chain facilities, silos, and modern warehouses—to extend the shelf life of perishable goods and minimize post-harvest losses,
- ✓ Promoting **regional diversification of agricultural production** to prevent the geographic concentration of food supply and reduce rural–urban imbalances, while also strengthening rural infrastructure and providing financial and technical support to small-scale producers;
- ✓ Supporting food banks, soup kitchens, and mobile **food distribution networks** in collaboration with civil society organizations,
- ✓ Encouraging **digital integrated systems** to minimize food loss and **cooperatives** to reduce the number of intermediaries between producers and consumers, thereby ensuring fairer income distribution, improving price efficiency and decreasing the costs.
- ✓ Implementing nutrition **education programs** and food waste awareness campaigns that promote public health and responsible consumption behaviors,
- ✓ Developing **emergency response plans**, stock management strategies, and mobile distribution mechanisms to mitigate the impacts of unforeseen crises on food security,

- ✓ Introducing **food voucher systems**, school meal programs, and targeted nutritional support for vulnerable groups such as pregnant or breastfeeding women in financial hardship to address socioeconomic barriers to access,
- ✓ Supporting **local production** to reduce dependence on food imports and incorporating rural development objectives into agricultural policy reforms,
- ✓ Establishing procurement schemes, agricultural insurance programs, and flexible **market regulations** to secure farmers' incomes and reduce market-induced price volatility.
- ✓ Promoting productivity gains through **high-tech agricultural practices** such as greenhouse technologies, drone- and sensor-assisted farming, and AI-driven fertilizer and water management.
- ✓ In order to **reduce food waste**, regulating and implementing certain practices such as obligating retail chains to deliver surplus food to food banks.
- ✓ Providing necessary **training programs for farmers** on technological adaptation and sustainable agriculture practices.

It is anticipated that these policies and structural reforms will contribute to a decline in food insecurity. Among the findings of our study, the significant impact of food insecurity in the previous period on the current level of food insecurity is also expected to diminish through these comprehensive structural adjustments and transformative interventions.

Addressing food insecurity beginning from its root causes not only significantly contributes to sustainable agriculture and, consequently, enhances food security, but also exerts a substantial impact on sustainable development. Such progress in development, in turn, fosters increased support and investment, further advancing both sustainable agriculture and food security and creates a compounding effect that amplifies the overall impact. Accordingly, prompt and coordinated action is essential to break this vicious cycle and convert it into a virtuous cycle, thereby generating broad-based benefits for both economic systems and societal well-being.

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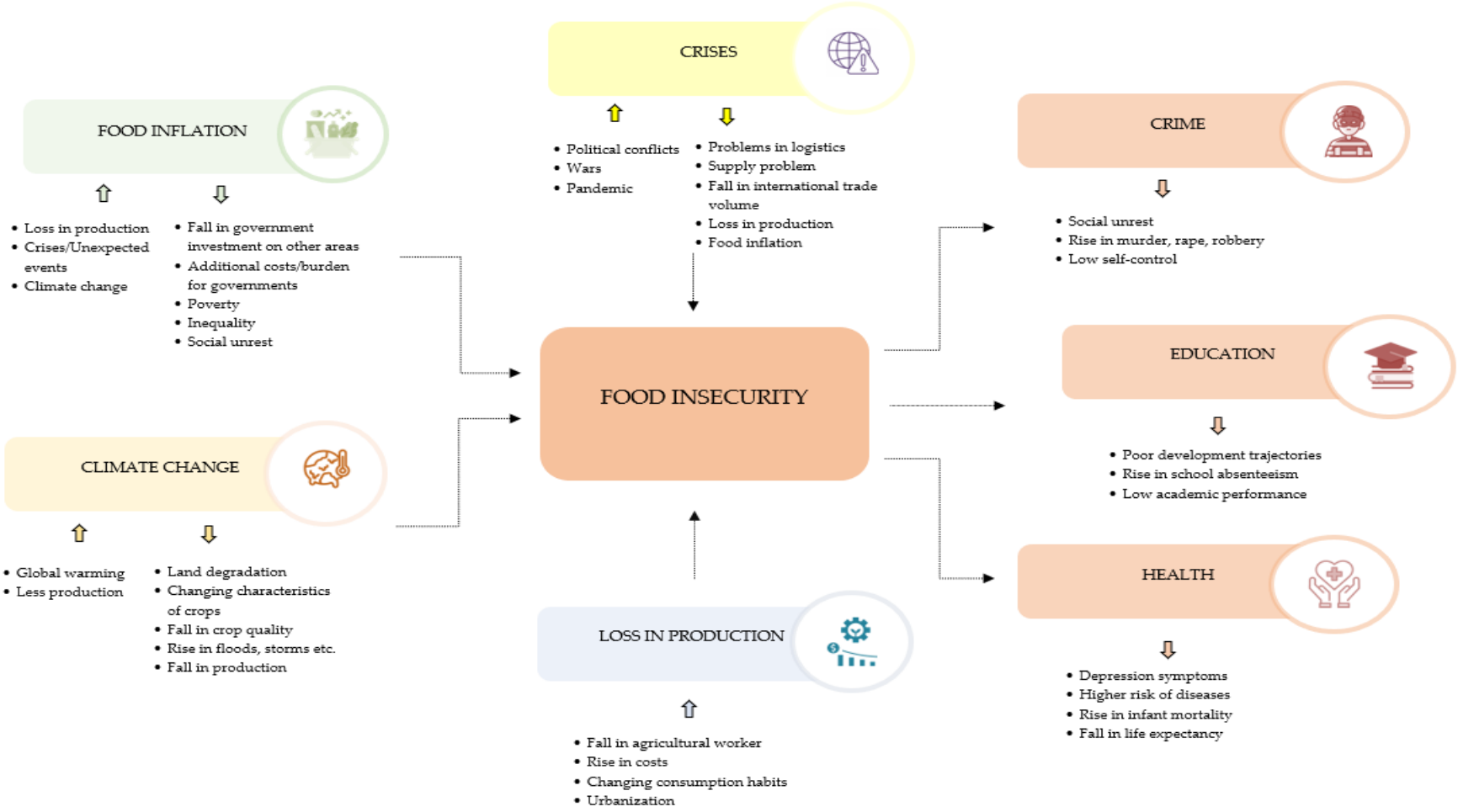
APPENDIX 1. THE FACTORS AFFECTING FOOD INSECURITY AND BEING AFFECTED BY FOOD INSECURITY



APPENDIX 2. COUNTRIES ADDRESSED IN THE STUDY

Developed		In Transition	Developing		
Australia	Latvia	Albania	Afghanistan	Gabon	Nicaragua
Austria	Lithuania	Armenia	Algeria	Gambia	Niger
Belgium	Luxembourg	Azerbaijan	Angola	Ghana	Nigeria
Bulgaria	Malta	Belarus	Argentina	Guatemala	Oman
Canada	Netherlands	Bosnia and Herzegovina	Bangladesh	Guinea	Pakistan
Croatia	New Zealand	Georgia	Barbados	Haiti	Panama
Cyprus	Norway	Kazakhstan	Belize	Honduras	Paraguay
Czechia	Poland	Kyrgyzstan	Benin	India	Peru
Denmark	Portugal	Moldova	Bolivia	Indonesia	Philippines
Estonia	Romania	North Macedonia	Botswana	Iran	Rwanda
Finland	Slovak Republic	Russian Federation	Brazil	Israel	Saudi Arabia
France	Slovenia	Tajikistan	Burkina Faso	Jamaica	Senegal
Germany	Spain	Ukraine	Cabo Verde	Jordan	Sierra Leone
Greece	Sweden	Uzbekistan	Cambodia	Kenya	South Africa
Hungary	Switzerland		Cameroon	Korea	Sri Lanka
Ireland	United Kingdom		Chad	Kuwait	Suriname
Italy	United States		Chile	Lao PDR	Tanzania
Japan			China	Lebanon	Thailand
			Colombia	Liberia	Timor-Leste
			Congo Rep.	Madagascar	Togo
			Costa Rica	Malawi	Trinidad and Tobago
			Cote d'Ivoire	Malaysia	Tunisia
			Djibouti	Mauritius	Türkiye
			Dominican Republic	Mexico	Uganda
			Ecuador	Mongolia	United Arab Emirates
			Egypt	Morocco	Uruguay
			El Salvador	Mozambique	Vanuatu
			Eswatini	Myanmar	Viet Nam
			Ethiopia	Namibia	Zambia
			Fiji	Nepal	

APPENDIX 3. DESCRIPTIVE STATISTICS

Descriptive Statistics

	lnCotton	*lnMaize*	*lnOliveOil*	*lnWheat*	*GovEff*	*PolS*	*Reg*	*lnStocks*	*lnOil*	*lnNitr*	*lnPest*	*lnWPI*	*lnM1*	*lnExc*	*lnGDP*	*lnInt*	*lnRain*	*lnTemp*	*Aircraft*	*COVID*	*GFC*
Mean	11.516	10.801	0.928	10.210	0.149	−1.098	0.199	26.355	4.107	14.213	10.624	5.327	18.949	0.828	27.233	2.689	6.426	2.628	0.100	0.150	0.100
Median	11.460	10.967	0.798	10.420	0.125	−1.058	0.269	26.574	4.147	14.193	10.587	5.329	18.955	0.551	27.374	2.670	6.455	2.620	0.000	0.000	0.000
Maximum	12.351	13.323	1.810	13.249	0.432	−0.590	0.463	27.490	4.716	14.535	11.002	6.104	21.470	2.180	27.588	3.981	6.680	2.710	1.000	1.000	1.000
Minimum	10.812	8.823	0.000	6.035	−0.159	−2.007	−0.101	24.942	3.161	13.940	10.219	4.605	16.58	0.264	26.205	2.103	6.200	2.550	0.000	0.000	0.000
Std. Dev.	0.428	1.470	0.461	1.974	0.190	0.370	0.180	0.565	0.451	0.151	0.228	0.489	1.291	0.608	0.375	0.498	0.110	0.045	0.308	0.366	0.308
Observations	20	20	20	20	20	20	20	19	20	20	20	20	20	20	20	20	20	20	20	20	20

APPENDIX 4. ARDL RESULTS

ARDL Results

Dependent Variable: lnWheat

Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Model	Model	Variable	Coefficient
ARDL (1, 1, 1, 1, 1, 1, 1, 1, 1) AIC (−4.1274)	*lnWheat(-1)*	−0.3732	ARDL (1, 1, 0, 1, 1, 1, 1, 1, 0) AIC (−3.2161)	*lnWheat (-1)*	−0.3579	ARDL (1, 1, 0, 1, 1, 1, 1, 1, 0) AIC (−6.8981)	*lnWheat(-1)*	−0.4030	ARDL (1, 0, 0, 0, 0, 0, 0) AIC (−0.0573)	*lnWheat(-1)*	0.0826
	GovEff	−17.0136		*lnOil*	4.8049		*lnM1*	17.1996 **		*lnRain*	3.7562
	GovEff(-1)	−30.2759		*lnOil(-1)*	2.4199		*lnM1(-1)*	9.3663 *		*lnTemp*	21.3338
	PolS	−0.3068		*lnNitr*	20.6407 *		*lnExcRate*	−31.4813 **		*Aircraft*	−0.2904
	PolS(-1)	−3.9123		*lnNitr(-1)*	18.7366		*lnGDP*	−28.1222 **		*COVID*	0.4179
	Reg	25.4486		*lnPest*	5.9568		*lnGDP(-1)*	−8.5694		*GFC*	0.2944
	Reg(-1)	31.0303		*lnPest(-1)*	10.6401		*lnInt*	−1.1334		*C*	−70.9138
	lnStocks	−6.2819		*lnWPI*	−22.0011		*lnInt(-1)*	5.1283			
	lnStocks(-1)	3.7785		*lnWPI(-1)*	8.0241		*Aircraft*	−0.5280			
	Aircraft	−0.4908		*Aircraft*	5.8689		*Aircraft(-1)*	−3.1974 *			
	Aircraft(-1)	−5.4917		*Aircraft(-1)*	−3.0705 *		*COVID*	−4.9441			
	COVID	2.3551		*COVID*	−0.2889		*COVID(-1)*	−7.4344 **			
	COVID(-1)	6.3266		*GFC*	−0.9675		*GFC*	−1.0138			
	GFC	−1.1958		*GFC (-1)*	4.1177 *		*C*	528.7231 **			
	GFC(-1)	7.3718		*C*	−677.7797 **						
	C	70.9475									
	LM(1) = 38.5628 (0.1016) Ramsey Reset test = 0.0919 (0.8127) BPG = 0.1954 (0.9798)			LM(1) = 1.8061 (0.3111) Ramsey Reset Test = 2.3071 (0.1474) BPG = 3.1253 (0.1892)			LM(1) = 0.0132 (0.9140) Ramsey Reset Test = 0.4923 (0.5216) BPG = 2.1462 (0.2051)			LM(1) = 0.6749 (0.4288) Ramsey Reset Test = 0.4869 (0.4998) BPG = 1.7166 (0.2004)	

Dependent Variable: lnMaize

Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Coefficient
ARDL (1, 1, 1, 1, 1, 1, 1, 1) AIC (−7.4539)	*lnMaize(-1)*	−0.7125 *	ARDL (1, 1, 1, 1, 1, 1, 1, 0, 0) AIC (−4.3392)	*lnMaize(-1)*	−0.4066	ARDL (1, 0 , 0, 0, 0, 0, 1, 1) AIC (−7.8251)	*lnMaize(-1)*	0.1918	ARDL (1, 1, 0, 0, 1, 1) AIC (−2.0885)	*lnMaize (-1)*	−0.1820
	GovEff	−21.4179 **		*lnOil*	0.0257		*lnM1*	6.9200 **		*lnRain*	−8.1191
	GovEff(-1)	−12.5592		*lnOil(-1)*	1.8393		*lnExc*	−6.4788 *		*lnRain(-1)*	−10.2601 *
	PolS	1.0241		*lnNitr*	14.1047 *		*lnGDP*	−16.2247 ***		*lnTemp*	−5.8631
	PolS(-1)	−4.2086 **		*lnNitr(-1)*	13.2890 *		*lnInt*	−2.9650 *		*Aircraft*	0.8981
	Reg	20.7717 **		*lnPest*	0.4266		*Aircraft*	−1.0074		*COVID*	3.8056 **
	Reg(-1)	19.7214 *		*lnPest(-1)*	3.6827		*COVID*	0.2715		*COVID(-1)*	−2.7715
	lnStocks	2.2542		*lnWPI*	−18.7280 *		*COVID(-1)*	−5.1735 **		*GFC*	−2.9221
	lnStocks(-1)	−3.0339		*lnWPI(-1)*	13.7521		*GFC*	2.7121 **		*GFC(-1)*	3.8836
	Aircraft	0.4709		*Aircraft*	1.7760		*GFC (-1)*	−2.5221 *		*C*	145.8996
	Aircraft(-1)	−3.4185 *		*Aircraft(-1)*	−2.5513		*C*	333.4524 ***			
	COVID	5.3984 **		*COVID*	−0.3084						
	COVID(-1)	−3.1591		*GFC*	2.5242						
	GFC	1.7996 *		*C*	−397.9657						
	GFC(-1)	1.7751									
	C	31.3386									
	LM(1) = 2.4626 (0.3612) Ramsey Reset test = 0.2459 (0.7069) BPG = 0.5673 (0.7947)			LM(1) = 4.9309 (0.1130) Ramsey Reset test = 1.8061 (0.2716) BPG = 4.7642 (0.0717)			LM(1) = 0.0398 (0.8476) Ramsey Reset Test = 1.4421 (0.1925) BPG = 0.5715 (0.7994)			LM(1) = 0.3523 (0.5692) Ramsey Reset Test = 0.6863 (0.4314) BPG = 1.0522 (0.4704)	

APPENDIX 4. Cont.

ARDL Results

Dependent Variable: lnOliveOil

Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Coefficient
ARDL (1, 1, 0, 1, 1, 1, 1) AIC (−13.3036)	*lnOliveOil(-1)*	−1.4309 ***	ARDL (1, 1, 1, 0, 1, 0, 1, 0) AIC (−8.8352)	*lnOliveOil(-1)*	0.7738 *	ARDL (1, 0, 1, 1, 0, 0, 1, 0) AIC (−12.4628)	*lnOliveOil(-1)*	0.1880	ARDL (1, 0, 1, 1, 1, 1, 1) AIC (−6.5721)	*lnOliveOil(-1)*	0.4260 **
	GovEff	−2.1325 **		*lnOil*	−0.1998		*lnM1*	0.6770 **		*lnRain*	1.0348 **
	GovEff(-1)	−4.7576 ***		*lnOil(-1)*	0.2248		*lnExc*	−2.1728 **		*lnTemp*	3.4734 **
	PolS	−0.9712 ***		*lnNitr*	−0.5906		*lnExc(-1)*	1.7968 **		*lnTemp(-1)*	1.5290
	Reg	0.2437		*lnNitr(-1)*	0.4964 *		*lnGDP*	−2.0659 ***		*Aircraft*	−0.0089
	Reg(-1)	3.6406 ***		*lnPest*	0.4964 *		*lnGDP(-1)*	1.4695 **		*Aircraft(-1)*	0.2669 *
	lnStocks	−0.1512		*lnWPI*	−2.8356 *		*lnInt*	0.4639 **		*COVID*	−0.0064
	lnStocks(-1)	1.3054 ***		*lnWPI(-1)*	2.6977 *		*Aircraft*	0.0313		*COVID(-1)*	0.4172 **
	Aircraft	−0.1912 *		*Aircraft*	0.2201		*COVID*	−0.2550		*GFC*	0.2218 *
	Aircraft(-1)	−0.8100 ***		*COVID*	−0.2369		*COVID(-1)*	0.1518		*GFC(-1)*	−0.5641 ***
	COVID	0.0592		*COVID(-1)*	0.4973 *		*GFC*	−0.0571		*C*	−19.2299 **
	COVID(-1)	0.7522 *		*GFC*	0.1999		*C*	3.5656			
	GFC	0.3914 **		*C*	−12.1579						
	GFC(-1)	0.3610 **									
	C	−28.9651 **									
	LM(1) = 5.1623 (0.1510) Ramsey Reset test = 3.5755 (0.1992) BPG = 2.3630 (0.2607)			LM(1) = 6.8651 (0.0588) Ramsey Reset test = 0.9381 (0.3876) BPG = 4.8353 (0.0.0468)			LM(1) = 0.7298 (0.4257) Ramsey Reset test = 0.4451 (0.5295) BPG = 0.3864 (0.9231)			LM(1) = 0.2460 (0.6351) Ramsey Reset Test = 0.0025 (0.9614) BPG = 0.3360 (0.9453)	

Dependent Variable: lnCotton

Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Coefficient	Model	Variable	Coefficient
ARDL (1, 1, 1, 1, 1, 1, 0) AIC (−8.2823)	*lnCotton(-1)*	−0.4894 *	ARDL (1, 1, 1, 0, 1, 1, 1) AIC (−10.0201)	*lnCotton(-1)*	−1.0997 **	ARDL (1, 1, 1, 1, 0, 0, 0, 1) AIC (−11.6691)	*lnCotton*	−0.5292 **	ARDL (1, 0, 0, 1, 0, 1) AIC (−4.7990)	*lnCotton(-1)*	−0.2936
	GovEff	−0.7206		*lnOil*	−0.0999		*lnM1*	−0.6299 *		*lnRain*	1.0740
	GovEff(-1)	−4.8631 **		*lnOi(-1)*	−0.8439 **		*lnM1(-1)*	1.0069 **		*lnTemp*	2.6564
	PolS	−2.0945 **		*lnNitr*	3.2767 **		*lnExc*	−2.6147 *		*Aircraft*	−0.1676
	PolS(-1)	0.7290		*lnNitr(-1)*	−2.3431 **		*lnExc(-1)*	3.0944 *		*Aircraft(-1)*	0.3508
	Reg	−0.2369		*lnPest*	0.7400 **		*lnGDP*	−2.0736 *		*COVID*	0.8684 ***
	Reg(-1)	3.6681 **		*lnWPI*	8.3946 ***		*lnGDP(-1)*	1.1358		*GFC*	0.4147
	lnStocks	−1.5762 **		*lnWPI(-1)*	−8.0411 ***		*lnInt*	0.3701		*GFC(-1)*	−1.1210 ***
	lnStocks(-1)	1.0414 **		*Aircraft*	−0.7021 *		*Aircraft*	−0.0860		*C*	0.9469
	Aircraft	−0.9610 *		*Aircraft(-1)*	−0.6455 **		*COVID*	0.3053			
	Aircraft(-1)	−1.2819**		*COVID*	1.6962 ***		*GFC*	0.3538			
	COVID	−0.2254		*COVID(-1)*	−1.6966 ***		*GFC(-1)*	−0.5565 ***			
	COVID(-1)	2.0550 **		*GFC*	0.3125		*C*	35.2437 **			
	GFC	0.0801		*GFC(-1)*	−1.1714 ***						
	C	30.2240 **		*C*	4.4707						
	LM(1) = 2.7651 (0.2382) Ramsey Reset test = 0.6253 (0.5956) BPG = 1.4600 (0.4241)			LM(1) = 66.1355 (0.0148) Ramsey Reset test = 0.0257 (0.8874) BPG = 1.2309 (0.4920)			LM(1) = 2.9560 (0.1462) Ramsey Reset test = 9.2570 (0.0287) BPG = 0.5009 (0.8549)			LM(1) = 0.0004 (0.9853) Ramsey Reset Test = 0.2713 (0.6151) BPG = 1.4525 (0.2848)	

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

APPENDIX 5. PRICES OF FOUR SELECTED REPRESENTATIVE AGRICULTURAL PRODUCTS