EFFECTS OF MACROECONOMIC VARIABLES ON SUSTAINABLE FOOD SECURITY IN TURKEY

(Master's Thesis)

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KUTAHYA DUMLUPINAR UNIVERSITY
INSTITUTE OF GRADUATE EDUCATION
DEPARTMENT OF ECONOMICS

Master's Thesis

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To the Directorate of Institute of Graduate Education,

Our jury has accepted this study as a MASTER'S THESIS STUDY REPORT in the Department of Economics.

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Confirmation

I confirm that the signatures above belong to the aforementioned faculty members.

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بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمْ

In the name of Allah Almighty, the Most Merciful, the Most Magnificent!

BIOGRAPHY

Ahmadullah Barimen, son of Sediqullah Bariman, started his primary schooling in a local school in Wardak Province and completed his high school in Kabul's top school, Ariana Afghan Turk High School. In 2013 Mr. Barimen went to Islamabad to complete his undergraduate studies. In 2017 he received a bachelor's degree in economics, specialized in development studies from International Islamic University, Islamabad, with a very good CGPA. In 2019 he went to Turkey in pursuit of graduate studies; he has just completed his master's degree in economics focused on sustainable development and food security. Meanwhile, he went to Portugal for a semester on Erasmus+ Exchange Program. In short, he has an impressive educational background, and he is a professional at his specialization.

Alongside Pashto and Dari, Mr. Barimen is fluent in more than five languages, such as English, Turkish, Urdu, and Hindi. He has traveled to more than twenty cities across Asia and Europe. Besides his major, he has a good hand in arts and mechanical works, which shows his well-rounded career. His communication, writing, reading, and digital skills are all at a proficient level. Ahmadullah has one year of working experience in the banking sector. Before starting his master's degree, he worked in the Islamic Bank of Afghanistan (IBA). Since 2014, Mr. Barimen is writing about various issues, specifically economics, environment, development, food security, culture, and arts. These writings were primarily concentrated on the environment, the necessity of its conservation, and the perils of its deterioration. The role of culture in creating a better society, methods of reformation in the cultural values, and the adversaries of vast symbolic boundaries. His writings can be accessed at
personal blog.

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All praise goes to ALLAH SWT! who gave me the ability to read, the wisdom to think, and the knowledge to write and complete this thesis, alongside countless other blessings. I want to thank each and every individual in the BARIMAN FAMILY. A mere thank you will not be enough for all the sacrifices my father made for me; he has always supported me in every possible way. Thank you, my dear father, Dr. SEDIQULLAH BARIMAN! My mother and my siblings have given up a lot for me, and I will always be indebted to them; thank you all! I send my love and gratitude to my beloved wife, ABIDA BARIMEN, and my clever child, YAHYA BARIMEN; they have always hoped for me and supported me in realizing my dreams.

I thank my thesis supervisor Dr. Muhammet Yunus ŞİŞMAN, for his encouragements, guidance, and valuable time; thank You, Sir! and all other professors who have taught me during my masters in Turkey and Portugal. I am grateful to my friends and buddies, Mr. Abdulhanan ZARIFY, Mr. Jawid ASEFI, and all others who have supported and guided me throughout my life. While researching and writing this thesis, I learned a lot. I hope this thesis will guide and help future researchers interested in sustainable economic development.

ABSTRACT

EFFECTS OF MACROECONOMIC VARIABLES ON SUSTAINABLE FOOD SECURITY IN TURKEY

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Every living being depends upon food to live, grow, and reproduce. Food security is simply that every human being knows where their next nutritious and safe meal is coming from. A food system that does not jeopardize the food security of the future generation is sustainable food security. Researchers fear that feeding the nine billion population expected by 2050 will be very challenging. This research shares the same concern, but the main problem is not human growth or the earth's limited resources. The problem lies in the political decisions and economic policies of governments, corporations, institutions, and organizations. These problems include environmental damage, political conflicts, unequal distribution of resources, food wastage, financialization of food, monopolization of the food industry, and many more. Therefore, to shape macro policies such that will contribute positively to sustainable food security, this thesis econometrically analyzes the effects of macroeconomic variables on sustainable food security.

Quarterly data of Turkey, from 2012 till 2020, is employed for the analysis. The quantile-on-quantile regression (QQR) approach is preferred for the empirical analysis as it shows the effect more clearly and thoroughly. Turkey's key macroeconomic variables, GDP per capita, interest rate, consumer price index (CPI), exchange rate, unemployment rate, exports, and imports variables are taken as independent variables. Food security is selected as a dependent variable in the analysis. Data for the response variable is retrieved from the Global Food Security Index (GFSI). The results of seven individual QQR models show that GDP per capita, exports, and imports positively affect food security at high levels. In contrast, food security is negatively affected by the high rates of interest, CPI, exchange, and unemployment. These variables will contribute positively if they are kept at their possible lowest rates.

Keywords: Food Security, Nutrition, Sustainability, Food Safety, Macroeconomics, Quantile-on-quantile Regression Model, Turkey

ÖZET

TÜRKİYE'DE MAKROEKONOMİK DEĞİŞKENLERİN SÜRDÜRÜLEBİLİR GIDA GÜVENLİĞİ ÜZERİNE ETKİLERİ

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Nisan 2021, 106 Sayfa

Her canlı, yaşamak, büyümek ve çoğalmak için gıdaya bağımlıdır. Gıda güvenliği, her insanın bir sonraki besleyici ve güvenli yemeğinin nereden geldiğini bilmesidir. Gelecek neslin gıda güvenliğini tehlikeye atmayan bir gıda sistemi, sürdürülebilir gıda güvenliğidir. Araştırmacılar, 2050 yılına kadar beklenen dokuz milyar nüfusu beslemenin çok zor olacağından korkuyor. Bu araştırma aynı endişeyi paylaşıyor, ancak asıl sorun nufüsün büyümesi veya dünyanın sınırlı kaynakları değil. Sorun, hükümetlerin, kurumların ve kuruluşların siyasi kararlarında ve ekonomik politikalarında yatmaktadır. Bu sorunlar, çevresel zarar, siyasi çatışmalar, eşit olmayan dağıtım kaynakları, gıda israfı, gıdanın finansallaşması, gıda endüstrisinin tekelleşmesi ve daha fazlasını içerir. Bu nedenle, makro politikaları sürdürülebilir gıda güvenliğine olumlu katkı sağlayacak şekilde şekillendirmek için bu tez, makroekonomik değişkenlerin sürdürülebilir gıda güvenliği üzerindeki etkilerini ekonometrik olarak analiz etmektedir.

Analiz için 2012'den 2020'ye kadar Türkiye'nin dönemlik verileri kullanılmaktadır. Etkiyi daha net ve kapsamlı gösterdiği için kantil-kantil regresyon (QQR) modeli ampirik analiz için tercih edilmiştir. Türkiye'nin temel makroekonomik değişkenleri, kişi başı GSYİH, faiz oranı, tüketici fiyat endeksi (TÜFE), döviz kuru, işsizlik oranı, ihracat ve ithalat değişkenleri bağımsız değişkenler olarak alınmış ve analizde bağımlı değişken olarak gıda güvenliği seçilmiştir. Yanıt değişkenine ilişkin veriler, Küresel Gıda Güvenliği Endeksinden (GFSI)'ten alınmıtır. Yedi ayrı QQR modelinin sonuçları, kişi başına GSYİH, ihracat ve ithalatın yüksek seviyelerde gıda güvenliğini olumlu etkilediğini göstermektedir. Aksine, gıda güvenliği yüksek faiz, TÜFE, döviz ve işsizlik oranlarından olumsuz etkilenmektedir. Bu değişkenler, mümkün olan en düşük oranlarında tutulurlarsa olumlu katkıda bulunacaktır.

Anahtar Kelimeler: Gıda Güvenliği, Beslenme, Sürdürülebilirlik, Gıda Güvencesi, Makroekonomi, Kantil-Kantil Regresyon Modeli, Türkiye

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ACRONYMS AND ABBREVIATIONS

ACC	Agricultural Credit Cooperatives
BC	Before Christ
BoT	Balance of Trade
CARE	Cooperative for Assistance and Relief Everywhere
CH4	Methane
CIA	Centeral Intelligence Agency
CO2	Carbon di Oxide
COVID19	Corona Virus Disease of 2019
CPI	Consumer Price Index
Estim.	Esmtimated
EUI	The Economist Intelligence Unit
F'cast	Forcasted
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
FIES	Food Insecurity Experience Scale
FRED	Federal Reserve Economic Data
GDP	Gross Domestic Products
GFSI	Global Food Security Index
GHG	Green House Gas
GHI	Global Hunger Index
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IHS	Information Handling Services
Ln	Natural Logarithm
LRM	Linear Regression Model
Max	Maximum
Min	Minimum
MMT	Million Metric Tonnes
n.r.	Not Reported

N2O	Nitrous Oxide
NGOs	Non-Governamental Organizations
NRDC	Natural Resources Defense Council, Inc.
OECD	Organisation for Economic Co-operation and Development
PCI	Project Concern International
PPP	Purchasing Power Parity
QQR	Quantile on quantile Regression
R&D	Research and Development
SDG	Sustainable Development Goals
SOFI	The State of Food Security and Nutrition in the World
SPI	Seed Programs International
Std. Dev.	Standard Daviation
SWT	Subhanahu Wa Ta'ala (The Most Glorified)
T.C.	Türkiye Cumhuriyeti (Republic of Turkey)
UAE	United Arabic Emirates
UN	United Nations
UNDP	United Nations Development Programme
UNFAO	Food and Agriculture Organization of the United Nations
UNICEF	United Nations International Children’s Emergency Fund
USA	United States of America
USD	United States Dollars
WFP	World Food Program
WHO	World Health Organization
WTO	World Trade Organization
X	Independent Variables
Y	Dependent Variable
θ	Theta Quantiles of Dependent Variable
τ	Tau Quantiles of Independent Variables

Thesis Text

INTRODUCTION

۞ وَمَا مِن دَآبَّةٍ فِى ٱلْأَرْضِ إِلَّا عَلَى ٱللَّهِ رِزْقُهَا وَيَعْلَمُ مُسْتَقَرَّهَا وَمُسْتَوْدَعَهَا ۚ كُلٌّ فِى كِتَٰبٍ مُّبِينٍ

There is no creature on earth whose sustenance is not undertaken by Allah. He knows its permanent and its temporary place. Everything is in a clear book.

— (Al Quran - 11:6)

I want to start my thesis with this ayah from the Holy Quran, where Allah SWT says that he has written the sustenance of every living being. The term "Rizq," meaning sustenance, does not cover only food; it is a broad term encompassing everything that can bring goodness and benefit to us. Family ties, wealth, food, drinks, intellect, health, faith, knowledge, and much other material and spiritual blessings of Allah. In this ayah, Allah SWT confirms that he knows its permanent and its temporary place. This ayah ensures us, humans, that the food is secure. However, the problem lies in human activities; our desires, greediness, and wastefulness are causing some people to be food insecure.

Food Security is one of the vital issues that the twenty-first century's human is facing, and the challenge is increasing day by day. To maintain life and growth, food is a necessity for all the livings. Food's importance is at the highest, and it should be the main focus in our economic, social, and political policies. Failure to do so, it will be impossible to fill the gap in the demand and supply of food for the rapidly growing population of the earth. Food security until now is considered predominantly as an agricultural, environmental, and microeconomic issue. It has to be studied from every possible affecting perspective. Industrialization, financial systems, economics, sociology, politics, science, conflicts, and others are all somehow affecting people's ability to acquire nutritious food.

Most of the existing literature covers the social side, the environmental side, and the agricultural side of food security. There seems a lack of cross-disciplinary study of food security from the macroeconomic perspective in Turkey. This research will study the effect of trade openness, inflation rate, interest rate, unemployment, and GDP (GDP per capita) on food security sustainability. As the case study, Turkey has experienced different economic changes in the macroeconomic variables during the last decades. Technological advancement, trade openness, increase in the output. On the other hand,

Political instability in the region, war against terrorism, migrations, and the 2008 world economic crises. All of these caused significant changes in Turkey's Economy. The impact of these changes on sustainable food security will be undertaken in this study.

To see the effect of macroeconomic variables of Turkey on its food security. The recently developed quantile-on-quantile regression (QQR) analysis approach was selected for the empirical analysis. The non-parametric QQR analysis method was first developed by (Sim & Zhou, 2015) as an extension of the quantile regression of (Ma & Koenker, 2006). This non-parametric regression model analyses the effect of multiple quantiles of the explanatory variable on multiple quantiles of the response variable. The method is very practical and effective because it has the ability to study the relationship between dependent and independent variables in very fine details.

For the empirical analysis, nine years of food security data of Turkey was retrieved from the Global Food Security Index (GFSI) 2020 developed by (The Economist Intelligence Unit, 2020) in 2012 to be used as an independent variable. GDP per capita, interest rate, inflation rate (CPI), exchange rate, unemployment rate, exports, and imports variables were selected as independent variables for which quarterly data is retrieved from (FRED, 2021). From 2012 till 2020, nine years of time-series quarterly data making a total of 36 quarterly observations for seven macroeconomic variables and one food security variable of Turkey are employed in the analysis.

Food security is measured with multiple indicators, at multiple levels. Some of the indicators measures food security at individual and household levels via surveys and questionnaires. Some measures it at a national or regional level. Many organizations and governments have their own system of collecting and calculating the food security data. Each one focuses on the topics which are most important to them. For instance, FAO collects and publishes food security data at the household level. And they are mainly focused on agricultural sector. The Global Hunger Index is also collecting and publishing food security and hunger related data. However, they are primarily focused on nutrition levels of children.

The Global Food Security Index (GFSI) is selected as the dependent variable for the econometric analysis in this thesis, because it publishes a macrolevel data. Affordability, availability, quality and safety, and natural resources and resilience are the four core issues related to food security based on which the GFSI is calculated. These

core issues cover the main problems of food insecurity at a macro-level in a country. The GFSI encompasses the developmental, agricultural, environmental and political side of the food security in a country. Other main reason behind choosing this indicator as a dependent variable is that it has the most recent data. The last version of the GFSI published on 23rd of February 2021 has the data of the index for 113 countries from 2012 till 2020.

Starting from this introduction, this thesis consists of three chapters. The first chapter is focused on food and nutrition, their history, industry, safety, sustainability, and security. Great significance is given to food security, its importance in the UN 2030 agenda, and the impact of the COVID-19 pandemic on global food security. The second chapter is focused on the theoretical framework of the research, beginning with the literature review on food security. Organizations working on food security, nutrition, and hunger are explored, along with the explanatory study of various food security and macroeconomic indicators. The third and final chapter of this thesis is dedicated to the empirical analysis of the framework. Research objectives, and Research question are followed by data and methodology. Analysis and the discussions related to the results are followed by some policy implications and implications for future research studies. Finally, the thesis is wrapped up by a conclusion after the end of the third chapter.

CHAPTER ONE
FOOD AND NUTRITION: INDUSTRY, SECURITY, SAFETY, AND SUSTAINABILITY

1.1 HISTORY OF FOOD

We see that the first humans started hunting and gathering for their sustaining so me million years ago if we look at human history. It must have been very challenging for them. To have food security in those days, they were continually moving from one area to another. Before this area depletes from edibles, they would try to find new sites full of animals to hunt and wild fruits to gather (Widlok, 2020). Their strategies were diverse, depending mostly upon the surrounding environment. Food foraging strategies have included hunting or trapping big and small animals, fishing and gathering shellfish or insects, and wild plant foods such as fruits, vegetables, tubers, seeds, and nuts. Most hunter-gatherers combine various strategies to ensure a balanced diet (Britannica, 2020). Archeological evidence shows signs of this part of our history.

Around 12,000 BC, the humans in asea started farming, cultivating, and growing agricultural products and domesticating animals for their food consumption. Early studies related to the origins and expansion of agriculture are focused on environmental factors, population pressure, and co-dependent plant, animal, and human interactions as the main factors of shifting humans from hunting and gathering towards farming and agriculture (Ofstehage, 2020). Unlike hunting and gathering, people started to settle on the banks of rivers and lakes where lots of fertile soil was around, and they started farming in families and groups, which led to societies. As the societies got bigger and bigger, farmers started intensive agriculture to have food security. Intensive agriculture keeps fallow periods shorter between crops, increased use of labor and machinery, and heavy usage of other inputs such as seeds, fertilizers, or irrigation (Ofstehage, 2020).

With the population boom from hundreds of thousands to millions and billions, people started depleting the soils to the point that it would decline the outputs. Eventually, the soil got degraded to an extent where people got to import food from other parts of the world. By 1798, economist Thomas Malthus cautioned that the population growth would outpace food production, making widespread starvation possible. History is familiar with this scenario – from 1300 to 1850, depleted farmland lead to periodic famines throughout much of Europe (Driver & Health, 2020). In the 19^{th} and 20^{th} centuries, scientists researched various ways to increase the same resources' production. From genetically changing crops and animals to producing different types of fertilizers, pesticides, and extensive farming technological machines, which changed agriculture and resulted in

what we call the green revolution. A substantial increase in food production and a considerable step toward partial food security.

In the 19th century, to feed the population well, humans started industrial farming with help from the latest technology and science. Large-scale, intensive production of animals and crops is industrial agriculture. Most frequently using chemical fertilizers on crops and extensive use of antibiotics for animals. Animals are drugged to compensate for filthy conditions, even when the animals are not sick. It may also involve genetically modifying crops, intense use of pesticides, and other practices that deplete the land, mistreat animals, and increase various forms of pollution (NRDC, 2020). Industrial agriculture produces mainly commodity crops, which are then utilized in a wide variety of cheap, calorie-dense, and broadly available foods. Thus, 60 percent of all dietary energy is obtained from just three cereal crops –rice, maize, and wheat. Despite the fact that it has successfully brought down the proportion of people suffering from hunger, this calorie-based approach fails to meet nutritional recommendations, for example, consuming fruits, vegetables, and pulses (Environment UN, 2020). Which helped increase the production, but it also created some significant issues. For instance, deforestation, climate change, and the shift of production from small farmers to huge industries are causing an unequal distribution of food and wealth, which has to be addressed.

Before the 1970s, governments, economists, and policymakers focused on industry-first economic growth and development policies. Still, after the 1970s, they started realizing the cruciality of the development of the agricultural sector. Since then, academics and policymakers began to call for an agriculture first development strategy. One good example of this change in focus can be the green revolution, which came due to the advancement of high-yielding seed varieties of grain, mainly rice.

1.2 FOOD INDUSTRY

The food industry is a versatile network of diverse industrial activities combining the supply chain and consumption of food products and services. The food industry comprises different components such as agriculture, food processing, food distribution, food regulations, food trade, food finance, research and development, marketing, and food disposition. In its entirety, the food industry is not one industry but a collection of several industry types supplying a wide range of food products. It covers

agriculture, food production, food processing, conservation, packaging, dispersion, selling, and cooking (Sadiku et al., 2019).

Agriculture consists of cultivating the soil, growing plants, and raising livestock for different life purposes, mainly food. Farms growing vegetables, cereal grain crops, fruits, nuts, and farms that raise livestock such as broilers, turkeys, ducks, cattle, fisheries, so on, and all activities related to these are regarded as agriculture.

Food processing is the transformational change of agricultural raw products into marketable fine food. It can be as simple as grinding wheat in a meal to make flour for a loaf of bread and can be a very complex industrial process to make lavish food products.

Food distribution is the process in which food is stored, transported, and marketed to various consumers. Warehouses, logistic, and transportation network is needed for the food industry to distribute the products.

Food regulations Like any other industry food industry also has its own rules and regulation set to maintain the quality, equity, and safety of food for all. These sets of limitations vary from country to country, and each government authority has its laws, which a food-based company has to follow. There are also international regulations set by the UN, WTO, WHO, and players involved in the food industry.

Food trade is the international transportation of food items from one country to another. Besides economic benefits, countries trade food to have an adequate and varied food supply. Food trade is a very ancient historical phenomenon; a good example can be the food trade along the silk road bringing spices, dry fruits, and other items from South Asia to Europe using Turkey as a bridge between Asia and Europe.

Food finance includes investments, credits, insurances, and all other financial activities that promote the production, distribution, and consumption of food products and services.

Research and development are essential components of the food industry. As the industry grows more prominent and the food choices become more diverse additional research and development are needed. Research is required to increase production, decrease the cost of processing and distribution to have food safety, and achieve food security.

Marketing as a critical economic component of the food industry is the advertisement of suppliers' food and services to attract more consumers. Marketing can significantly affect consumer behavior in choosing food items. Promotion of information related to quality, price, and food affect consumer choice of food diet.

Wholesale and retail selling are the supply of food materials via the distributing channels to the consumers in big wholesale markets or as retail in supermarkets, groceries, and small shops. Food services are also worth mentioning in this section; it is the catering of food. Hotels, restaurants, and cafeterias are the prominent ones.

Food disposition is the aftermath of food processing and food consumption. The massive waste created during the supply chain or the leftover from the consumption needs to be disposed of. Some are recycled or as animal feed, or fertilizers and some are just dumped into the environment. The recycling and disposing of the waste for agricultural and food purposes are included in the food industry.

1.2.1 Global Food Supply

Geographical, environmental, economic, social, cultural, and political factors drive global food supply. The food supply chain is the process of bringing food from farm to plate. Anything and any operation in between are all included in the food supply chain. This section focuses on global food supply, which will cover major food crops such as wheat, rice, maize, sugar, meat, dairy products, and fisheries. Food trade, mainly exports and food stocks, is included in the food supply alongside the leading food items discussed in this chapter. In addition, this section will also discuss the share of intensive farming and processed food in the global food supply.

Here I will explore the global wheat production and trade in the beginning because it is one of the oldest and most crucial edible grain. Wheat is the leading and sub ingredient of many food products worldwide, such as bread, pasta, spaghetti, bakery, pizza, and other products. Plantation, growth, and harvest possible in various climates make wheat production one of the world's most straightforward crop cultivation. Rich in carbohydrates and extra proteins, wheat is a relatively low-cost and easily attainable source of energy. Total World wheat production in 2018 was 732.1 million metric tons. Table 1.1 shows the largest wheat-producing countries in 2020. China is the biggest wheat-producing country globally; China produced 135 million metric tons of wheat in

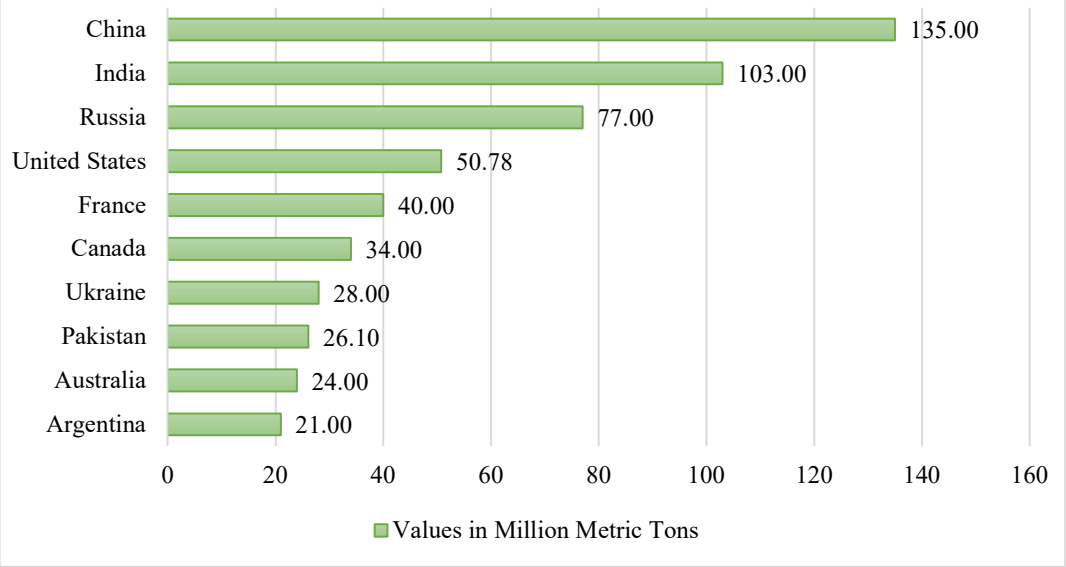
2020, making 29% of the world's total wheat production. The second top producer of wheat in India, with 103 million metric tons of product in 2020. With whole produce of 77 million metric tons, Russia is in third place, followed by the US, France, Canada, Ukraine, and others. The same data is graphed in Figure 1.1 for better visualization.

Table 1.1 Largest Wheat Producers (2020)

Rank	1	2	3	4	5	6	7	8	9	10
Country	China	India	Russia	USA	France	Canada	Ukraine	Pakistan	Australia	Argentina
MMT	135.00	103.00	77.00	50.78	40.00	34.00	28.00	26.10	24.00	21.00

Source: (World Atlas, 2020b)

Figure 1.1 Largest Wheat Producing Countries (2020)



Source: (World Atlas, 2020b)

Food export is a substantial portion of the food supply, and in wheat export, At the top of the list in Table 1.2 is the Russian Federation with exporting nearly 43.97 million metric tons of wheat in 2018. Russia is planning to limit its wheat export to protect its food supply, as an effect of COVID-19. The agricultural ministry of Russia proposed to limit its all-grain export to seven to eight million tons from April to June 2020. Canada is second on the list with the total export of 22.87 million metric tons of wheat export in 2018, followed closely by the USA with 22.5 million metric tons of total export in 2018.

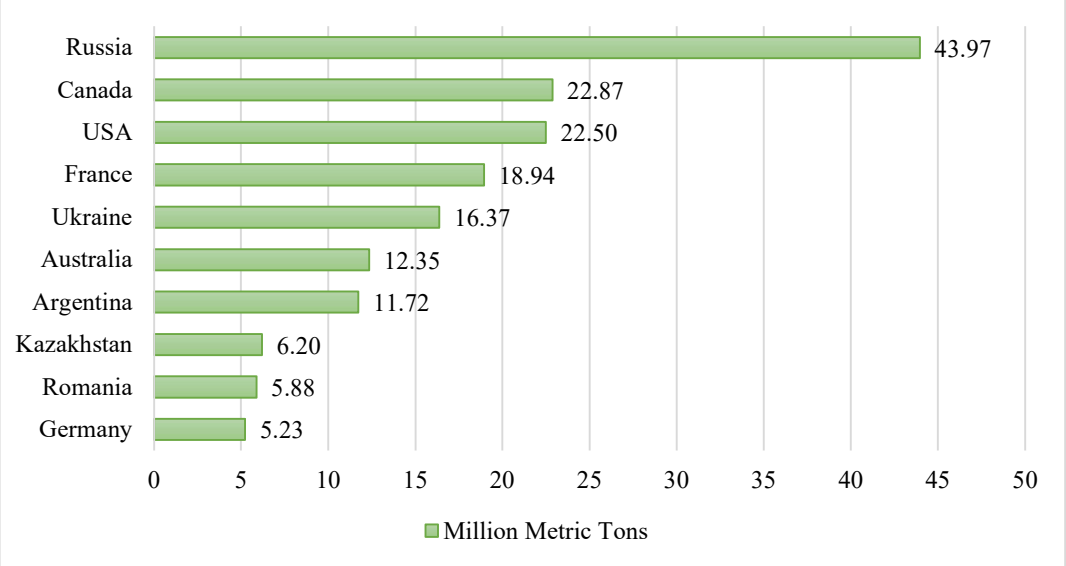
France with 18.94 million metric tons of export and Ukraine with 16.37 million metric tons of export are fourth and fifth respectively in the top exporting wheat countries list. The list goes on with Australia, Argentina, Kazakhstan, Romania, Germany, and others. The data is visualized in Figure 1.2 for better understanding.

Table 1.2 Top Wheat Exporters (2018)

Rank	1	2	3	4	5	6	7	8	9	10
Country	Russia	Canada	USA	France	Ukraine	Australia	Argentina	Kazakhstan	Romania	Germany
MMT	43.97	22.87	22.50	18.94	16.37	12.35	11.72	6.20	5.88	5.23

Source: (World Atlas, 2020b)

Figure 1.2 Top Wheat Exporting Countries (2018)



Source: (World Atlas, 2020b)

The second essential food item is rice, which is the seed of Oryza Sativa (Asian rice) and Oryza Glaberrima (African rice), two grass species. Although there are two main rice species, there are over forty thousand different varieties found worldwide. Some of the most popular ones are long grain, basmati, wild, and jasmine. Humans eat 95% of the world's rice, and over half of the human population is consuming rice as a staple food. Rice can be eaten independently by just boiling it, but it is typically eaten alongside main

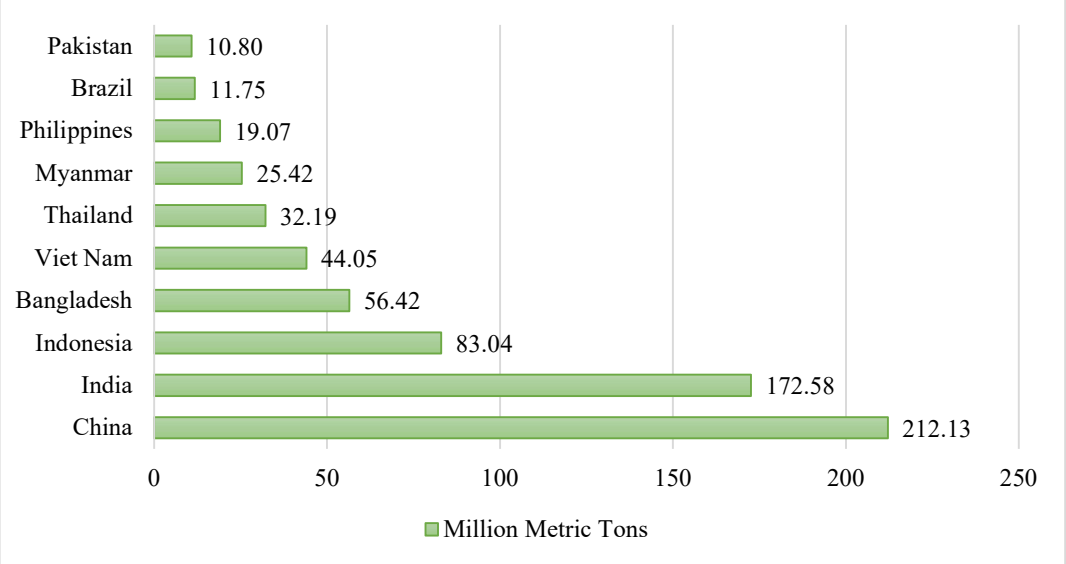
dishes (World Atlas, 2020a). According to Table 1.3 in 2018, China is the top producer of rice paddies globally, producing 212.13 million metric tons. Second on the list is India, with a total production of 172.58 million metric tons, followed by Indonesia with 83 million metric tons of the total output. Bangladesh produced 56.42 million metric tons ranking fourth, followed by Vietnam, with 44 million metric tons of rice paddies holding the fifth position on the top rice paddies growing countries list. These countries are followed by Thailand, Myanmar, Philippines, Brazil, Pakistan, and so on. Figure 1.3 shows bar charts of the top ten rice producing countries in the world.

Table 1.3 Top Rice Producers (2018)

Rank	1	2	3	4	5	6	7	8	9	10
Country	China	India	Indonesia	Bangladesh	Viet Nam	Thailand	Myanmar	Philippines	Brazil	Pakistan
MMT	212.12	172.58	83.03	56.41	44.04	32.19	25.41	19.06	11.74	10.80

Source: (*FAOSTAT*, retrieved on November 2020)

Figure 1.3 Top Ten Rice Producing Countries (2018)



Source: (FAO, 2020a)

Although China is the biggest rice paddies producer globally, India is the biggest exporter of milled rice globally. Table 1.4 show a list of the ranking exporting countries of milled rice in 2018. India exported 10 million metric tons of milled rice in 2018, closely

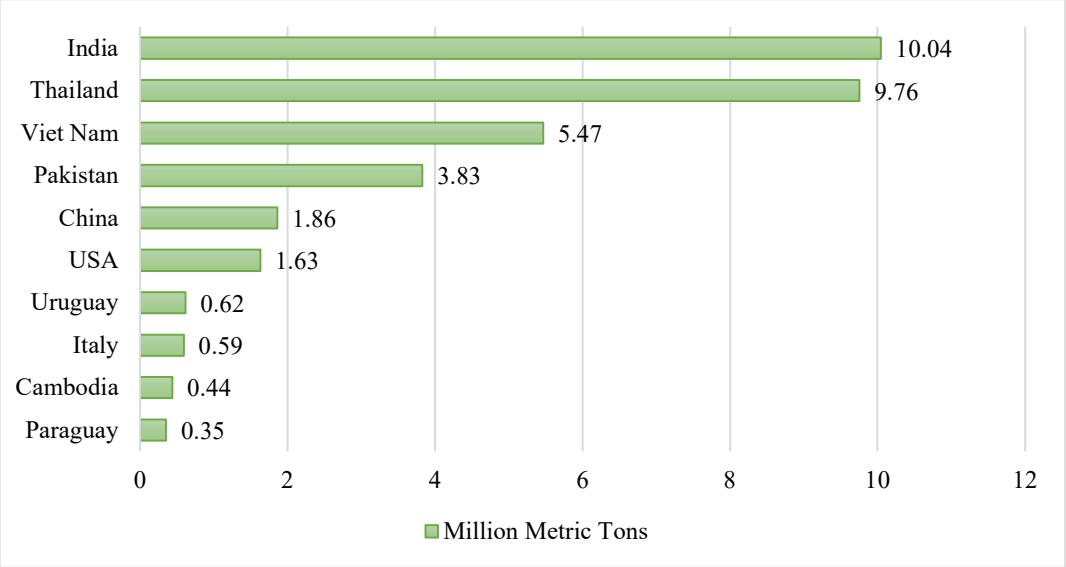
followed by Thailand with 9.76 million metric tons of milled rice export. Vietnam with 5.5 million metric tons, Pakistan with 3.83 million metric tons, China with 1.86 million metric tons, and the USA with 1. 63 million metric tons of milled rice export are positioned third, fourth, fifth, and sixth in the list, respectively, along with other countries with the export quantity of less than a million metric tons. Figure 1.4 plots data on the top ten milled rice producing countries in the world.

Table 1.4 Top Rice Exporters (2018)

Rank	1	2	3	4	5	6	7	8	9	10
Country	India	Thailand	Viet Nam	Pakistan	China	USA	Uruguay	Italy	Cambodia	Paraguay
MMT	10.04	9.76	5.47	3.83	1.86	1.63	0.62	0.59	0.44	0.35

Source: (FAO, 2020a)

Figure 1.4 Top Rice Exporting Countries (2018)



Source: (FAO, 2020a)

Maize is the basis for food security in some of the planet's poorest areas in Africa, Asia, and Latin America. Seven hundred sixty-five million metric tons of maize were reaped from less than 153 million hectares in 2010. About 73% of this maize harvesting land was located in developing countries. In 125 developing countries, maize is presently grown on nearly a hundred million hectares and is among the three most

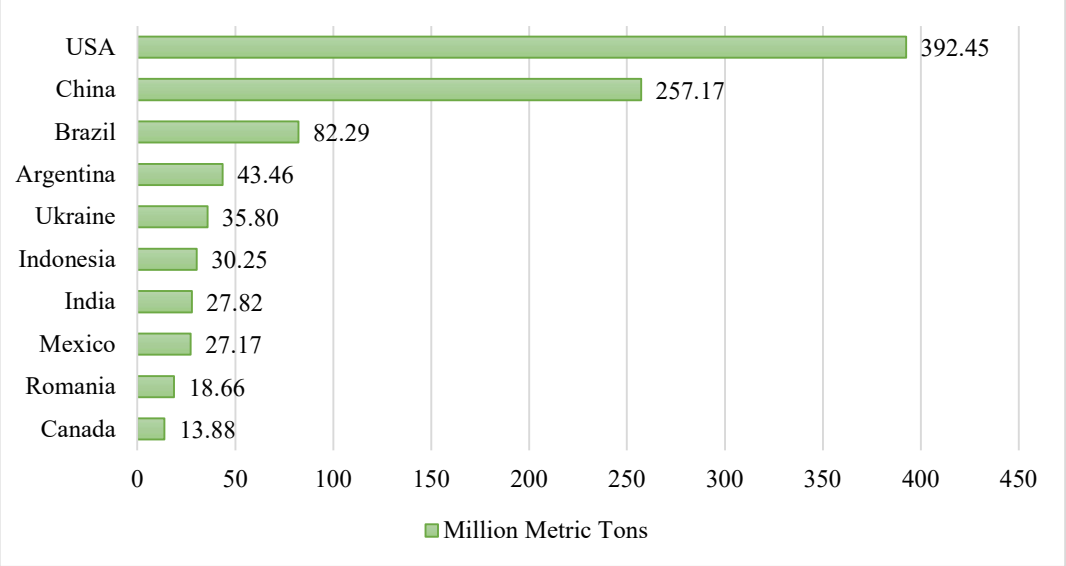
widely produced crops in seventy-five of those countries (CGIAR & MAIZE, 2020). Maize is of the top three crops produced in most developing countries as alongside wheat and rice and is used as a staple food in many of the world's developing countries. Additionally, one-third of all malnourished children have been found in countries where maize is among the top three crops. Shown on the Table 1.5 the leading producers of maize are the USA and China. According to Figure 1.5, the USA produced 392.45 million metric tons of maize in 2018, and China had 257.17 million metric tons of maize in 2018. As a third big producer of maize, Brazil produced 82.29 million metric tons of maize, and Argentina produced 43.46 million metric tons of maize in 2018. The list is followed by Ukraine, Indonesia, India, Mexico, Romania, Canada, and others as maize production ranking goes down.

Table 1.5 Top Maize Producers (2018)

Rank	1	2	3	4	5	6	7	8	9	10
Country	USA	China	Brazil	Argentina	Ukraine	Indonesia	India	Mexico	Romania	Canada
MMT	392.45	257.17	82.29	43.46	35.80	30.25	27.82	27.17	18.66	13.88

Source: (FAO, 2020a)

Figure 1.5 Top Ten Maize Producing Countries (2018)



Source: (FAO, 2020a)

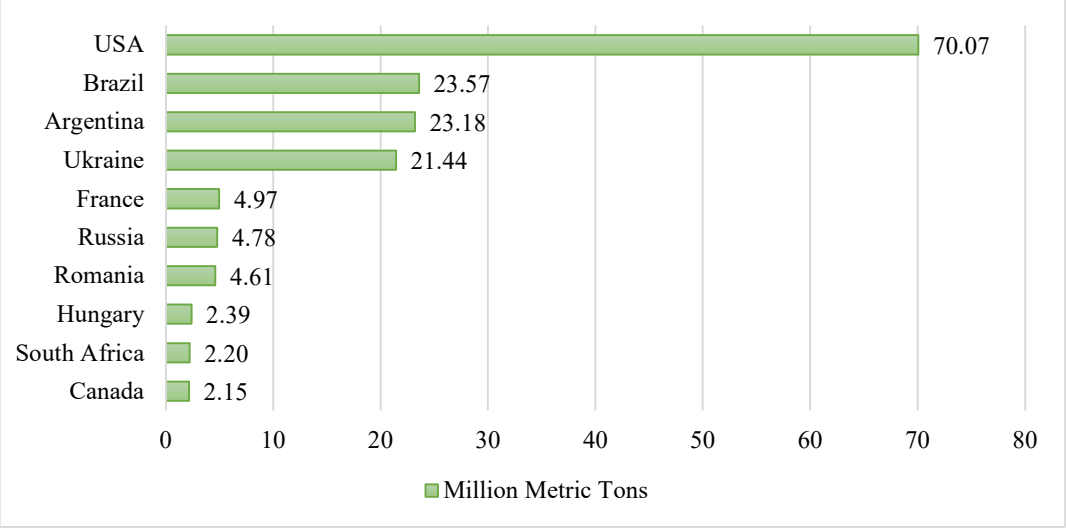
The demand for maize worldwide is high as people use it in various ways like natural staple food, a notable ingredient in many dishes, companies use its syrup in most processed foods, and many countries produce it less. Many make more but with inefficiency as the yield per hectare is very low. Hence, to meet such a demand, big producers export their surplus, and the first exporter is the USA, with a total of 70 million metric tons of maize in 2018. The second top exporter of maize was Brazil, with a total export of 23.57 million metric tons. The third-ranking exporter was Argentina, with 23.18 million metric tons of maize export in the year 2018. With 21.44 million metric tons, Ukraine held 5th position in the top maize exporting countries list in 2018. France, Russia, and Romania closely followed each other with some hundred thousand difference with 4.97, 4.78, and 4.61 million metric tons of maize export in 2018. The list in Table 1.6 goes on with Hungary, South Africa, Canada, and others.

Table 1.6 Top Maize Exporter (2018)

Rank	1	2	3	4	5	6	7	8	9	10
Country	USA	Brazil	Argentina	Ukraine	France	Russia	Romania	Hungary	South Africa	Canada
MMT	70.07	23.57	23.18	21.44	4.97	4.78	4.61	2.39	2.20	2.15

Source: (FAO, 2020a)

Figure 1.6 Top Ten Maize Exporting Countries (2018)



Source: (FAO, 2020a)

Table 1.7 shows data on global food supply in the year 2018, estimated for 2019 and forecasted for 2020 with percentage change of 2020 over 2019. the estimated data shows a significant growth in the overall food production even though some items' output is lower than the previous, such as rice production, total meat, and fisheries production. Still, this decrease can be counterbalanced with other items' production growth, which higher in 2019 than the previous year. But the overall forecasted food production for 2020 is lower than the estimated one in 2019. There are many reasons behind this lower growth, including the extraordinary effect of Covid19 on the global economy. The table above also shows data on international food trade and global food stocks, which are crucial factors of world food supply and production. Despite many challenges during 2020, some products' forecasted data is excellent, such as global cereals production with 2.6% percent of growth, global coarse grain production with 4.5% growth, and international rice production with a 1.6% growth rate.

Table 1.7 World Food Supply (FAO Food Outlook, 2020)

World Food Supply		**2018/19**	**2019/20 estim.**	**2020/21 f'cast**	**Change: 2020/21 over 2019/20**
		million tons			%
Cereals	Production	2648.7	2710.9	2780.5	2.6
	Trade	410.4	423.7	433	2.2
	Ending stocks	871.9	882.7	926.8	5
Wheat	Production	732.1	762.2	758.3	-0.5
	Trade	168.2	175.1	177.5	1.4
	Ending stocks	271.9	276.2	280.3	1.5
Coarse Grains	Production	1410.3	1448.1	1513.5	4.5
	Trade	198.1	203.7	207.9	2.1
	Ending stocks	415.4	423.1	464.6	9.8
Rice	Production	506.3	500.6	508.7	1.6
	Trade	44.1	44.9	47.6	6.2
	Ending stocks	184.6	183.4	182	-0.8
Total Oil crops	Production	593.1	612.3	584.3	-4.6

Oils and Fats	Production	236.3	241	235.4	-2.3
	Supply	273.4	281.3	274.3	-2.5
	Trade	126.3	132	131.1	-0.7
Meals and Cakes	Production	153.1	158.7	149.2	-6
	Supply	184.1	189	181.9	-3.8
	Trade	98.1	98.7	100	1.2
Sugar	Production	181.1	174.6	169.6	-2.9
	Trade	61.6	55.8	58.7	5.3
	Ending stocks	93.1	93.9	87.8	-6.6
Meat	Production	342.2	338.9	333	-1.7
	Bovine meat	71.5	72.6	72	-0.8
	Poultry meat	127.3	133.6	136.8	2.4
	Pig meat	120.9	109.8	101	-8
	Ovine meat	15.8	16	16.2	0.9
	Trade	33.8	36.1	37	2.4
	Bovine meat	10.5	11.2	11.1	-1
	Poultry meat	13.5	13.9	13.8	-0.3
	Pig meat	8.4	9.5	10.6	11.2
	Ovine meat	1	1	1	-2.9
Milk	Total milk production	840.5	851.8	858.9	0.8
	Total trade	75.9	76.7	73.6	-4.1
Fish	Production	178.5	175.9	172.9	-1.7
	Capture fisheries	96.4	91.8	89.9	-2
	Aquaculture	82.1	84.1	82.9	-1.4
	Trade value (exports USD billion)	164.1	159.6	150.4	-5.8
	Trade volume (live weight)	67.1	65.3	63.2	-3.2

Source: (FAO, 2020b)

Initially, food production was mainly done organically simple farming with a minimum in hand local inputs and essential farming tools in vast agricultural fields. But with the advancement of technology and science, people started using heavy machinery, synthetic chemical inputs and started genetically modifying seeds and animals for higher productivity to increase profit. While the resources on earth are limited and food supply has to grow annually to meet the increasing demand, researchers and scientists have started experimenting on different crops and animals to increase the harvest yield. A lot of work is done to gain more from limited resources. In intensive farming worldwide, farmers produce many-many times more than what they could make like two centuries ago.

To have a good market for the supplied food production, companies worldwide started processing food in various ways. After harvesting different food items from the forms, they enter into the supply chain process starting with packaging, cleaning, raw cooking, precooking, canning, bottling, fertilizing, chemically, biologically, and physically improving the storage time, the test and color of the food item. Food is processed not only to improve the quality but mostly for marketing purposes to increase sales and another significant cause is to decrease the cost of some products. Food processing can be as simple as packaging fruit in a fancy way or complicated as making different types of juices, jams, powders, mixing it with other edible items, and so on. Raw meat is processed into various final marketable goods such as freshly processed meat products, cured meat cuts, raw-cooked meat products, precooked-cooked meat products, raw-fermented sausages, dried meat products. With the inventions of microwave, fridge, and freezers, the processed food market grew bigger and bigger during some previous decades.

1.2.2 Global Food Demand

Food demand is another significant component of the Food Industry. Table 8 shows data on the total utilization of various food item on the year 2008/19, which is then estimated to 2019/20 and forecasted to the year 2020/21 by FAOSTAT and the percentage change or growth rate from the year 2019/20 till 2020/21 is shown on the last column of the table. Data shown on the table is in million metric tons except the previous column, which is a percentage change. Besides total utilization, the table contains data on how much that particular food item is used for what purpose? Is it used directly as a food for

human beings, or is it used as animal feed to produce other animal-based food items like meat or dairy products?

Table 1.8 Global Food Demand for Main Items

Food Demand		2018/19	2019/20 estim.	2020/21 f'cast	Change: 2020/21 over 2019/20
		million tons			%
Cereals	Total utilization	2678	2689	2732	1.6
	Food	1141	1154	1168	1.2
	Feed	960.3	976.8	998.7	2.2
	Other uses	576.4	558.6	565.9	1.3
Wheat	Total utilization	751.1	757.5	754.3	-0.4
	Food	514.9	521.1	525.4	0.8
	Feed	142	142.5	138.7	-2.6
	Other uses	94.2	93.9	90.2	-3.9
Coarse Grains	Total utilization	1427	1430	1468	2.7
	Food	218.1	219.5	222.4	1.3
	Feed	801.1	818	843.7	3.1
	Other uses	407.5	392.3	401.9	2.4
Rice	Total utilization	499.9	502	510	1.6
	Food	408.2	413.3	420	1.6
Total Oil crops	Utilization	229.5	242.2	240.9	-0.6
Meals and Cakes	Utilization	151.5	153.9	155.3	0.9
Sugar	Total utilization	171.1	173.9	175.7	1
Fish	Total utilization	178.5	175.9	172.9	-1.7
	Food	156.4	156.4	154.2	-1.4
	Feed	18.2	15.5	15	-3.5
	Other uses	4	4	3.7	-7.5

Source: (FAO, 2020a)

Cereal crops as essential food items are at the top of the list with total utilization of 2687 MMT in the year 2018/19, which is estimated to be 2689 MMT in 2019/20 and with a 1.5% expected growth its total utilization in the year 2020/21 is forecasted to be 2732 MMT. According to the Table 1.8, 1141 MMT of cereals, which makes 42.6% of total utilization in 2018/19, were used as direct human food. 960.3 MMT, which are 35.86% of the total, were utilized as animal feed, and the remaining 21.5% were being used in other uses. The forecasted data for 2020/21 shows a bit changes in the share of utilization with a slight increase in direct food share, considerable increase in animal feed share, and the cost of deducting the percentage of cereals utilization for other purposes.

Total wheat utilization in 2018/19 was 751.1 MMT, which is more than the global production in that same year. The stock comes in handy when the surplus of a year is stored to be used in the coming year's shortage. The utilization was estimated to be higher by 6.6 MMT in 2019/20, but the forecasted data for 2020/21 shows a 0.4 percent reduction in the consumption, which will still be more than 2018/19. Annually, more than 500 MMT of wheat is utilized as a portion of human food. Nearly 150 MMT is used in animal feed, and around 90 MMT is utilized for other uses.

In 2018/19 total of 1427 MMT of coarse grains were utilized globally, from which just 218.1 MMT were used as food, most of which 801.1 MMT were used to produce animal feed, and the remaining 407.5 MMT were used for other purposes. And the utilization is expected to be grown in the following two years both for food and feed purposes. Almost 500 MMT of rice was utilized in 2018/19, and it was estimated to be 502 MMT in 2019/20 and forecasted to be 510 MMT in 2020/21. And the list shown in table 8 goes on with the utilization of oil crops, sugar, and fish meat.

1.2.3 Food Pricing

Food pricing is an important topic. Food prices are determined by various factors called market forces such as supply and demand, governments, speculations and expectations, and others. If the supply is somehow decreased, the prices will rise and vice versa, and if the demand falls, the prices will increase and vice versa. Some governments directly control the prices by implicating different policies like minimum wage rate, regulating the demand and supply by providing subsidy to agricultural products, and sometimes setting a minimum price to save the small producers. Governments use

different tools to control the rates, such as minimum commodity prices, tariffs and quotas on trade, stock of grains, etc.

Furthermore, speculations and expectations also primarily affect the prices. It works in a way that people speculate that the supply of certain goods will shorten due to some reasons, then the prices automatically start increasing. Sometimes, the suppliers assume that the demand may fall due to some reasons. Hence, they start reducing the prices. A good example can be the food prices during March and April 2020, when the lockdowns began in some cities worldwide. People expected that they might not be able to access the food, the expectations were that the supply might reduce, and the demand may increase; thus, the prices went high. In Afghanistan, where I was at that time, people started hoarding and storing the primary food commodities like flour, grains, cooking oils, rice, etc. In two days, the price of these commodities doubled in most of the cities in Afghanistan. Until the government intervened, gave some necessary food items to the most vulnerable, forced the unjust sellers to control the prices, and raised awareness about the false speculations and expectations, which led to significant problems for everyone but the poor in particular.

Food Security is "that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for active and healthy life" (IFPRI, 2020). In this definition of food security, the term economic access refers to food prices in the market and the individual consumers' ability to buy the food with their income. Hence, food pricing is an essential component of food security. Food-related economic policies should be designed to keep the producers producing more products economically with some benefits, and the consumer would be able to consume them. At the beginning of the 1970s, food prices went up high due to natural calamity, resulting in destroying crops, eventually creating a supply shortage. This food price crisis made UN and other world leaders come together at a summit in 1972. They introduced the term food security and called for action to combat the situations and make sure that food will be available for everyone at every time.

Table 1.9 shows annual data of the FAO Food Price Index from 2003 up to 2020. And it also contains monthly data from March 2020 up to March 2021. The third column on the table shows the average food price index for the five commodity groups. The remaining columns consist of the average price of each group's food items.

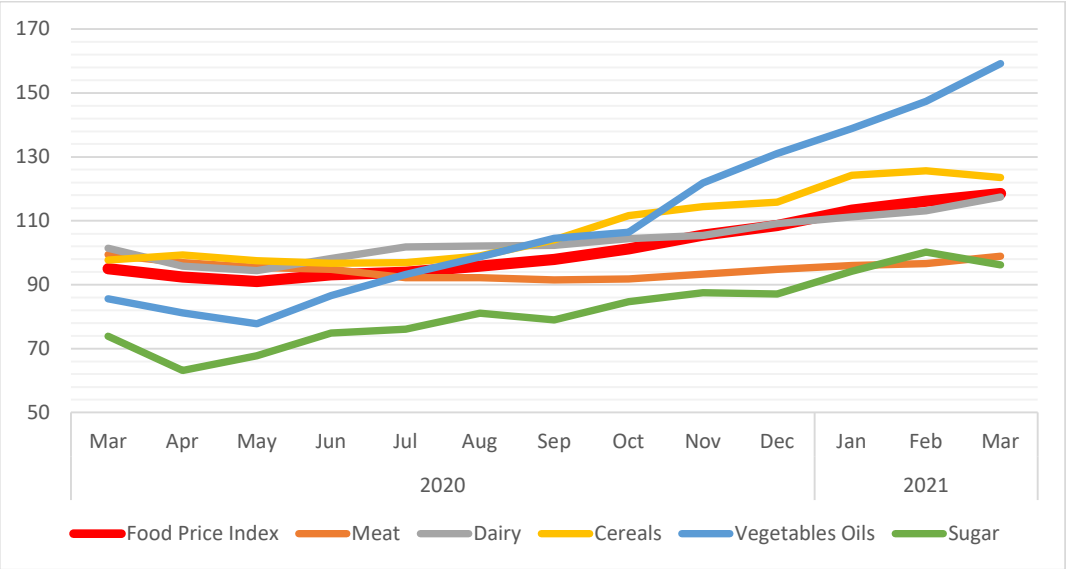
Table 1.9 FAO Food Price Index

		Food Price Index	Meat	Dairy	Cereals	Vegetables' Oils	Sugar
2003		57.8	58.3	54.5	59.4	62.6	43.9
2004		65.5	67.6	69.8	64.0	69.6	44.3
2005		67.4	71.8	77.2	60.8	64.4	61.2
2006		72.6	70.5	73.1	71.2	70.6	91.4
2007		94.2	76.9	122.4	100.9	107.3	62.4
2008		117.5	90.2	132.3	137.6	141.0	79.2
2009		91.7	81.2	91.4	97.2	94.4	112.2
2010		106.7	91.0	111.9	107.5	121.9	131.7
2011		131.9	105.3	129.9	142.2	156.4	160.9
2012		122.8	105.0	111.7	137.4	138.3	133.3
2013		120.1	106.2	140.9	129.1	119.5	109.5
2014		115.0	112.2	130.2	115.8	110.6	105.2
2015		93.1	96.7	87.1	95.9	90.0	83.2
2016		91.9	91.0	82.6	88.3	99.4	111.6
2017		98.0	97.7	108.0	91.0	101.9	99.1
2018		95.9	94.9	107.3	100.6	87.8	77.4
2019		95.0	100.0	102.8	96.4	83.3	78.6
2020		98.0	95.5	101.8	102.7	99.4	79.5
2020	Mar	95.1	99.4	101.5	97.7	85.5	73.9
	Apr	92.4	96.9	95.8	99.3	81.2	63.2
	May	91.0	95.4	94.4	97.5	77.8	67.8
	Jun	93.1	94.8	98.3	96.7	86.6	74.9
	Jul	93.9	92.2	101.8	96.9	93.2	76.0
	Aug	95.8	92.2	102.1	99.0	98.7	81.1
	Sep	97.9	91.5	102.3	104.0	104.6	79.0
	Oct	101.2	91.8	104.5	111.6	106.4	84.7
	Nov	105.5	93.3	105.4	114.4	121.9	87.5
	Dec	108.5	94.8	109.2	115.9	131.1	87.1
2021	Jan	113.3	96.0	111.2	124.2	138.8	94.2
	Feb	116.1	96.7	113.1	125.7	147.4	100.2
	Mar	118.5	98.9	117.4	123.6	159.2	96.2

Source: (FAO, 2021)

In the table, we see data increment for three specific periods. The first one is during the 2007-2008 financial crises. Where the value of the food price index goes up by approximately 45 points, from 72.6 in 2006 up to 117.5 in 2008. The second one is in response to the 2011-2012 global crises. Where the inflation starts rising in 2010, and it continues for five consecutive years. And finally, it rises in 2020 for the third time in response to the COVID 19 global pandemic and lockdown. The prices start rising from mid-2020, and since then it continues increasing month to month.

Figure 1.7 FAO Food Price Index



Source: (FAO, 2021)

Figure 1.7 plots the FAO Food Price Index available values for the years 2020 and 2021. Each line represents a group of food, and the thick red line represents the average of all the remaining five food groups. The graph clearly shows that vegetable oils –colored with light blue, have increased the most since March 2020. In March 2021, the line crosses double its value in just ten months since May 2020. The least impacted food group is meat, shown on the orange-colored line. The line starts just below hundred it continues to decrease until September-2020 to 91.5, and from then on it starts to rise again reaching its previous year position in this March just below hundred. Sugar prices are also highly affected by the pandemic. The line denoted by the light green color increased by almost 40 values during the previous year. Overall, the graph shows a continuous increase in the prices of food globally.

1.3 NUTRITION

Food is vital for the body to have a healthy and active life. However, food security ensures the availability, access, and ability to acquire food. The food should be safe for the body to grow, fight infections and diseases, and have a healthy and active life. The quality of diet is very significant; it should contain the necessary nutrients. Nutrition is an important topic associated with food security. The quality of health lays in the quality of diet, it may lead to a healthy life, may lead to malnutrition, and it can lead to obesity and overweight. There are significant divergences in the per heads availability of

foods across different income group countries. Developing countries depend more on staple foods. And high-income countries rely more on fruits and vegies and livestock based food products (FAO et al., 2020, p. 40).

Globally in upper-middle-income countries and only in Asia, there are sufficient fruits and vegetables produced for the human intake to answer the FAO and WHO suggestion of eating a minimum of 400 g/person/day. Worldwide with a wide variation on the regions, only of the three of six to twenty-three months of age children meets that required dietary diversity. Individual-level and household-level surveys data analysis indicates that food intake quality is adversely affected by food insecurity, even at modest severity levels. People who suffer mild or acute food insecurity eat less livestock products (meat and diary), fruits and vegetables than those who are secure or slightly food insecure (FAO et al., 2020). It is necessary to place nutrition into the main food strategies to lessen the problem of illnesses, diseases, and infections in order to provide sustainable, nutritious, secure, safe, and ethical food for the wellbeing of humans, animals, and the environmental (Barling & Fanzo, 2018).

The Food Insecurity Experience Scale's theoretical basis is consisting of the finding that an increase in the severity of food insecurity worsens the diet quality. This means that people who face mild food insecurity are facing uncertainties about their food acquisition ability and are pushed to compromise on the nutritive quality and/or quantity of the diet. This refers to the expense and affordability of nutritious foods as a critical element influencing food security and, accordingly, diet quality (FAO et al., 2020, p. 40). Although the data on food nutrition and what people are eating across the globe is scarce, there are studies done by various organizations and individuals on this topic, focusing on this section. In the late twentieth century, food security was argued as a sufficient supply of food that mainly focused on staple food production with a lesser amount of interest given to the diet's health effect. In the following years, scientists and researchers observed the misguidance of this method to food security because people have no access to the safe, affordable healthy diets all year round in adequate quantity required to support healthiness and wellbeing. After that, the nutrient sufficiency of diets became a central aspect of food security and nutrition programs. In the latter decades, the topic of overweight and obesity also entered into food insecurity, which spotlights the quality of diets in the nutrition and food security policies.

Diet quality encompasses four crucial characteristics: food diversity, nutrient advocacy and sufficiency, moderate in quantity and the amount of food, and overall balance of micronutrients. According to World Health Organization, a healthy diet shelters from malnutrition in all its forms and non-transmittable diseases such as diabetes, heart disease, stroke, and cancer (FAO et al., 2020, p. 41). A balance of macronutrients such as fats, proteins, carbohydrates, fibers, and essential micronutrients must be included in a healthy diet, like vitamins and minerals particular to the sex, age, bodily activities, and psychological condition of a person.

1.4 FOOD SAFETY

Food as a source of life is a basic need of all living beings. Food safety is a significant complement of food security. From the sprouting seed, from the hatching egg, and from the baby animal that starts life in its mother's womb to the cooked and prepared meal on our plates ready to be eaten. The whole process of growing, raising, harvesting, marketing, preparing, and cooking has the challenge of keeping it safe. These challenges include microbial, chemical, personal, and environmental hygiene (Fung et al., 2018). Food by kind is organic and chemical. It is efficient of assisting the development of microorganisms which are possible causes of foodborne illnesses. Deaths and hospitalizations related to foodborne illnesses are caused by bacterials. While Viruses are more to blame for the bulk of foodborne diseases. The syndromes vary from slight intestinal flu to neurological, liverwort, and renal disorders triggered by either contaminant from the illness-causing microorganism. Foodborne bacteriology is the foremost cause of acute and deadly foodborne diseases; Staphylococcus, Salmonella, Clostridium, Campylobacter, Listeria, Vibrio, Bacillus, and E. coli species causes over 90% of food-poisoning diseases. (Fung et al., 2018).

Food safety is related to various human activities. The hazardous trash we dump into the river, the soil, and the oceans destroy food quality. All of the synthetic pesticides used in agriculture and livestock farming come back to our food in various ways. Nonfood grade chemical additives, for instance, colorants used for food coloring and preservatives used to preserve the food, and contaminants, such as pesticide residues from agricultural use, have been found in foods. Bacteria, viruses, parasites, worms, and other chemicals added to the food in various steps along the food chain cause foodborne illnesses. Table

1.10 shows how dangerous it can be medically and economically. This thesis will focus on the processed food and intensive farming, which plays a massive role in the food chain.

Table 1.10 Common foodborne pathogens and their impacts

Foodborne Hazard	Common Infectious of Toxic Agents	Incidence of Foodborne Illness	Death Due Foodborne illness	Total DALYs
Bacteria	Salmonella, Vibrio, E. Coli, Shigella, Listeria, Brucella, Listeria, Campylobacter	359747420	272554	20188792
Virus	Norovirus, Hepatitis A	138513782	120814	3849845
Protozoa	Entamoeba, Giardia, Cryptococcus, Toxoplasma	77462734	6242	1311435
Worms	Cestodes (tapeworms), Nematodes (round worms), Trematodes (flatworms); helminths (parasites)	26063664	90261	11599735
Chemicals	Aflatoxins, Cyanogenic, Dioxin, Heavy Metals	217632	19712	908356

Source: (World Health Organization, 2015)

1.4.1 Processed Food

In the big cities worldwide, we see processed food in supermarkets that most people do not know about the actual contents. A high percentage of the food items on the shelves in the supermarkets contain added sugar. The metabolic system works so that when we consume more sugar than the required limits as most of the processed food and beverages have lots of sugar or carbohydrates, then the role of insulin hormones comes to play, which is to store the energy, in this case, is sugar. Insulins convert sugar into fat. The more insulin hormones released it will trick the mind that it feels hungry even while someone is fed up with stopping the Leptins, which tells the brain to feel full. Here begins the vicious cycle of eating more and more, leading to obesity and overweight.

Obesity will lead to many chronic diseases in the long run, such as heart attack, diabetes, kidney failure, strokes, cancer, lipid problems, and more. Overall, fat, saturated fat, cholesterol, sugar, and salt are the primary source of obesity and other chronic diseases. When consumers got concerns about the fat in products, producers introduced goods, especially dairy products with less or no fat, to the market, which is a bit tasteless. To recover the taste, they had to add sugar to it. This sugar eventually turns back to fat as

stored energy, which brings the main problem back again. Corn syrup is also used as a cheaper alternative to sugar, which is used to flavor the processed food. Corn is way less expensive than sugar because of its mass production, and with the start of its syrup usage, the market is flooded with such products.

Diabetes is a persistent metabolic disorder, portrayed by high blood glucose levels (or blood sugar), that precedes over time to severe harm to the heart, blood vessels, eyes, kidneys, and nerves. The most common one is type 2 diabetes, typically in a grown person, which appears when the body becomes resilient to insulin or doesn't produce sufficient insulin. During the past thirty years, the occurrence of type 2 diabetes has increased dramatically in nations of all income levels. Around 422 million persons around the world have diabetes, most of them living in low-income and middle-income countries, and 1.6 million deaths are directly related to diabetes per annum. The number of incidents and the occurrence of diabetes both has been gradually rising over the past few decades (*WHO Website*, reteieved on 2020).

Type 2 diabetes, previously known as non-insulin-dependent, results from the body's ineffective insulin use. Type 2 diabetes is the most pervasive type of diabetes among people. Type 2 diabetes is mainly caused by a lack of physical activity and high body weight. Signs of this type may be similar to the symptoms of type 1 diabetes but are often less noticeable. Consequently, the diagnosis may be several years after onset, after problems have already surfaced. Type 2 diabetes was only diagnosed in adults until recently, but it is now also appearing increasingly frequently in children (*WHO Website*, Retreived on 2020).

Children and the younger population are exceedingly affected by this type of food unsafety. Results of studies done on animals show that sugar is addictive (DiNicolantonio et al., 2018). Child formulas include sugar under different names; most junk food products for children and teenagers, such as snacks, cereals, fries, chips, juices, cakes, pizza, soft drinks, ice cream, etc. contain lots of sugar. Soda and soft drinks are the cigarettes of 21st century; it is cool and satisfying but deadly in the long run. Which eventually results in child obesity and other chronic diseases. Food commercials are targeting children, while it should be the other way around. Junk food commercials use the kids' favorite cartoon characters and give away gifts like toys and other satisfactory items to boost sales. These food items make kids' food addictive, and the habit stays for a long time. Once a child is obese, then it is tough to control his diet or weight.

1.4.2 Intensive Farming

To maximize the profit, farming of livestock, poultry, and fisheries has developed so intensively that it became a threat to food safety. Each farmer in the old days owned 10 to 20 heads of animals, but nowadays, an industrial farm owner owns hundreds and thousands of animals on a farm. Intensive farming of chicken, turkey, fish, pig, cattle, and so on for various purposes such as meat production, laying eggs, and dairy products are very inhuman and unsafe in the long run. Its negative impact goes beyond the animal itself, but it impacts us human beings and the environment at all. People think animals have no intelligence, they are dumb, and they have no emotions. But they are so wrong. Because many animals, especially farm animals, are very intelligent, social, and emotional. They build communities, babysit each other, feel the joy and pain, and mourn for the loss of each other.

Animals in the farms are treated as commodities rather than living beings. Chicken is by nature a very social, curious, and intelligent animal. Instead of hatching in a maternal nest, chicks are hatched in incubators, and as soon as they can stand, they are separated, vaccinated, packed up, and send to the enormous feeding lots. A normal hen in its ideal environment lives up to 20 years, but in farms, they are fed with growth hormones in processed feeds, which give them a brutally rapid growth of 2kg in 45 days. The weight increases so quickly that the skeleton cannot catch up, and the bird lays flat on its chest because its legs no longer support the weight. Some animals do not survive this abnormal growth, and they no longer can drag themselves to the feeding/watering pots. Others die of breathing-induced cardiovascular diseases; they stress and fall victim to cannibalism (H.O.P.E. What You Eat Matters, 2018).

In these animal prisons (farms), they reach slaughtering ways in record time. Never see daylight and spend their whole life in too crowded conditions. Movements are minimal, and the cages are barely larger than their bodies. A pig’s life expectancy is up to 25 years, but they are slaughtered in 6 months. A cattle’s life expectancy of up to 30 years just not imaginable by an industrial farm cattle. One step backward and one step forward is all the freedom a caged industrial farm cattle has in its whole life. Animals are abused in zoos, circuses, education, and research, but the worse of all is factory farming; they are torturing animals to the fullest.

Lack of hygiene, over breeding, and ignoring the animals' natural needs make them vulnerable to diseases. The crowded conditions of industrial farming making it easier for infections and viruses to spread in the farms. As a result, the animals are given lots of antibiotics. Up to three-quarters of antibiotics produced end up in industrial farms. If you take antibiotics out of the system massive Number of animals will get sick, and eventually, most of them will die, which means that the whole system is sick and vulnerable. Even if the massive death is surpassed with the help of antibiotics, it still creates another problem. The routine and improper usage of antibiotics increase health risks for animals and us human beings. Because progressively more bacteria become resistant to the antibiotics and antibodies of the animals. Suppose these antibody resistance animal bacteria infect human beings. Humans will get sick, and often, the medication would not work. Seven hundred thousand people die annually due to foodborne sickness worldwide (H.O.P.E. What You Eat Matters, 2018).

Vast areas of rain forests around the globe are cut down for this intensive industrial farming. With all the other causes in its place, intensive animal farming is one of the extremes causing factors of massive deforestation. Arable land is needed for the animals to posture but most importantly to grow the animal feed. A prominent percentage of the whole grains produced goes to animal feed. As an enormous reservoir of CO2 and home to hundreds of thousands of animal species and the keeper of biodiversity, rain forests are more important and valuable than the meat on the plates. Animals produce vast amounts of methane gas that are more dangerous than CO2. All of them have ammonia in their residues, thrown back to the environment, damaging the soil and drinking water. Along with animal farming, other agricultural intensive farming also uses synthetic fertilizers. Nitrous oxide, which is 300 times harmful, then CO2 is thrown into the environment, eventually damaging the environment for all.

1.5 FOOD WASTAGE

۞ يَٰبَنِيٓ ءَادَمَ خُذُواْ زِينَتَكُمۡ عِندَ كُلِّ مَسۡجِدٖ وَكُلُواْ وَٱشۡرَبُواْ وَلَا تُسۡرِفُوٓاْۚ إِنَّهُۥ لَا يُحِبُّ ٱلۡمُسۡرِفِينَ

"O Children of Adam! Dress properly whenever you are at worship. Eat and drink, but do not waste. Surely He does not like the wasteful."

— (Al Quran - 7:31)

Food waste results from carelessness, greed, and injustice of some people happening right now. Food wastage is happening both on the supply side of food and on the utilization side of food. Methods of production used to produce food and the supply chain in some developing countries are inefficient, which wastes some valuable food. These wastages happen due to lack of storage facilities and other crucial facilities, insufficient transportation channels, inability to access more significant markets, inadequate packaging, etc. On the other hand, in developed countries, food waste happens in supermarkets, groceries, food processing, restaurants, hotels, school kitchens, parties, celebrations, festivals, holidays, etc. Annually, tons of fresh fruit and vegetables are wasted in festivals like Halloween, La Tomatina, Spain, and other festivals.

> *"Earth provides enough to satisfy every man's need, but not every man's greed."*
>
> *— Mahatma Gandhi*

Table 1.11 Percentage of food wasted in different regions

Commodity group	Total in chain (min)	Total in chain (max)
Cereals	19% (Sub Saharan Africa)	32% (North America & Oceania)
Oil crops and pulses	18% (Industrialized Asia)	29% (North Africa, Western Asia, and Central Asia)
Roots and tubers	33% (North Africa, Western Asia, and Central Asia)	60% (North America and Oceania)
Fruit and vegetables	37% (Industrialized Asia)	55% (North Africa, Western Asia, and Central Asia)
Meat	20% (South and Southeast Asia)	27% (Sub Saharan Africa)
Fish and seafood	30% (Latin America)	50% (North America and Oceania)
Milk	11% (Industrialized Asia)	25% (Sub Saharan Africa)
Egg	12% (Sub Saharan Africa)	20% (North America and Oceania)

Source: (Jenny et al., 2011)

Table 1.11 shows data on the waste margin of food in different regions of the world. The data is retrieved from a study done by (Jenny et al., 2011) published by The Swedish Institute for Food and Biotechnology together with FAO. The loss of Roots and Tubers, fruit and vegetable, and fish and seafood are very notable. It is possible that up to 60% of roots and tubers produce in North America and Oceania are wasted. 37% of fresh fruit and vegetables grown in industrialized Asia are wasted. North Africa, Western

Asia, and Central Asia lose up to 55% of their total fresh fruit and vegetables annually. Seafood and fish are wasted in various parts of the world, but the highest region is North America and Oceania, which annually wastes 50% of its produce.

Table 1.12 Volume of food waste in low and high-income countries

Commodity Group	Low Income	High Income	Total
Cereals	155.8 MMT	161.1 MMT	316.9 MMT
Roots & Tubers	123.1 MMT	121.6 MMT	244.7 MMT
Oilseeds & Pulses	31.5 MMT	11.6 MMT	43.1 MMT
Fruit & Vegetables	221.6 MMT	270.4 MMT	492 MMT
Meat	20 MMT	40.7 MMT	60.7 MMT
Fish & Seafood	6.7 MMT	10.7 MMT	17.4 MMT
Milk & Eggs	64.7 MMT	55 MMT	119.7 MMT
Total	623.4 MMT	671.1 MMT	1,294.5 MMT

Source: (Jenny et al., 2011)

Table 1.12 shows data on food wasted in the world. The second column contains data on the share of food waste in low-income countries. The third column shows the share of food waste in high-income countries, and the fourth column shows the total waste value of each commodity group for both high-income and low-income countries. 48.2% of the entire food waste, which is 623.4 MMT, is produced in low-income countries, and 51.8% of total food waste, 671.1 MMT, is the share of high-income countries. The last cell on the table shows a shockingly high number of one billion food waste annually. 492 MMT, which is almost half of the total food waste, is only fruit and vegetables. Another highly wasted commodity is cereals and grains; 316.9 MMT is wasted annually.

> *"It is unacceptable that hunger is on the rise at a time when the world wastes more than 1 billion tons of food every year. It is time to change how we produce and consume, including reducing greenhouse emissions. Transforming the food system is crucial for delivering all the Sustainable Development Goals. As a human family, a world free of hunger is our imperative."*
>
> *— UN Secretary-General Antonio Guterres*

1.6 FOOD SUSTAINABILITY

Food Sustainability is a widely discussed subject in recent years. It is about sustaining food production. First of all, the research should discuss sustainability; what is sustainability? Sustainability is a term used in the development, which means to ensure that the resources are not fully depleted and that we are not growing on the future generations' expenses. Our actions do not damage the environment and ecological biodiversity. Sustainability ensures that the upcoming future generations will get their share of the resources and that we do not endanger the human future in any way possible. Secondly, we look at food sustainability. The relation amongst food and sustainability goes way back to the 1980s, when sustainable development became an overarching policy objective for all nations (Aiking & de Boer, 2004).

The global food system contributes to climate-changing greenhouse gas emissions with all stages in the supply chain, from farming all the way through processing, distribution, retailing, home food preparation, and waste, playing a part. It also increases to other major environmental impacts, including biodiversity loss and water extraction, and pollution (Garnett, 2013). food provision is the one human action with the most massive environmental impact (Aiking & de Boer, 2004). Most of the time, policymakers and those who can influence the system ignore its environmental cost to feed the world and that the current generation's food security is essential. However, During the same period, the food system appears not to be incredibly effective at performing its primary function: feeding people effectively. Some overeat and suffer the health consequences thereof, while others go hungry. others suffer from the hidden hunger of micronutrient deficiencies (Garnett, 2013).

Climate change and environmental deterioration will make food production very tough and unstable. Estimations find out that the food system as a whole contributes between 15 and 28 % to overall GHG emissions in developed countries, with all stages in the supply chain, from agricultural production through processing, distribution, retailing, home food preparation, and waste, playing a part. While the direct impacts of farming (from CH4 and N2O emissions) contribute around 10–12 % of global emissions, there are also indirect impacts to consider. Agriculturally induced deforestation causes the release of CO2 into the atmosphere, and taking this into account adds a further 6–17 % to agriculture's share of the burden (Garnett, 2013).

In addition to CO2 discharge, agriculturally stimulated deforestation is the leading cause of biodiversity loss in the world. 70–80 % of all human water withdrawals is also caused by deforestation (freshwater shortage is becoming more prevalent in many places around the world) and is a significant cause of water pollution. Soil deterioration is also a big issue related to agriculture. Livestock and animal farming are the largest contributor to environmentally hazardous byproducts. Livestock uses 70 % of overall agricultural land and a third of arable land. Hence, it performs a leading role in CO2 release and biodiversity loss related to deforestation. For example, cattle ranching and soy production (grown for animal feed) are the key drivers of deforestation in the fragile Amazon region (Garnett, 2013).

The food system needs to be enhanced by managing three significant aspects of it. The first is the production and supply side – changing the production patterns, the second being the demand or consumption side – restraining perspective on excessive consumptions. The third is the social and governmental side – which has to regulate the system. In the developed world in big cities, people have different choices and options available to them for which the main concern is food safety, they will choose that food which is healthier. Sustainability will be the issue of environmental challenges and different safe food resources, and the availability of choices. But in developing countries or impoverished parts of the world, people only have access to one or two types of food, mainly low on different minerals and nutrients. Work is to be done to tackle these problems, obesity and other chronic diseases in the developed world, hunger and malnutrition in the emerging world, and keeping the environment safe and undamaged. Hence, make the food system sustainable.

1.7 FOOD SECURITY

In 1972 food crises happened through much of Europe and some other parts of the world. Wheat and rice crop fields were damaged by natural disasters, which created a significant gap in the demand and supply of food in the market. This supply shock caused the prices to rise and finally making it hard for the average and poor consumers to acquire the necessary nutrition. This rise in the prices consequently went on for three years 1972, 1973 and 1974. Where in the year 1974, the UN FAO held a conference on food in Rome, Italy, to address this significant issue and came up with the definition of food security and

some basic plans and strategies on how to ensure food security (H.O.P.E. What You Eat Matters, 2018).

During 5 – 16 November 1974, governments and donors came together in Rome for World Food Conference to discuss food-related issues. The term food security first came to prominence in this conference. The first definition of food security was:

> *"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" (FAO, 2003)*

Which encompassed only the availability of food and the ability to access food. This definition has since evolved, building on pivotal works (most notably by economist Amartya Sen). Modern food security explanations incorporate four significant features: food availability, food access, food utilization, and stability (Ferranti et al., 2019). The most recent definition of food security on which most of the researchers agree is the definition by the United Nations' Committee on World Food Security. The UN defines food security as:

> *"That all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life." (IFPRI, 2020)*

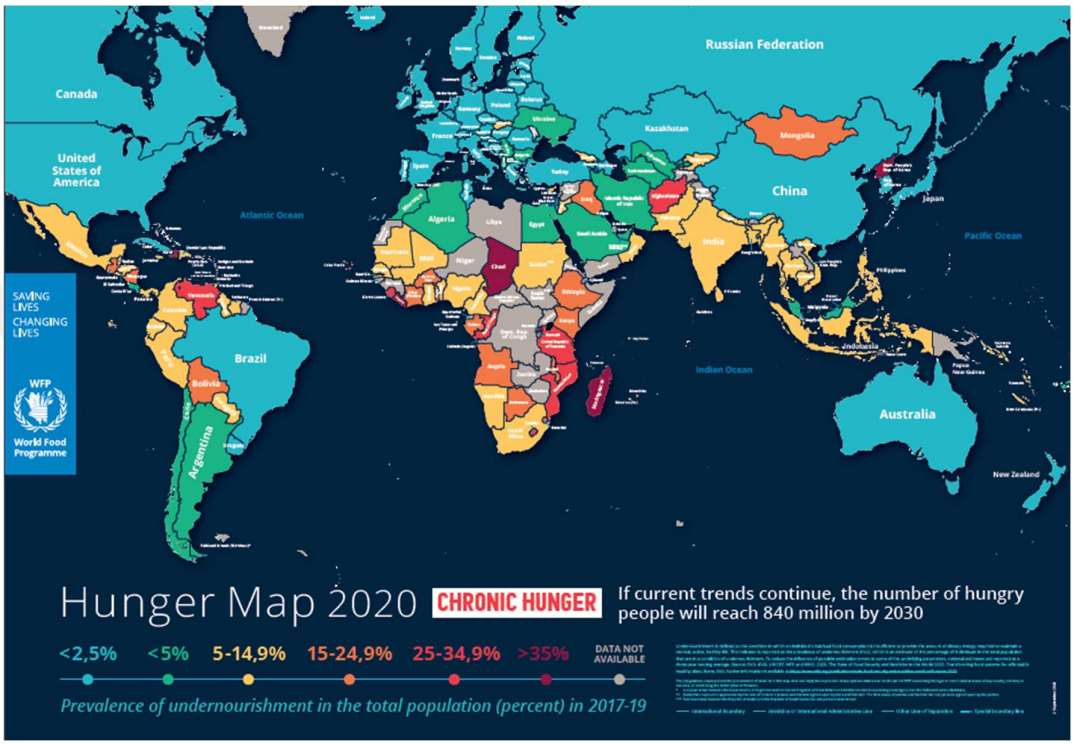
This definition covers a whole lot more than the earliest definition, which only focused on the availability and ability to access food. The recent definition covers the quantitative perspective of food and emphasizes the quality of food consumed by individuals worldwide.

The food system integrates all the components (environment, labor, inputs, methods, infrastructures, organizations, and etc.) and activities that relate to the production, distribution, processing, preparing and consumption of food, and the output of these activities, involving socio-economic and environmental outcomes (Béné et al., 2019).

Current estimates are that nearly 690 million people are hungry, or 8.9 percent of the world population – up by 10 million people in one year and almost 60 million in five years. The Number of people affected by severe food insecurity, which is another measure that approximates hunger, shows a similar upward trend. In 2019, close to 750 million – or nearly one in ten people in the world – were exposed to severe levels of food insecurity (FAO, IFAD, UNICEF, WFP and WHO, 2020). The recent COVID 19 crises,

which are happening worldwide, are also a significant threat to food security. Because it resulted in a lockdown over almost all countries, and the whole economy stopped or slowed down. Which will have a significant impact on the future of human beings.

Figure 1.8 World Hunger Map 2020



Source: (World Food Program, 2020a)

1.7.1 UN 2030 Agenda (SDG-2) Hunger and Food Security

In 2015, in the United Nations, 193 countries agreed on a set of goals and strategies for the year 2030. In total, 17 goals, along with 169 specified targets, indicators, and strategies, were set to achieve them all. The goal is to attain sustainable development by the year 2030 across the globe with the help of these 17 goals and their targets. These 17 SDG goals carry equal importance, but this thesis's focus will be on the second sustainable goal, which we can refer to as SDG-2. SDG-2 is to:

> *"End hunger, achieve food security and improved nutrition, and promote sustainable agriculture."*
> *(*Goal 2 | UN SDGs, retrieved in 2020*)*

Almost all countries and international organizations strive to achieve this goal and other SDGs till 2030 through various policies and agendas.

Table 1.13 Targets and Indicators of SDG-2

No	Target	Indicators
2.1	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2.1.1 Prevalence of undernourishment 2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.2	By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under five years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under five years of age 2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviations from the median of the WHO Child Growth Standards) among children under five years of age, by type (wasting and overweight)
2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists, and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 Volume of production per labor unit by classes of farming/pastoral/forestry enterprise size 2.3.2 Average income of small-scale food producers, by sex and indigenous status
2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding, and other disasters, and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
2.5	By 2020, maintain the genetic diversity of seeds, cultivated plants, and farmed and domesticated	2.5.1 Number of plant and animal genetic resources for food and agriculture secured

	animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional, and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	in either medium or long-term conservation facilities. 2.5.2 Proportion of local breeds classified as being at risk, not-at-risk, or unknown level of risk of extinction
2.a	Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development, and plant and livestock gene banks to enhance agricultural productive capacity in developing countries, in particular, least developed countries	2.a.1 The agriculture orientation index for government expenditures 2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
2.b	Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, following the mandate of the Doha Development Round	2.b.1 Producer Support Estimate 2.b.2 Agricultural export subsidies
2.c	Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, to help limit extreme food price volatility	2.c.1 Indicator of food price anomalies

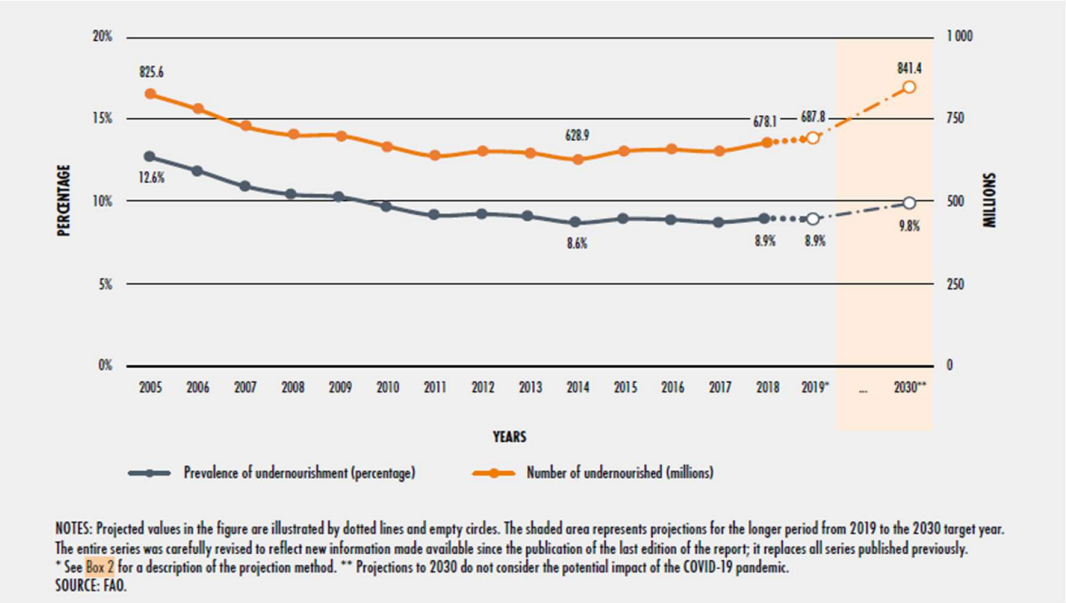
Source: (*Goal 2 | UN SDGs, retrieved in 2020*)

The problem of food security can be divided into two types of Transitory Food Insecurity and Chronic Food Insecurity. Transitory food insecurity is short-term food insecurity, mainly due to economic crises, famines, and other natural disasters. This type is relatively for a short period. The 1972-75 food crises, which happened due to the adverse weather effect, 2008 world economic crises, and the currently COVID 19 pandemic crises are examples of causes of transitory food insecurity. Chronic food insecurity is a continual absence of the ability to grow and acquire the minimum amount of food supplement; it has many reasons beyond the agricultural sector. Chronic food insecurity is the major challenge that policymakers and economists have. Sustainable

Development Goals' primary focus is to achieve food security and eliminate the chronic food security along the transitory mentioned above.

Due to advancements in agriculture such as technology and genetic science, yields (output per hectare) have increased due to research focused on the agricultural sector. However, the number of poor and malnourished people in rural areas is still high and rising, which in itself is a severe challenge to SDG-2. Governments and international NGOs use the agricultural extension as a tool to deal with this problem. Agricultural extension is educating the farmer about new, improved farming techniques and technologies to increase their productivity. Research and stretching are vital parts of achieving SDG-2. The study is done mostly by well-educated people in laboratories or strictly controlled research farms in some urban areas. The technology is also developed or made in highly industrialized societies or, in most cases, imported from other countries. On the other hand, agricultural food production is done mostly in rural areas by mainly uneducated people. This gap between them is closed by the extension—rural farmers and farming laborers' training and education.

Figure 1.9 Number of Undernourished People in the world



NOTES: Projected values in the figure are illustrated by dotted lines and empty circles. The shaded area represents projections for the longer period from 2019 to the 2030 target year. The entire series was carefully revised to reflect new information made available since the publication of the last edition of the report; it replaces all series published previously.
* See Box 2 for a description of the projection method. ** Projections to 2030 do not consider the potential impact of the COVID-19 pandemic.
SOURCE: FAO.

Figure 1.9 shows the number of undernourished people in the world since 2005; in 2019, the number of malnourished people in the world continued to rise. The SDG 2.1 Zero Hunger Target may not be accomplished if recent trends are not reversed (*FAO et al.*, 2020).

1.7.2 COVID-19: A Threat to Food Security

At the end of 2019, an unidentified infection got people in Wuhan City, China, and after researching on the 5th of January 2020, WHO reported the outbreak of a new virus.

Figure 1.10 WHO First Tweet on COVID-19

Source: (World Health Organization, 2020d)

On the 12th of January 2020, China publicly shared the genetic sequence of COVID-19. On tomorrow that day, on the 13th of January 2020, the first COVID 19 case was recorded outside of China in Thailand. By the end of January 2020, the virus spread to 18 countries infecting more than 7,000 people. WHO declared that COVID-19, with the alarming spread and severity and the alarming inaction levels, could be characterized as a pandemic on the 11th of March 2020. Globally, as of 6:43 pm CEST, 17 April 2021, there have been 139,501,934 confirmed cases of COVID-19, including 2,992,193 deaths, reported to WHO. As of 14 April 2021, a total of 751,452,536 vaccine doses have been administered (World Health Organization, 2020c).

WHO requested countries to take this pandemic seriously and prepare to lockdown every populated area, make travel bans and keep the social distance in every gathering. Following the WHO request, some countries in March and some countries in April started the lockdown procedures by quarantining the big cities. Almost all educational institutions were closed worldwide, and big markets were all closed, sports events canceled, big conferences and scientific meetings canceled, rescheduled, or held online. Restaurants and hotels were shut. Hefty travel bans came into existence, and some

countries even restricted the movement of goods. Most of the international borders get closed. Roughly all economic activities were shut down, and human movements were ban by May 2020.

Due to the lockdown, significant economic changes happened: most people lost their jobs, and many countries' unemployment rates went up. People lost their sources of income. Prices for the necessities went up in most of the countries. And a big threat to food security has arisen around the globe. A needy and average individual doesn't have access to proper nutritional food consumption due to the unavailability or inability to buy it at a high price. In emerging nations, prices doubled, tripled, and even quadrupled for some products due to the gap in demand and food supply in the markets. The gap mostly happened due to the supply shock that the supply of certain goods slowed down, and the prices increased. In some markets, the demand for non-perishable goods went up for stocking intentions leading to a positive demand shock. On the other hand, the need for fresh food decreased due to restaurants and hotels' closure, which led to a negative demand shock in the market.

Crop production is the starting point in the food production chain that needs numerous inputs consisting of machinery, labor force, fertilizers, pesticides, insecticides, advertising - marketing channels, transport services, etc. Plenty of industries have been working for agricultural raw materials users and input suppliers. Many agricultural production inputs have to be imported by transport from other cities or foreign countries. Due to the COVID-19, all nations enforced restrictions on the airport, seaport, transportation, transit, and other transport networks. Therefore, agricultural production inputs and raw material processing products can't be moved globally. It has been slow down, and agro-processing industries are on the door to shut down.

Another essential contributor to food is livestock. It has a crucial economic role for 60% of rural households in developing countries of the world. It contributes to the livelihood of 1.7 billion poverty-stricken families, women's employment, and ensuring food security (Basnet et al., 2020). The protein, vitamin, and mineral-rich products given by livestock as meat and dairy products play an essential role in a healthy diet. Furthermore, it establishes many other industries like the manure industry, the leather industry, crop production, and the agro-business industries. Since the COVID 19 pandemic and the world are in lockdown, people cannot provide enough workforce, feeds, grasses, straws, medicines, transport, and other logistics support to the livestock. Thus,

COVID-19 has caused the unemployment of many laborers and staff in livestock production, processing, preservation, and marketing sectors, which eventually may result in a fall in the livestock industry globally.

The first market that closed due to COVID 19 was the seafood market in Wuhan, the capital city of Hubei Province of China, which many believed was the primary spreading source of the virus. Since then, lots of fishing activities have been steady and slowed down or closed. Fisheries and aquaculture provide the livelihoods of almost 820 million people in the world. More than a billion people consumed daily animal protein from fish (Basnet et al., 2020). Moreover, fish provides nutrients to balance a healthy diet and child development. Fish is the primary source to meet up the protein in many countries in the world. Many poor and vulnerable people of least and developing countries earn money from fish catching in natural water bodies (ponds, rivers, seas, channels, etc.) and selling in the local bazaar. The thriving culture of modern fish and aquaculture depends on fish feed production, transport, marketing, processing and preservation, labor availability in the industries and transport sectors, etc. (Basnet et al., 2020). However, the lockdown caused significant damage to the fish and fishery industry. Whatever the time frame, a prolonged market downturn can be expected even after current restrictions are lifted or relaxed. Luxury products and species that are primarily marketed fresh and through the food service will be the most heavily affected. Most seafood trade events will continue to be postponed or canceled for some time to come (*FAO*, 2020).

In conclusion, we can say that the Coronavirus has had a substantial adverse effect on food security. Still, in the long run, the food sector will show more resilience than the other economic sectors. By resilience, we mean that it will recover quicker than the different sectors in a comparative approach.

CHAPTER TWO
THEORETICAL BACKGROUND OF THE RESEARCH

2.1 ORGANIZATIONS WORKING ON FOOD SECURITY

2.1.1 Food and Agricultural Organization (FAO)

Born in 1945, The Food and Agriculture Organization (FAO) is a specialized agency of the United Nations that lead international efforts to end hunger and food insecurity. FAO works in over 130 countries worldwide, with over 194 member states. In addition to its headquarter, located in Rome, Italy, FAO has other regional and field offices worldwide. With its motto "Fiat Panis," which is translated as "Let there be Bread," FAO tries to achieve food security for all and aims to make sure that all people have regular access to sufficient high-quality food to have an active and healthy life.

FAO is working in the following areas:

- Help eliminate hunger, food insecurity, and malnutrition.
- Make agriculture, forestry, and fisheries more productive and sustainable.
- Reduce rural poverty.
- Enable inclusive and efficient agricultural and food systems.
- Increase the resilience of livelihoods to threats and crises.

FAO cooperates with governments and other development actors at national, regional, and global levels to develop supportive policy and institutional environments. FAO assist to boost countries' abilities to transform their political commitments into concrete actions to eliminate hunger, food insecurity, and malnutrition worldwide (*What We Do | FAO*, retrieved in 2020).

2.1.2 The International Fund for Agricultural Development (IFAD)

International Fund for Agricultural Development is a specialized agency of the United Nations working as an international financial institution. It was founded after the 1974 World Food Conference. It operates in developing countries to address poverty and hunger in rural areas. It is the only multilateral development organization that concentrates exclusively on rural economies and food security. IFAD has 177 member states, and since its establishment in 1977, IFAD has given US$22.4 billion in loans and grants and coordinated an additional US$31 billion in global and national co-financing. With head office in Rome, Italy, IFAD is engaged in over two hundred projects in around

hundred countries. IFAD funds and sponsors projects that enhance land and water management, develop rural infrastructure, train and educate farmers in more efficient technologies, build up resilience against climate change, improving market accessibility, and more (*IFAD at a glance*, 2020).

2.1.3 World Food Program (WFP)

The 2020 Noble Peace Prize Winner World Food Program WFP is a prominent organization in leading the humanitarian cause to deliver food assistance and work with communities to enhance nutrition and build resilience in 88 countries. WFP's efforts are targeted at emergency assistance, development aid, relief and rehabilitation, and special operations. Majority of their projects are focused on communities in conflict-affected countries where the population is three times more likely to be underweight than those people living in conflit-free countries. In 2019, the organization provided more than four million metric tons of food and 2.1 billion US Dollars, assisting 97 million people. Increasingly, WFP assist peoples with cash-based transfers so that people could choose and shop for their preferred food locally. WFP is governed by a 36-member Executive Board. It operates closely with its two other Rome-based subsidary organizations, the Food and Agriculture Organization of the United Nations (FAO) and the International Fund for Agricultural Development (IFAD). WFP cooperates with more than 1,000 national and international Non-Governamental Organizations to provide food assistance and eradicate hunger's underlying causes (World Food Program, 2020b).

2.1.4 CARE International

The Cooperative for American Remittances to Europe (CARE) was first established in the USA in November 1945 to help the Europeans heal from World War 2. They were bringing the US Army food surplus in packages to the needy ones in Europe. With Europe near to recovery, CARE became more and more involved in Asia – initially in Japan and then in the Korea, Philippines, Pakistan, and India. CARE changed its name in 1953 to the Cooperative for American Relief Everywhere. In 1993, to reflect the broader scope of our programs and impact, CARE altered its acronym's meaning to "Cooperative for Assistance and Relief Everywhere" (Care International, 2020a). Until 1982 many autonomous CARE organizations were established in Canada and Europe. To work efficiently, an umbrella organization was made in 1982 called CARE International.

For more than half a century, CARE is caring for the world in different ways. CARE works in over 100 countries, helping more than 90 million people through 1300 projects. Alongside food and nutrition, CARE is working towards education and work, disaster response, and health. In the face of rising food insecurity, CARE is working in some of the world's most vulnerable communities to ensure that no one needs to die from hunger or suffer chronic malnutrition. CARE reaches to people to find sustainable ways and make sure the people know where their next meal is coming from and support long-term methods of reducing their vulnerability to hunger and malnutrition. CARE's work area includes supporting farming households to ensure local markets are well stocked, managing natural resources so that they are less at risk from the effects of climate change, and strengthening livelihoods. So that people can purchase foods (Care International, 2020b).

2.1.5 The Hunger Project

The Hunger Project is a global non-profit strategic organization. The organization envisions "a world where every woman, man, and child lead a healthy, fulfilling life of self-reliance and dignity." The Hunger Projects carry out programs and projects in Africa, Asia, and Latin America to assist rural people to achieve sustainable nutrition, eradicate family hunger, and improve health and education. The Hunger Project is striving for the sustainable eradication of hunger globally. The organization plans to put an end to poverty, hunger, and food insecurity by initiating sustainable grassroots and women-centered strategies ("Who We Are | The Hunger Project," retrieved in 2020).

The main issues on which The Hunger Project is working are hunger, poverty, gender equality, environment, health, nutrition, water and sanitation, local democracy, empowering girls, education, self-reliance, and social cohesion ("What We Do | The Hunger Project" retrieved in 2020). Their work reaches nearly 16 million people in more than 13 thousand communities worldwide. The organization is working for the following three core elements:

- Women empowerment as key change agents.
- Community mobilization for self-reliant action.
- Fostering effective partnerships with local governments.

2.1.6 Clean Cooking Alliance

The Clean Cooking Alliance, in collaboration with a group of collaborators, is working to build a comprehensive industry that makes clean cooking accessible. According to the organization, three billion people worldwide depend on open fires and inefficient stoves to prepare their food. That directly impacts their health, climate, and the environment. Women and girls, who often spend long time cooking food and collecting fuel, are extremely affected. Therefore, achieving universal access to clean cooking solutions necessitates innovative technologies and business models (Clean Cooking Alliance, 2020).

Polluting, open fires, and inefficient stoves cause many harmful impacts that impede economic and social development and lead to significant life loss in developing countries. Cleaner, modern stoves and burning fuels have the potential to reduce deaths from smoke-related illnesses, slow down climate change, and decrease air pollution. They can provide new sources of livelihoods for women while reducing the risk and drudgery of fuel collection and lower household expenditures on cooking fuel, which could be spent to fulfill other needs (Clean Cooking Alliance, 2020). The Cleaning Cooking Alliance's work revolves around three core pillars: first, driving consumer demand for cleaner and more modern stoves by awareness-raising; second, mobilizing investment to build businesses capable of bringing inexpensive and high-value clean cooking products; and finally, promoting for effective policies that address the issue. Clean cooking transforms lives by providing healthier nutrition to affected individuals.

2.1.7 Action Against Hunger

Action Against Hunger is a global organization with more than 8000 field staff assisting more than 17 million people in almost 50 countries responding to emergencies caused by conflict, natural disasters, and food crises (*About Us | Action Against Hunger*, retrieved in 2020). With the slogan of:

> *"FOR FOOD. AGAINST HUNGER AND MALNUTRITION.*
> *FOR CLEAN WATER. AGAINST KILLER DISEASES.*
> *FOR FREEDOM FROM HUNGER. FOR EVERYONE. FOR GOOD."*

Action Against Hunger is working on life-saving issues such as nutrition and health, food security and livelihoods, water, sanitation and hygiene, and emergency response (*What We Do | Action Against Hunger*, retrieved in 2020).

Action Against Hunger aims to empower vulnerable communities to improve their access to food, income, and markets. The organization also has a research and innovation program that helps find better ways to deal with hunger and food insecurity worldwide. The research project aims to improve the impact, scalability, and sustainability of other organization programs.

2.1.8 Rise Against Hunger

Rise Against Hunger is a non-profit global organization striving to end hunger and bring food security by empowering communities, nurturing lives, and responding to emergencies, aligned with the United Nations Sustainable Goal #2 of Zero Hunger. The organization was initially named "Stop Hunger Now" in 1998, and later it was rebranded to become "Rise Against Hunger" in 2017 (*Who We Are | Rise Against Hunger*, retrieved in 2020). In total, more than 543 million meal packages have been delivered to people who need them in 78 countries around the world (*Global Impact | Rise Against Hunger*, retrieved in 2020).

The organization distributes millions of nutritious meal packages in different countries worldwide, produced by meal packaging volunteers. The whole program is evaluated and monitored by the organization to ensure that meals bring changes in the lives by promoting education, students' health, nutrition, fighting child labor, etc. Food is often the most immediate need in crises and emergencies. Rise Against Hunger is working with their partners in countries to address the need in response to the situations -be it human-made conflicts or natural disasters. The third way Rise Against Hunger is fighting food insecurity is to work in communities to train the farmers with improved agricultural methods and business skills and access quality seeds and fertilizers. In addition, they are supporting the production of fish and livestock. As a result, a pathway is provided to diverse diets and improve nutritional outcomes (Who We Are | Rise Against Hunger, retrieved in 2020).

2.1.9 SPOON

In the year 2007, SPOON was established. SPOON has a vision of a world where all kids are nourished and cherished. Since then, the organization has worked in the fields of nutrition, pediatric medicine, orphan supervision, epidemiology, nursing, disability, child growth, and public health with prominent professionals. SPOON’s work is based

on science and comes with strong evidence, results, and outcomes (Spoon Foundation, 2020).

The SPOON Foundation does NOT provide food aid but instead teaches others how to feed children safely and adequately using the organization's resources. Spoon gives them the tools and expertise needed to provide optimal care in low resource settings and train them to teach others, thereby cascading SPOON's impact to reach more children.

SPOON complements traditional nutrition programs through SPOON's package of assessment and intervention tools that address what and how children are fed. SPOON professionals have designed solutions to assist the crucial and exclusive nutrition and feeding requirements of children affected by disability and/or institutional care. Most of the core causes of malnutrition are addressed by these tools.

2.1.10 UNICEF

UNICEF is an international organization that is also a specialized agency of the United Nations working for children and adolescents in need worldwide. The organization is working in more than 190 countries to provide vaccines, support child health, nutrition, safe water, sanitation, etc. UNICEF is fighting for many children and their families' rights, seeking safe shelter, nutrition, protection from disasters and conflicts, and equality for more than the past seventy years (UNICEF, retrieved in 2020).

UNICEF focuses on child protection and inclusion by promoting policies and expanding services that protect all children. Child survival by helping the most vulnerable children to reduce child mortality, education by supporting quality learning for every girl and boy, social policy to reduce child poverty and its lifelong consequences, emergencies - reaching children with lifesaving aid and long-term assistance, gender equality by working to empower girls and women, innovation for children to accelerate the progress with innovative solutions, supply and logistics of lifesaving aids, research, and analysis about the situation of children (*What We Do* | UNICEF, retrieved in 2020).

Among many programs, UNICEF’s key component is nutrition. During famine and disaster situations, the organization is providing nutritious food in emergency feeding programs. UNICEF has established community clinics in rural areas around the world that offer newly young mothers nutrition education. One can undoubtedly say that

UNICEF is the biggest supplier and provider of food and help for malnourished children in the world.

2.1.11 Heifer International

Heifer International is a global non-profit organization headquartered in Little Rock, Arkansas. Since its establishment in 1944, it has been 75 years struggle by Heifer International working along with people on different projects in 21 countries to end hunger and poverty. Food security and nutrition at the top, risk mitigation and resilience, environmental sustainability, economic development, women empowerment, and social capital are the organization's primary work areas (*About Us | Heifer International*, retrieved in 2020). Heifer International operates in cooperation with its beneficiaries and executes plans to assist entrepreneurs. Heifer International provides local farmers with livestock such as chickens, goats, and cows and helps them with the provision of mentorship to build a local family business and gain access to market chains.

Heifer International provides low-income families and farmers with livestock, tools, and expertise and trains them to start a local business. By helping farmers earn a living income, Heifer is changing farmers' living situations, families, and communities. The organization has many projects, such as Hatching Hope, which helps farmers and communities in India, Mexico, and Kenya start a poultry farm in their backyards. Bihar, India, is a project focused on one of the poorest states located in India's northeast. Through this project, 4000 families have received three goats each to get their business started. Blue flames is another project focused on Senegal, which helps families produce biogas from the animal waste by constructing biodigesters devices with underground tanks that break down organic matter into biogas, primarily made up of methane gas, which is then used for cooking indoors in the connected kitchen ranges (*Flagship Projects | Heifer International*, retrieved in 2020).

2.1.12 Project Concern International

Founded in 1961, Project Concern International (PCI) is a global development organization. Project Concern International works in 13 countries in three continents, namely Africa, Asia, and America, including the United States. PCI’s programs reached over 21 million people worldwide last year. PCI merged with Global Communities – the global development and humanitarian assistance organization in April 2020. Hence, from

that date onward, the organization's name will be PCI, a Global Communities Partner. Together PCI and Global Communities will work for sustainable change in the lives of millions of people in over 35 countries (*About | PCI*, retrieved in 2020).

PCI implements the food security programs while identifying the primary causes of this issue to ensure sustainable solutions. Its work addresses food security pillars in its programs so that it can offer comprehensive, contextualized, and integrated interventions. The organization uses an integrated approach to prevent hunger and malnutrition through programming in climate-smart and nutrition-sensitive agriculture, livelihood security and strengthening access to markets, improving health, nutrition, hygiene practices, and integrated food for education programs. These approaches are driven by intense community engagement and ownership and a commitment to sustainability (*Food Security | PCI*, retrieved in 2020).

2.1.13 Penny Appeal USA

Penny Appeal USA is a non-profit relief and development organization working to alleviate poverty through sustainable programs. Since its establishment in 2009, Penny Appeal USA has been offering poverty relief in the United Kingdom, the Middle East, Asia, and Africa by providing water solutions, food distribution programs, orphan support, and providing food and medical aid in emergencies.

With the program Feed our World, the organization is addressing food insecurity and famine around the globe. Penny Appeal USA is utilizing donations for providing hot meals and food distribution for those in immediate need. And more sustainable long-term agricultural development programs to increase food security in over 30 countries (*Feed Our World | Appeals by Penny Appeal USA*, retrieved in 2020).

2.1.14 Feed the Children

Feed the Children, as a non-profit organization, was founded in the USA in 1979. It has been 40 years that Feed the Children provides food and assistance to help eradicate childhood hunger. The organization is distributing product donations of food and other items from corporate donors to local community partners. In the USA, they provide classroom support and school supplies to vulnerable students. They also offer aid recovery efforts when natural disasters strike. Besides, Feed the Children manages child-focused community development programs to reduce hunger and malnutrition, health and

promote self-reliance in 10 countries in Asia, Africa, Central and South Americas (*2020-Annual-Report | Feed the Children*, 2020).

Feed the Children operates with local communities and vulnerable children to improve their social, economic, cultural, and environmental conditions. The organization's goal is to enhance mothers' and children's security in food and nutrition by supplying them with the basic abilities to attain this. Feed the Children have 600 staff internationally who cooperates closely with other organizations and players to accomplish long-term sustainable changes. Through their programs in the United States and internationally, in the fiscal year 2020, Feed the Children distributed approximately 87.8 million pounds of food and essential items with a total value of more than $361 million, working with partners to benefit more than 7.3 million people globally (Feed the Children | *2020-Annual-Report*, 2020).

2.1.15 Food for the Hungry

Food for the Hungry is a Christian faith-based organization working in over 20 countries to end human poverty for almost five decades since 1971. The organization provides clean water and food, and other life-changing resources to communities in countries where they work (*About FH.Org*, retrieved in 2020).

2.1.16 CARITAS International

Caritas International is a catholic faith-based confederation of over 160 members working together in many countries, helping the poor, vulnerable, and excluded. The organization's headquarters is placed in Rome, while all national Caritas organizations are members of regional Caritas networks and the international confederation.

Amongst different issues related to poverty, Caritas advocates for the privilege of food, where everybody gets satisfactory and nutritious food. Caritas tends the lack food by working on the main drivers of hunger. Hence, it actively promotes rural development and agriculture and addresses climate changes to ensure that communities are less vulnerable. Caritas teaches communities the importance of eating well and growing the right food. Caritas distributes food during emergencies and provides supplementary feeding to the most susceptible (Caritas, 2020).

2.1.17 Seed Programs International

Seed Programs International is a global nonprofit, non-governmental humanitarian organization working to eradicate food insecurity in a very sustainable way. The organization provides quality seeds and expertise to impoverished communities in developing countries enabling poor people to grow their food. The organization has four main programs: Seeds Fight Hunger, Crisis Recovery, Livelihood, and Women's Empowerment.

SPI is run by folks with over 50 years of seed industry experience and more than two decades of vegetable research and production experience. The organization also has 15 years of experience operating programs that have successfully shipped seed to over 70 countries on five continents. SPI has shipped enough seed to plant over 1,000,000 vegetable gardens, providing more than 20 kinds of vegetables rich in vitamins and minerals often missing in people's diets (*https://seedprograms.org/*, retrieved in 2020).

2.2 FOOD SECURITY INDICATORS

Over past decades many indicators have been proposed to measure food security. Some focused on a specific problem related to food security such as percentage of undernourished children, the proportion of underweight children, etc. and some others were complex indices concentrate on the multiple dimensions of food security such as Global Food Security Index, Global Hunger Index, etc. (Santeramo, 2015)

Routinely having sufficient nutritious food to eat or food security is essential for people to flourish. In any case, food security is something a huge number of individuals battle with around the world—almost 11% of the worldwide population is battling with hunger. Most of these individuals live in developing, or potentially poverty struck nations where food security issues are at any rate 40% higher than developed countries, making food security and poverty indistinguishably connected.

Adequate food production, the capacity to acquire it, climate change, and conflicts, alongside a growing worldwide population, are among the numerous difficulties confronting families and communities who battle to put nutritious food on the table. These families and communities also sometimes earn enough to pay the rent from cultivating.

recently, we've seen a dramatic expansion in the number of people forced to leave their homes because of conflicts, which is a contributing cause of food insecurity.

Individuals additionally had their livelihoods pushed from an escalation of recurrent natural disastrous events like droughts and floods with a 50 % increase from the earlier decade. These repeating shocks frequently have extreme ramifications on numerous vulnerable people's food security and living conditions (PCI, retrieved in 2020).

Food security is measured differently by different organizations. The most frequently used measurement is probably The State of Food Security and Nutrition in the World, a collaborative work of FAO, IFAD, WFP, UNICEF, and WHO published annually on food security and nutrition status. Another frequently used source for food security and nutrition is Global Hunger Index (GHI), developed by International Food Policy Institute in collaboration with WeltHungerHilfe and Concern Worldwide. Besides, the Global Food Security Index (GFSI) is also a prominent and widely used indicator of food security. The Economist Intelligence Unit developed this index, which focuses on three core issues related to food affordability, availability, and quality and safety. The index covers 113 countries across developing and developed countries.

2.2.1 FAO: SOFI

Before 2015, the report only focused on cutting the hunger in half, and UNICEF and WHO were not added as authors. Since the start of SDGs and the importance of health and nutrition became more relevant to food and agriculture, the report's title changed from previously The State of Food Insecurity (SOFI) to The State of Food Security and Nutrition in the World. With the addition of WHO and UNICEF into the authors' list (*Haug R., 2018*).

The following eight indicators are employed in the State of Food Security and Nutrition in the World:

- Number of undernourished people in regional and country level
- Number of severely undernourished people
- Number of children affected by wasting
- Number of stunted children
- Number of children who are overweight
- Number of adults who are obese
- Number of women affected by anemia
- Number of children age 0-5 months exclusively breastfed

After using these indicators, FAO published the number of undernourished people worldwide to be 678.1 million people in 2018.

Table 2.1 Number of Undernourished People in the World (Millions)

	2018	**2019***	**2030****
World	678.1	687.8	841.4
Africa	236.8	250.3	433.2
Asia	385.3	381.1	329.2
Latin America & the Caribbean	46.6	47.7	66.9
Oceania	2.4	2.4	3.4
North America and Europe	n.r.	n.r.	n.r.
NOTES: * Projected values. ** The projections up to 2030 do not reflect the potential impact of the COVID-19 pandemic. n.r. = not reported, as the prevalence is less than 2.5 percent.			

Source: (*FAO et al.*, 2020)

Table 2.1 shows the number of undernourished people in the world and the continents shares of the total, published by FAO in The State of Food Security and Nutrition in the World report of 2020. The data is shown for 2018 and projected for 2019 and 2030. The number of undernourished people worldwide is projected to increase from 678.1 million people to 841.4 million people in 2030. Currently, the highest number of undernourished people exists in Asia, which is 385.3 million people, more than half of the total number in the world. But it is expected that Africa's situation will worsen by 2030. The number will almost double from 236.8 million to 433.2 million people, making half of the world's total undernourished people.

2.2.2 Global Hunger Index (GHI)

When it comes to hunger, especially child hunger and undernourishment Global Hunger Index is in the lead. IFPRI develops the Global Hunger Index in collaboration with WeltHungerHilfe and Concern Worldwide. The index employs four leading

indicators: undernourishment, child wasting, child stunting, and child mortality. (Klaus von et al., 2020).

- UNDERNOURISHMENT: the share of the population that is undernourished, reflecting insufficient caloric intake.
- CHILD WASTING: the share of children under the age of five who are wasted (low weight-for-height), reflecting acute undernutrition.
- CHILD STUNTING: the share of children under the age of five who are stunted (low height-for-age), reflecting chronic undernutrition.
- CHILD MORTALITY: the death rate of children who are under the age of five.

Based on the four indicators, the GHI scores vary from 0 to 100 for every country for which data is available.

Figure 2.1 Global Hunger Index Severity Scale

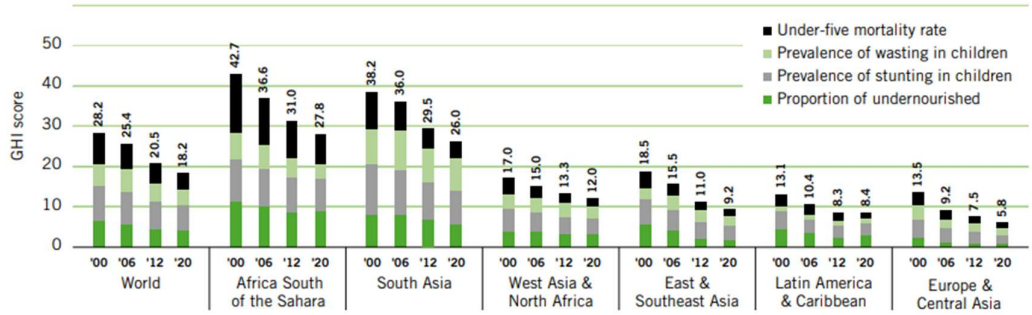
Source: (Klaus von et al., 2020)

Figure 2.1 shows the severity levels of the calculated scores. Scores equal to or less than 9.9 are considered as low severity or that the nation is relatively food secure. Scores equal to or more than 50 are an extremely alarming situation that needs urgent solutions. From around the globe, 132 countries were assessed to be included in the index. However, due to some indicators' insufficient data, only 107 countries could be ranked in the 2020 GHI report (Klaus von et al., 2020, p. 9). In the 2020 GHI report, 17 countries, namely Belarus, Bosnia & Herzegovina, Brazil, Chile, China, Costa Rica, Croatia, Cuba, Estonia, Kuwait, Latvia, Lithuania, Montenegro, Romania, Turkey, Ukraine, and Uruguay, have less than five scores. Which makes them all ranked top collectively from the first position to the seventeenth position. They are listed based on alphabetical order because the scores are equal. 107th country in the ranking order is Chad having 44.7 scores which are considered an alarming level of hunger (Klaus von et al., 2020, p. 9).

Figure 2.2 shows global and regional 2000, 2006, 2012, and 2020 Global Hunger Index scores for the 2000, 2006, 2012, and 2020 years, with the share of each indicators. The graph clearly shows improvement in global hunger by ten score points from 28.2 in 2000 to 18.2 in 2020 in the past two decades. According to the regional data on the bars

in Figure 2.2, the most severe scores are related to South of Saharan Africa, 27.8, which puts the region in the serious severity level. Before 2006 both Africa, South of the Sahara, and South Asia were in the alarming severity level. Still, in the two recent reference years, 2012 and 2020, both regions have improved by almost ten score points.

Figure 2.2 GHI Global and Regional Scores



Source: (Klaus von et al., 2020)

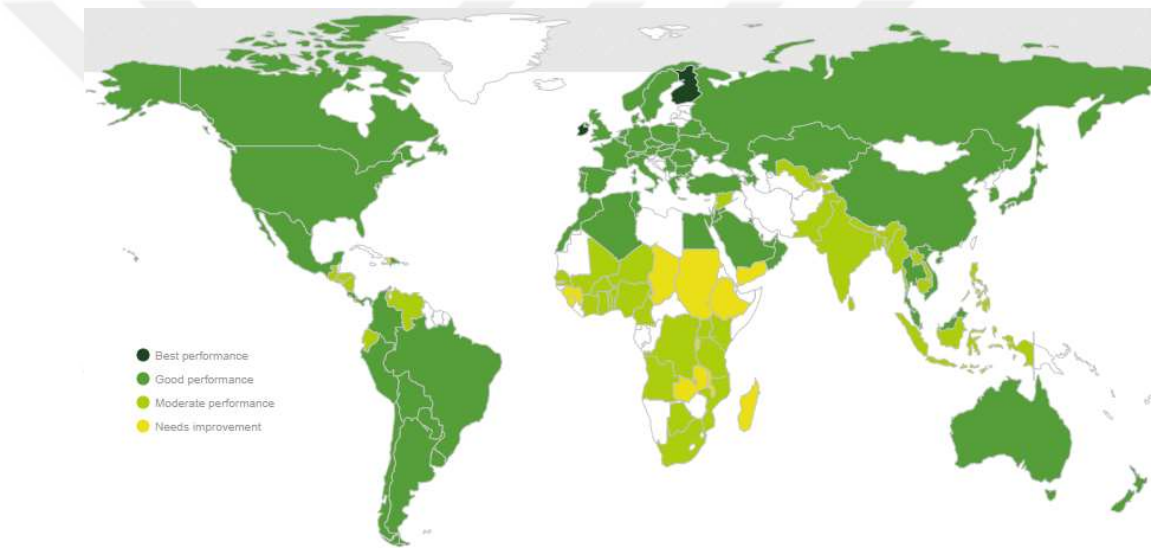
2.2.3 Global Food Security Index (GFSI)

The new 2020 version of the index has just released on the 23rd of February 2021. The Global Food Security Index is developed by the Economist Intelligence Unit (EIU) and supported by Corteva Agriscience. The index employs different qualitative and quantitative indicators to measure food security in 113 countries from around the world. The index was first introduced in 2012, and it has been evolved a lot since its first version. The methodology has changed, and some indicators were given more importance, and some new variables were introduced into the index, which changes its scores from its previous predecessors. As a result, the scores and rankings published in this version are not directly comparable to scores and rankings published in the earlier versions. However, it is essential to mention that data for the last eight years have also been converted for comparative reasons using the new methodology and published along with the latest data.

The recent version is based on four main categories, namely: Affordability, Availability, Quality and Safety, and Natural Resources and Resilience. Natural Resources and Resilience's core issue is now, for the first time, added as a core category to the index. This category evaluates each countries exposure to climate change, its vulnerability to natural disasters, and how each country is adapting to these changes and risks, all of which affect food security. This category was first introduced in 2017 as an adjusting factor. Still, as the issue's importance grows and its impact on food security got

riskier, it has been included as a core issue or main assessing category for the first time this year. This year's index is based on a model constructed from 59 qualitative and quantitative indicators measuring food security and its drivers across 113 developing and developed countries. These 113 countries cover five regions, namely: Asia Pacific, Europe, Latin America, the Middle East, and Africa, and North America. Like in the previous versions, this time, along with the global report, individual reports focused on each region have also been published, providing more insight into region-specific food security performance in the 2020 GFSI index (The Economist Intelligence Unit, 2021).

Figure 2.3 World Countries Performance in the GFSI 2020



Source: (*Global Food Security Index (GFSI)*, retrieved on 2021)

The Global Food Security Index 2020 report highlights that overall food security was continuously improving from 2012 till 2018. The global food environment showed deterioration in 2019, followed by a second marginal decline in 2020. The Covid19 Pandemic reveals the vulnerabilities and flaws in the global food system, which may not be identified easily in the time of peace, economic prosperity, and political stability. The GFSI identifies these vulnerabilities and highlights where changes and policies are needed to reduce the risk of acute food insecurity in crisis times. The GFSI 2020 provides new data and insights on armed conflicts, gender inequalities, and inequality-adjusted income, in addition to other food insecurity factors.

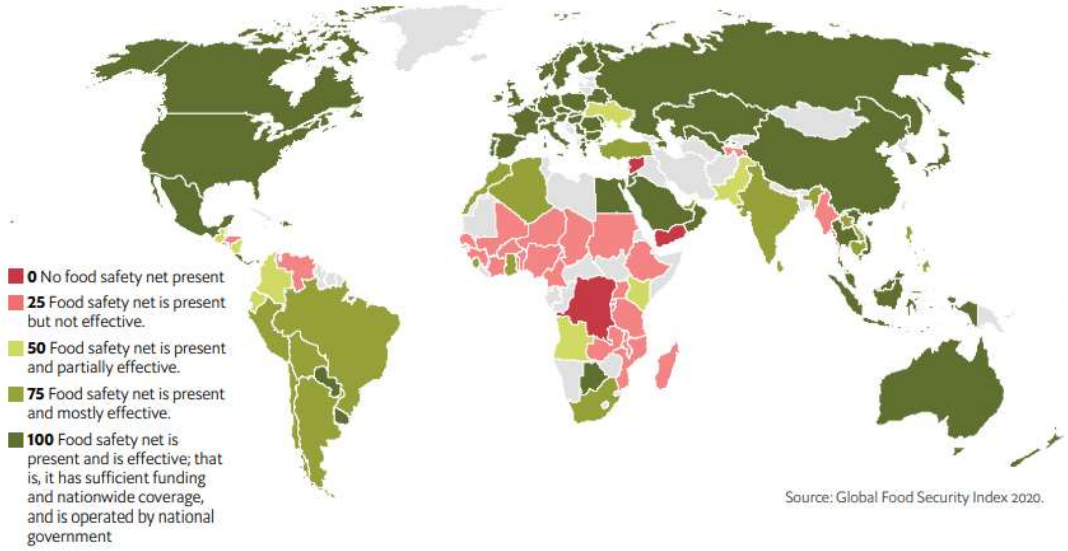
2.2.3.1 Key Findings of the GFSI 2020

The new report published by The Economist Intelligence Unit presents twelve critical findings from the Global Food Security Index 2020:

i. China, Myanmar, and Indonesia, along with Ghana, have made the most remarkable progress in reducing poverty since 2012. On the other hand, globally, twenty countries had an increase in poverty rates which could further be accelerated with the Pandemic of Covid19, likely reversing the gains made to reduce it in the past two decades.

ii. The GFSI 2020 also employs inequality-adjusted income levels, which can help cope with unexpected economic and income shocks that can drive food security if improved by raising income with less inequality. Some South American countries such as Bolivia, Panama, and Peru have made significant improvements since 2012.

Figure 2.4 Food Safety Nets Across the World



Source: (The Economist Intelligence Unit, 2021)

iii. Food safety nets and their practical implementation can save vulnerable people. Only three countries Democratic Republic of Congo, Syria, and Yemen, are the only three countries among the 113 GFSI, including countries that unfortunately do not have any food safety net. According to the report, 47 countries lack sufficient funding resources, and 36 countries lack national coverage for the food safety nets. Figure 2.4

shows a world map of the countries which has food safety nets in place and those that don't have food safety nets in place. The different colors show the effectiveness of those safety nets.

iv. Mobile banking and access to food market data have been improved in 63 countries out of 113. Asia and Sub-Saharan Africa show the most progress in this area. Governments can use mobile technology to provide targeted agricultural advice/information and financial services to smallholder farmers.

v. The GFSI 2020 has included gender inequality measures for the first time and finds some disparities in health, education, political representation, and labor-market opportunities. Since 2012 almost 90% of the countries have made improvements. Still, significant gaps remain to be filled with further efforts and sound policies.

vi. From the 113 countries in the GFSI 2020, only 54 countries have a national food security strategy. Prioritizing food security agenda is needed in every country. However, eighty-two out of 113 countries lack a dedicated food security agency that can help design, prioritize and implement such strategies.

vii. Many countries are implementing measures to ensure access to essential micronutrients. Bangladesh, Indonesia, El Salvador, and Kenya are shaping food supply chains. So, that farmers produce highly profitable food items with having high levels of micronutrients. Thus, addressing the nutritional needs of the population. Addressing national nutritional gaps by shaping the food value chain can be made by governments.

viii. By measuring the Natural Resources and Resilience category for the first time, the GFSI 2020 found out that rising temperatures, climate change, and rain shortages are causing crop failures and land degradation. Climate change and its resulting events are already disrupting agriculture, desertification, and land degradation are happening, and it is interrupting the planting season in many countries.

ix. In 49 countries out of 113, agricultural products have become more vulnerable than the previous year due to climate change, droughts, and extreme summers.

x. Food import dependency has been increased in sixty-seven countries since 2012. High-income countries such as Singapore, Bahrain, Qatar, UAE, and Kuwait are the most import-dependent countries. These countries are using various techniques to boost their domestic food productions, such as hydroponics, aquaponics, vertical farming, and diversifying their food suppliers. Sixteen countries out of 113, the majority from Sub-Saharan Africa, have lowered their food import dependency rate.

xi. Agricultural water contamination and flooding are threatening developing countries. Niger, Chad, India, South Korea, Bangladesh, and China face extreme flooding risks. China is adapting by heavily investing in water conservancy projects. Israel utilizes artificial intelligence, machine learning, and smart meters to minimize water waste and treat the wastewater for agriculture use.

xii. Preparation for the impending environmental risks can be achieved via policy commitment to adaptation, technological innovation, and agricultural R&D. Majority of the European countries have deployed early warning measures. Some countries, for the first time, have started climate change adaptation strategies. In Africa, two million farmers grow drought-tolerant maize as a part of the Drought Tolerant Maize for Africa initiative.

In conclusion, the GFSI 2020 by (The Economist Intelligence Unit, 2021) suggests that the stakeholders are required to maintain and quicken the progress of adopting new techniques, innovations, and policies that will widen access to nutritious food within tightening ecological limits. Efficient policies, innovations, and agricultural R&D are required both from the governments and the private sector globally.

2.3 MACROECONOMIC INDICATORS AND FOOD SECURITY

Macroeconomics studies economics at a country or regional level. Economists, organizations, and governments worldwide collect data on economic activities such as prices, incomes, unemployment, and many other variables over different periods of time from many sectors. They then formulate general theories that facilitate explaining these

data. Macroeconomic topics are at the core of world politics. That is why world leaders and governments then take the knowledge and use it to clarify economic incidents and plan economic policies for their countries.

Macroeconomic variables are the indicators of a country's economic status. Using these variables, economists can measure how a country is performing economically. Governments across the globe use macroeconomic variables to make policies and strategies to stabilize and grow the economy as a whole. The most important macroeconomic variables discussed in this chapter and used in the analysis of this thesis are GDP per capita, interest rate, inflation (CPI), exchange rate, unemployment, and trade.

Food security, like other main development economics topics, is a macro-level issue that has to be addressed and studied at a regional and country level. If a country's economy is doing its best, it means they have the potential to eliminate food insecurity and works towards nutritional, sustainable food security for its nationals. Food security is highly dependent on macroeconomic variables. Some of these variables will impact the supply side more, and some will impact the demand side of food more from different perspectives. Such as GDP per Capita, CPI and Employment impact the demand side of food security more directly as it gives people the ability to acquire food. And the food imports, food production, interest rates have a more supply-side perspective.

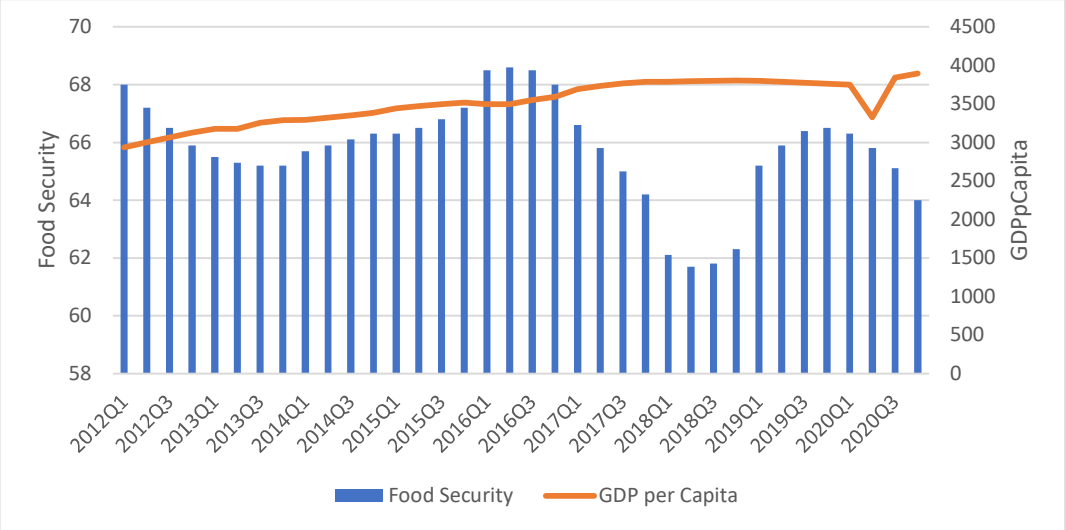
2.3.1 GDP per Capita

GDP that is the abbreviation of Gross Domestic Product is a country's income for a given period. It is calculated by adding the dollar value of all the goods and services produced in a specific period -quarterly, inside a country's boundaries. GDP per capita is computed by dividing GDP over population. The importance is given to GDP per capita in this thesis because it shows the population's ability to enjoy a standard quality of life. A countries high GDP per capita will mean that the government is rich and people living in that country have higher incomes. And with good-paying jobs, there will be a high standard of living where people will be having access to good quality healthy and nutritional food alongside adequate sanitation, healthcare, enough housing, and so on. GDP per capita indicates that the wages are high or low in a specific country.

Error! Not a valid bookmark self-reference. shows Turkey's food security and GDP per capita data from the 2012 first quarter till the 4th quarter of 2020. The blue

bars represent food security data shown on the left axis, and the orange line represents the GDP per capita data trend shown on the left axis.

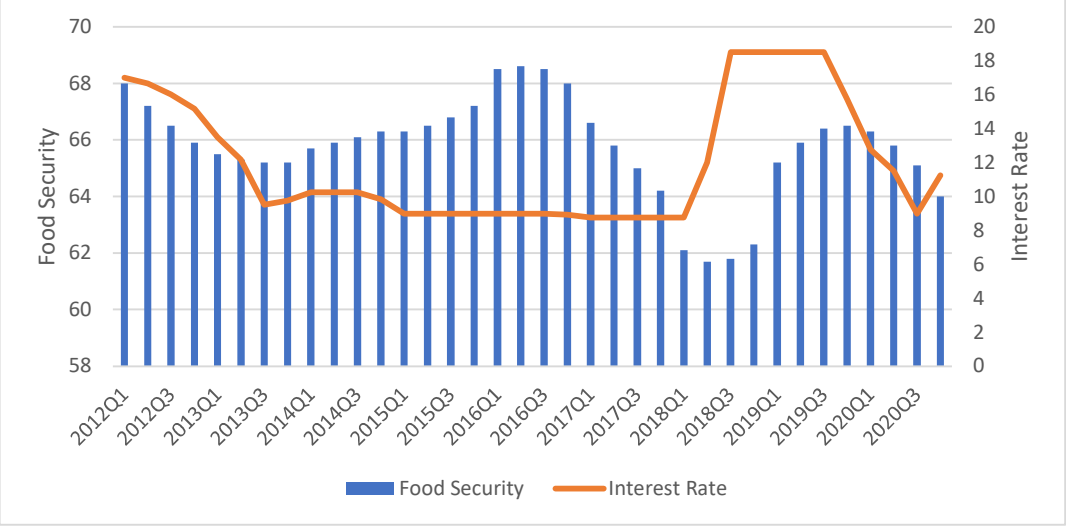
Figure 2.5 Food Security and GDP per Capita



Source: GDP per capita data is retrieved from **(FRED, 2021)**, food security data is obtained from **(The Economist Intelligence Unit, 2020)** and plotted by the author.

2.3.2 Interest Rate

Figure 2.6 Food Security and Interest Rate



Source: Interest rate data is retrieved from **(FRED, 2021)**, food security data is obtained from **(The Economist Intelligence Unit, 2020)** and plotted by the author.

Interest is a sum of money taken by a lender from a borrower against a sum of money lent for a specific period at a specific rate. The rate at which money is borrowed is called the interest rate. Interest rate is a backbone of the conventional banking system,

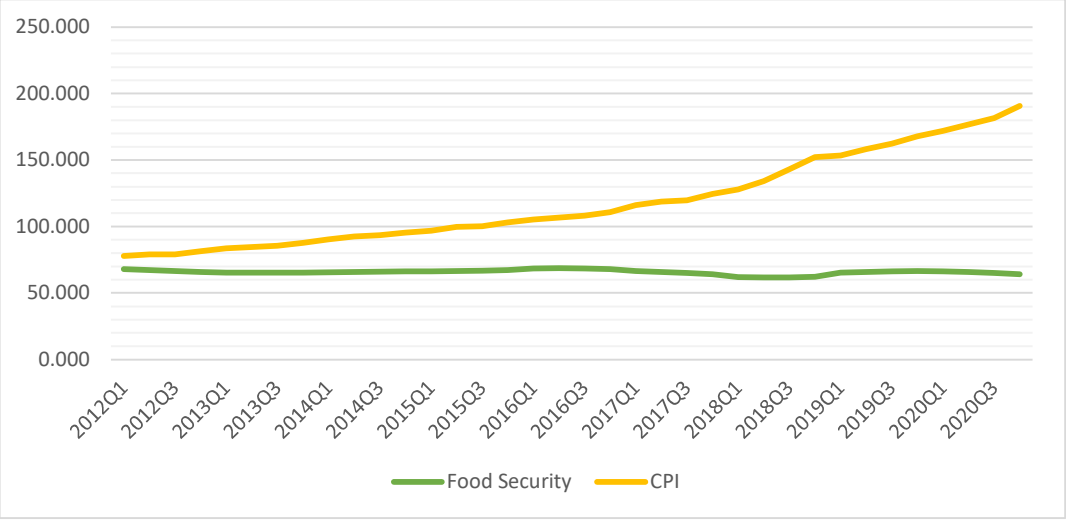
which eventually affects every side of the economy. A higher interest rate means higher savings, and a lower interest rate means more increased investment. Theoretically lower interest rate is better for food security because there will be an increase in the investment, leading to incomes and wealth generation by which people can buy food, especially if the investment is in the food industry.

Figure 2.6 shows food security and interest rate data from 2012 quarter one till 2020 quarter four. The blue bars represent food security data presented on the left axis, and the orange line represents the interest rate presented on the right axis. Both the blue bars and the orange line shows clear variations in the data over time.

2.3.3 Inflation Rate (CPI)

Inflation is the high rate of prices in a country. It is technically the price comparison with the previous year. Inflation can be calculated in many ways, but the most common ones are CPI (Consumer Price Index) and GDP Deflator. GDP deflator calculates the prices of everything counted in GDP calculation means all the goods and services produced inside the country borders. And CPI is calculated by the prices of goods that an average consumer typically purchases, called a basket. Keeping food security in mind, this thesis will employ CPI because it is more relevant. CPI counts the value of all the necessary food items bought by an average consumer. It also considers the imported food items, which will not be calculated in the GDP Deflator.

Figure 2.7 Food Security and CPI



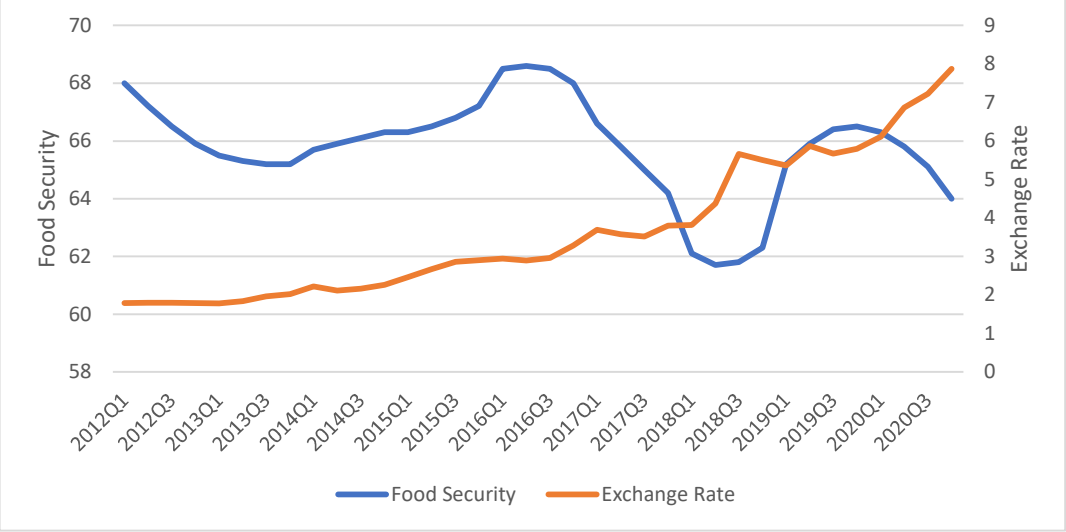
Source: CPI data is retrieved from **(FRED, 2021)**, food security data is obtained from **(The Economist Intelligence Unit, 2020)** and plotted by the author.

Figure 2.7 shows consumer price index and food security data trends from the first quarter of 2012 till the fourth quarter of 2020. The green line shows the food security data trend, and the yellow line represents the CPI data trend. The CPI data is in reference to 2015, which means that the index value for 2015 is 100. The trend in the yellow line clearly shows that the data have been rising since 2012. The rise is so significant that the line has increased more than two times from 2012.

2.3.4 Exchange Rate

The worth of local currency against foreign currency is called the exchange rate. It is the rate at which people buy other currencies or sell their currencies. The exchange rate is critical in the open economy model, where trade plays an important role. Exchange rates affect the import/ export ratio positively. A high exchange rate means a cheap currency, which will increase the export and of that country, but it will decrease the foreign investment because the return will be affordable, which is less beneficial. A low exchange rate will pull the cash inflow in by foreign investments, but it will start a cash outflow by increasing imports with a relatively worthy currency. That eventually may significantly impact food security, which will be analyzed in the last chapter.

Figure 2.8 Exchange Rate (USD/TL) and Food Security



Source: Exchange rate (USD/TL) data is retrieved from **(FRED, 2021)**, food security data is obtained from **(The Economist Intelligence Unit, 2020)**, and plotted by the author.

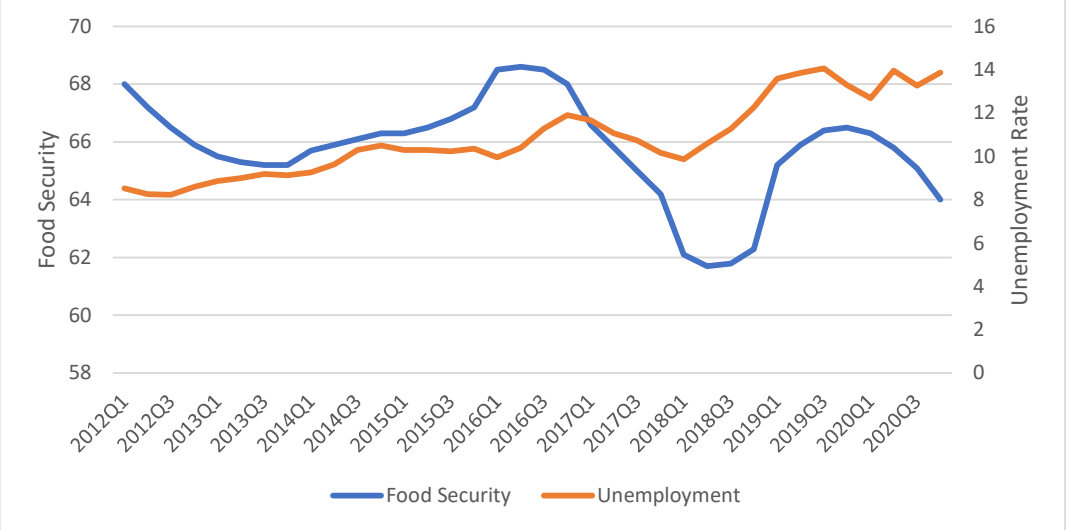
In Figure 2.8, we see two lines; the blue line represents food security data from the left axis, and the orange line represents the exchange rate data from the right axis. The

data is Turkey's quarterly data from the first quarter of 2012 till the fourth quarter of 2020. The orange line indicates that the Turkish Lira is losing its value against US Dollars overtime in the previous decade. The exchange rate has quadrupled in the past eight or nine years.

2.3.5 Unemployment Rate

Unemployed are those people who are looking for jobs but are unable to find one. The unemployment rate is the percentage of that part of the workforce who are unemployed. This means that there are people who can participate in the economy; however, they are not utilized, and they require income for a good healthy life but are not given a chance. Economists say there will always be a small percentage of unemployment, but it should not be high. A high unemployment rate damages a government and an economic system in every possible way. It is a massive cause of food insecurity in developing countries. Although people are actively looking for good-paying decent jobs, they can't find them, making it hard for them to acquire the necessities of life with no income.

Figure 2.9 Food Security and Unemployment Rate



Source: Unemployment rate data is retrieved from **(FRED, 2021)**, food security data is obtained from **(The Economist Intelligence Unit, 2020)** and plotted by the author.

Figure 2.9 shows data on Turkey's food security and unemployment rate from the 2012 first quarter till 2020 fourth quarter. The blue line shows food security data from the left axis, and the orange line shows unemployment rate data from the right axis. The

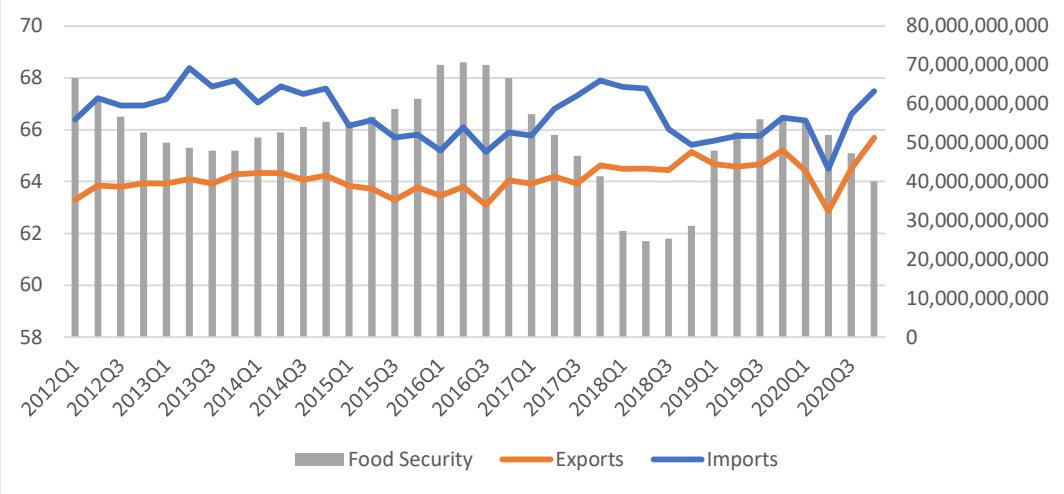
orange line indicates that the unemployment rate in Turkey is gradually increasing overtime during the past decade.

2.3.6 Trade

Currently, our world is called the global village. This is the era of globalization. Most of the economies boost their economy by increasing trade, especially the export sector. Netherland is a small country, but it is top in the export of vegetables and fruits, a significant food industry component. Foreign trade is a significant factor in ensuring the food supply. The blocking of free trade and Tariffs on agricultural imports are negatively affecting food security and lower consumer welfare.

For the purpose of analysis, the export and import quarterly data of Turkey will be used to see each one's effect on food security.

Figure 2.10 Turkey's Trade and Food Security Trends



Source: Trade data is retrieved from **(FRED, 2021)**, food security data is obtained from **(The Economist Intelligence Unit, 2020)** and plotted by the author.

Figure 2.10 shows trade and food security quarterly data for Turkey from 2012 first quarter till 2020 fourth quarter. The grey bars represent food security data from the left axis, and the orange and blue lines present trade dates from the right axis. The orange line shows export goods value in USD, and the blue line shows imported goods value in USD for Turkey. The blue is higher than the orange line that means Turkey's imports are higher than their exports. Hence, the balance of trade (BoT) of Turkey is negative.

2.4 TURKEY AS A CASE STUDY

Turkey was chosen as a case study for this thesis for various reasons. Among it is the strategic location of Turkey, which makes Turkey the linking bridge between Asia and Europe. The models developed for Turkey, in a sense, could be applied to both European countries and also to the countries in Asia or particularly the middle eastern countries. Another reason for choosing Turkey is that socially, economically, and politically Turkey has experienced various changes during the past decades. Some transformations were for the betterment, and some were deteriorating from different perspectives. Politically, over the past decade, Turkey has experienced many fluctuations. Such as the 2016 failed coup attempt, the Syrian war, other wars in the region, political instabilities in the region, and its relationship with other political superpowers also had some ups and downs. Economically, Turkey was affected by the 2012 economic crisis. The exchange rate of US Dollars to Turkish Lira is constantly increasing over the past decade, from around 1.4 in 2010 to 8.4 in 2020, which means that the Turkish Lira has lost a lot of its value. The inflation rate has doubled since 2016. The unemployment rate raised and the global climate changes are also affecting Turkey heavily. Above all of these challenges, 2020 COVID 19 hits the world, and Turkey is among the twenty most affected countries in the world. All of these major challenges and some opportunities faced by Turkey have threatened the sustainability of its food security.

2.4.1 Turkey: Country Profile

The Republic of Turkey is an emerging country located between two continents Asia and Europe. With a growing, young, and dynamic population, Turkey is among the twenty largest economies in the world. This middle-income country is located in a very strategic geographical location. Regionally Turkey is located in the middle east at the top of the Arabian Peninsula.

Figure 2.11 shows Turkey map in the off-white color written with its ancient historical name Anatolia. Ankara being the capital, Istanbul is a prominent city in Turkey. Historically, culturally and economically, Istanbul is one of the most important cities in the world. The Mediterranean Sea at its southwest, the Aegean Sea at its west, the Black Sea at its north, and the vast lands and rivers inside the country make it suitable for the production of various food products.

Figure 2.11 Turkey Map

Source: (CIA, 2021)

Turkey's population in 2020 was 83.6 million persons, have a total of 683,562 square kilometers of an area of which 769,632 square kilometers is located inland, and 13,930 square kilometers is located in waters, creating a 7,200 km long coastline (CIA, 2021). Table 2.2 contains data on some key macroeconomic variables of Turkey in 2019. The data is retrieved from the World Bank's World Development Indicators' Data Bank. Turkey's GDP in 2019 was 761 billion USD with a growth rate of 0.92%. Turkey had more than 83 million population whose per capita GDP in 2019 was 9,126 USD.

Table 2.2 Data on some Key Macroeconomic Variables of Turkey

Series Name	2019
GDP (current US$)	$ 761,425,499,358.16
GDP growth (annual %)	0.92%
GDP per capita (current US$)	$ 9,126.56
GDP per capita growth (annual %)	-0.43%
GDP per capita, PPP (current international $)	$ 28,133.09
Population, total	83,429,615
Consumer price index (2010 = 100)	234.44
Inflation, consumer prices (annual %)	15.18%
Inflation, GDP deflator (annual %)	13.91%
Exports of goods and services (current US$)	$ 249,301,402,127.95
Imports of goods and services (current US$)	$ 227,981,906,103.20
Unemployment, total (% of total labor force) (national estimate)	13.67%

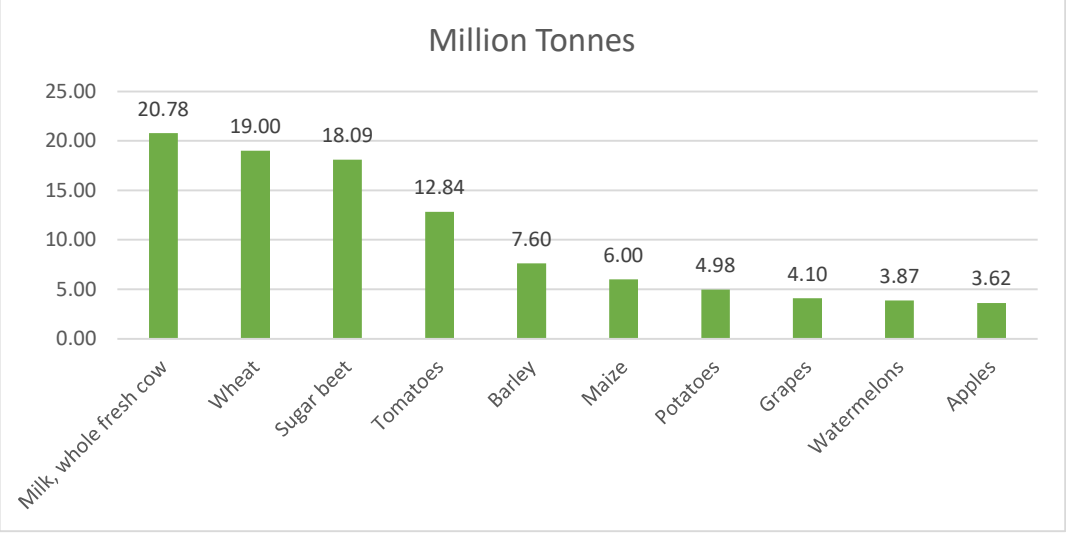
Source: (World Bank, 2019)

2.4.2 Food Security and Nutrition Status of Turkey

Turkey is the seventh-largest producer of agricultural products in the world (Giray, 2012). Figure 2.12 shows the top ten agriculturally produced commodities of Turkey. The data is from the year 2019 in a million tonnes. Fresh cow milk and its products are the highest-produced commodities in Turkey. Wheat is a staple food in Turkey, and bread is a must-have complementary food on every sofra (dining table) in Turkey (G. Pekcan, 2006). Wheat takes the second position on the bar chart, and it ranks first in the grain category. A total of 19 million tonnes of wheat were produced in 2019 in Turkey.

The consumption of quality and safe food for the continuation of growing up and development of a healthy life is Nutrition. Nutritious and safe food is important for every aspect of the socioeconomic development of a society or a country. Other factors ceteris paribus, with enough nutritious and safe food the labor force can be healthy, with less chronic diseases and high productivity in every sector. Nutrition is best in balance. Experts in high-income countries like the US are battling with nourishments, and in poor countries, they are battling with a low level of nutrition. However, in middle-income countries like Turkey, some people take insufficient nutrients in their diets, and some have excessive due to the imbalance in the income distribution (Akbay, 2018).

Figure 2.12 Agricultural Production Commodities of Turkey

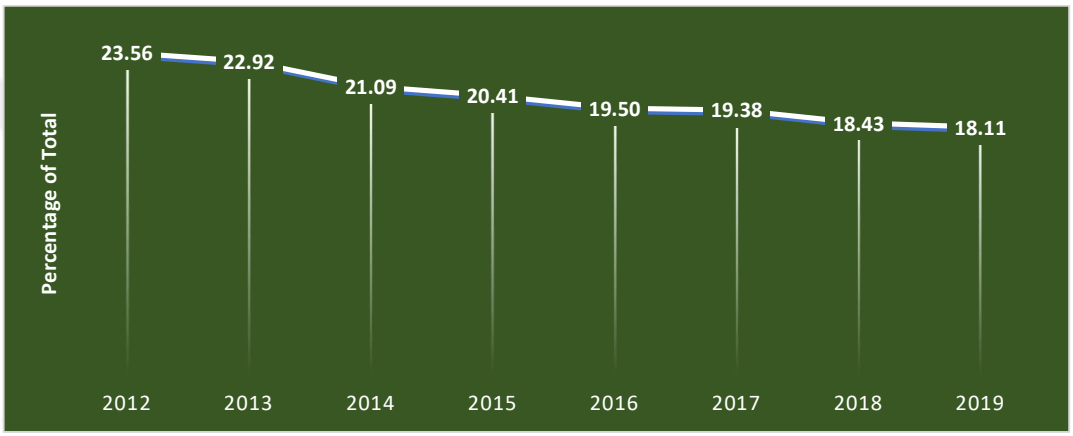


Source: (FAO, 2020a)

The agriculture sector employs a big chunk of Turkey's population. Figure 2.13 shows the percentage total labor force employed in the agricultural sector. In the year

2019, 18.11% of the total population is working in agriculture. The graph shows a decline in the percentage of employment. This downward slope could be the result of the labor force shift from agriculture to other sectors (Gürsoy, 2020). The old farmers living in the rural areas are getting older, and the young population tends toward other sectors for careers and professions. Less young people choose to be farmers. Urbanization and industrialization are also contributing to the decline of the share of agriculture in total employment.

Figure 2.13 Percentage of Total Employment in Agriculture



Source: (World Bank, 2019)

The income dispersion and the living area condition being rural and urban significantly affect the choices or options for the nutritional intakes of people. Households in urban areas with high income will tend towards fat and protein-based diets with the lack of minerals and vitamins. And people in the rural areas will have more minerals and vitamins but fewer animal proteins in their diets. There is a growing tendency, especially among the young generations, for the fast-food habits, which will affect the nutrition problems even worse than they already are. And it is inevitable that these nutrition habits will also lead to heart and vessel diseases (Akbay, 2018).

The effects of climate change will cause significant changes in the unemployment ratio. Consequently, the economy of Turkey would be negatively affected, and food security would be threatened.

Food Availability:

- With the use of fertile land for purposes other than agriculture, erosion, and pollution caused by industrialization. Shrinks the agricultural land.

Between 1988 and 2015, the agricultural area is decreased by 7.5%, and the cultivated area has decreased by 16%.

- Small farmers cannot afford new and technologically advanced agricultural equipment to increase their productivity, which is a big challenge to the future.
- The labor force shift between the sectors is negatively affecting the food sector in Turkey as more and more people leave the agricultural sector for other sectors. The employment percentage of agriculture in Turkey is declining annually.
- Food trade is important for ensuring the food supply. The blocking of free trade and Tariffs on agricultural imports are negatively affecting food security and lower consumer welfare.

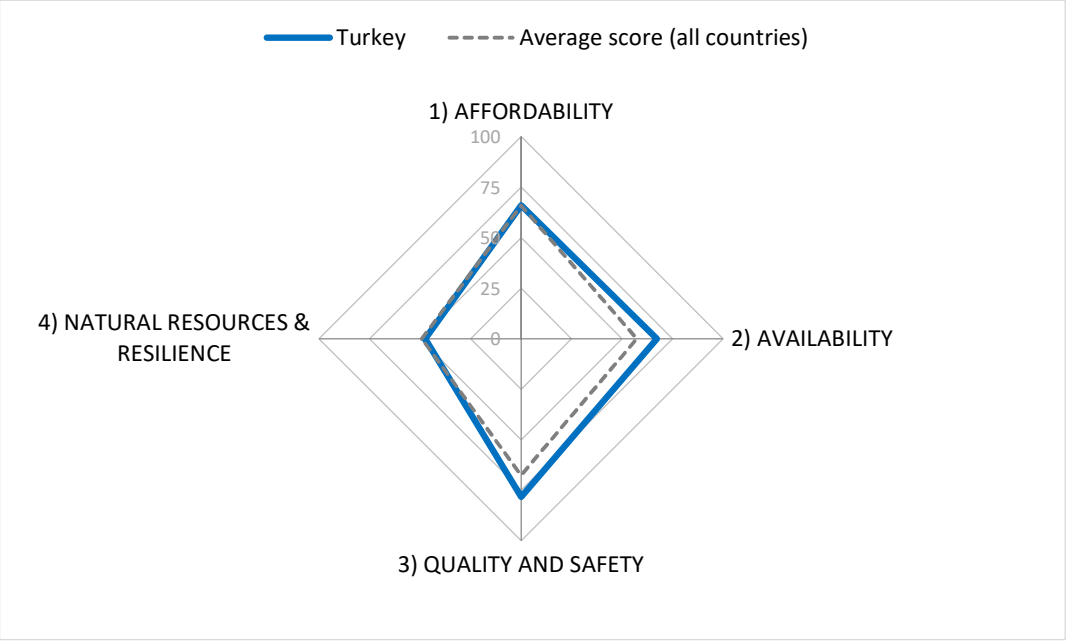
Sub-Regional Office of FAO was established in 2007 in Ankara.

The second phase of the FAO-Turkey Partnership Program (2015–2019), with a US$10 million budget, will focus on food security and nutrition, agricultural and rural development, the protection and management of natural resources, agricultural policies, and food safety.2 The 30th FAO Regional Conference held in Turkey highlighted the importance of Turkey's partnership with the FAO for extending technical expertise and better assisting neighboring countries. This partnership would also help Turkey assist Syrian refugees both in local communities and camps as part of its humanitarian work. In addition to these initiatives, after the Paris Agreement of 2015, the FAO stated that it would kick off projects and household surveys in Turkey and the region to ensure food security and agricultural sustainability by addressing climate change (Gürsoy, 2020).

The Global Food Security Index developed by the Intelligence Unit of The Economist is publishing food security development data. The index was developed in 2012, and since then, it is publishing data from 113 countries from around the world. The index is made of four main categories based on which the overall scores are calculated. **Error! Not a valid bookmark self-reference.** shows the radar chart of the GFSI's four core issues scores of Turkey in 2020. The blue line represents Turkey's scores, and the grey dashed line represents the world's average scores for comparison. The chart shows that the quality and safety category has the highest scores, and natural resources & resilience had the lowest scores for Turkey in 2020. In the second and third categories,

Turkey is doing better, and the scores are above the world average. The first category is almost equal to the world average. However, the fourth category needs a lot of improvements. The lowest scores are taken in the natural resources and resilience category. Turkey has an overall of 65.3 scores in the GFSI 2020.

Figure 2.14 Turkey's data in the GFSI 2020



Source: (The Economist Intelligence Unit, 2021)

2.4.3 Food and Nutrition Policies of Turkey

Food security, nutrition, and food safety policies are made, changed, and improved over time in Turkey. Force of Law No: 560, concerning the production, consumption, and inspection of foodstuffs, was enacted in 1995. The law, in particular, was involved with the provisions of hygienic and technological production, processing, preservation, and storage of food. In June 2004, the "Food Law" was enacted for the first time in Turkey (Gürsoy, 2020). The following institutions were established after the food law in 2004:

- Establishment of National Food Codex Commission
- Establishment Risk Analysis
- The Formation of Scientific Committees
- The Establishment of a National Food Assembly
- Establishment of Food Banks

- Crises Management and Traceability

11th Development Plan of the Republic of Turkey was announced in 2019, aiming for the year 2023. The agricultural policy of the plan is to develop an efficient agricultural sector. An agricultural sector that is sustainable economically and environmentally. Advance technology usage is a priority over competing with international competitors and providing an adequate and balanced food supply. A number of policies, measures, and targets are set to achieve them by 2023. Such as the increase in oilseeds and red meat production (Presidency of Strategy and Badget Turkey, 2019). Following are some of the policies directly relating to food security, food safety, food sustainability:

- An accurate and reliable data collection, monitoring, and evaluation activities will be institutionalized.
- Agricultural subsidies and their impact will be increased.
- Efficient use and protection of arable lands will be ensured.
- Effective investments will be maintained and prioritized for the expansion of irrigated areas. Efforts will be made for water preservation and its efficient use.
- Plantation and plant production of various reliable species will be increased.
- Measures will be taken to develop livestock farming.
- The aquaculture sector will improve to increase its production and exports.
- Food safety measures will be enacted. Efficiency and inspection will be increased.
- Market regulations will improve to ensure food safety and food loss.
- To ensure sustainability and biodiversity, local breeds and seeds will be preserved.

Currently, in the Republic of Turkey, alongside Agricultural Credit Cooperatives (ACC), T.C. Ziraat Bank is also providing concessional loans to agricultural enterprises, businesses, and farmers. In 2015, Turkey introduced the Action Plan for the Program on Enhancing Efficiency of Water Use in Agriculture. The plan aims to preserve the underground water and enhance the use of water-saving techniques and technologies. In 2019 another joint plan was prepared in collaboration with the FAO. This was a part of

the “Save Food” global initiative campaign in line with the SDG 12.3. This action plan was to prevent, reduce, and manage food losses and wastes (OECD, 2020).

2.5 LITERATURE REVIEW

This research analyzes the effects of macroeconomic variables on food security in Turkey. The researcher conducted a thorough literature review using online research tools and databases. The already existing research on the subjects of food, food security, sustainable food security, food security and Turkey, food security and macroeconomics, food economics, and food security, and Turkey's macroeconomic variables are reviewed. The literature on food security has been started before the 1970s. A huge amount of research is done in this area. And this research area is gaining significance at a very fast pace. Following are some of the research papers covering the subject at a macro level.

(Headey, 2013) has analyzed an aggregate sample of 198 observations of malnutrition from various regions worldwide. This research paper is studying the nutrition changes from developmental factors perspective inside countries. Results of their analysis indicate that economic growth strongly predicts the nutritional performance in a country. Only in more food-insecure nations, food production growth is a strong predictor of nutritional performance. The study finds no evidence of the direct importance of infrastructure. Greater asset ownership, high rates of female secondary education, improved access to health services, and low fertility rates are all pretty strong predictors of improvement in nutrition.

The Development Strategy and Governance Division of International Food Policy and Research Institute has published a research paper by (Ecker & Breisinger, 2012). The research paper tries to provide a policy framework that will lead the promising pathways for attaining food security and enhanced nutrition. This research paper studies the effects of external shocks on food availability, access to food, and the nutritional status of people affected by those shocks.

This is a chapter of the International Agricultural Development book published by Johns Hopkins University Press. A book chapter written by (Timmer, 1998) on key macroeconomic variables that determines the pace of economic growth and the mechanisms by which they also influence the food and agricultural sector. The book, in general, including this chapter as a development studies subject, focuses the topics on the

context of developing countries. The food price dilemma - generalized as the macro price dilemma, confronted by the poor societies is discussed in the chapter. This dilemma is that low prices increase the ability of poor consumers to acquire food. However, its high food prices raise the productivity and household income of the farmers. This study also discusses the significant positive role of agriculture in the growth of an entire economy of developing countries.

(Block et al., 2004) Indonesia was hit by drought and financial crises during 1997 and 1998. This research paper studies the impact of those crises on the nutritional status of children and mothers. The paper employs survey data of households in rural Java. The researchers found out that significant nutritional impact is revealed by the time-age-cohort decomposition. Despite the household consumption shock caused by increased food prices, child weight-for-age did not change throughout the crises, and it remained constant. Their evidence shows that mothers buffered children's caloric intake, which led to an increase in maternal wasting.

(Cranfield et al., 1998) This research paper is estimating the response of food demand to per capita expenditure changes using a then newly developed demand system. Assuming the population and per capita expenditure changes, the paper then forecasts the food and food product demand for 2020. Engel elasticities are used for these projections. Their results indicate that the food expenditures in 2020 will grow. Also, the demand will shift more towards livestock from grains in low-income countries in 2020.

(Akbay, 2018) This paper studies the effect of socioeconomic and demographic factors on nutrition demand and consumption behavior of households in Turkey. Both income and prices, alongside a broad range of other factors, determine the nutritional quality of the diet. The income dispersion and the living area condition being rural and urban significantly affect the choices or options for the nutritional intakes of people. Households in urban areas with high income will tend towards fat and protein-based diets with the lack of minerals and vitamins. And people in the rural areas will have more minerals and vitamins but fewer animal proteins in their diets. There is a growing tendency, especially among the young generations, for the fast-food habits, which will affect the nutrition problems even worse than they already are. And it is inevitable that these nutrition habits will also lead to heart and vessel diseases.

A vast amount of the papers in the literature covers nutrition and food safety. Including (D. G. Pekcan et al., 2001; G. Pekcan, 2006) and also (Akbay, 2018) who are concerned with the nutrition and safety of food. On the other hand, numerous research studies are studying food security at a microlevel. Individual or household surveys are conducted for most of the analysis. Fewer macro-level data and research exist for food security. Nonetheless, food researchers are varied about the environmental and climate change impact. Along with this, importance is given to the study of the agricultural sector and how to improve the production of food. (Gürsoy, 2020) is one of those studies which investigate the agricultural side of food security and food safety in Turkey. Food security is barely studied from a macroeconomic perspective. The political and economic decisions of governments affect food security at national and regional levels, which needs to be studied. Therefore, this research paper will conduct an econometric analysis to see the effects of macroeconomic variables on food security in Turkey.

CHAPTER THREE
ECONOMETRIC ANALYSIS

3.1 EMPIRICAL FRAMEWORK

This chapter is mainly focused on the empirical econometric analysis of the research framework. In the beginning, we discuss the research objectives, and question. Then we have data and methodology followed by the QQR analysis and its results. The chapter is concluded with some key findings from the empirical results, policy implications based on the empirical results, and implications for further research in the subject area.

3.1.1 Research Objectives

Studying food security from a different perspective, the perspective of macro-level economics, is the main objective of this thesis. The main objective behind choosing Turkey is that Turkey as an emerging economy is a country that resembles both the developed countries and the developing countries. These resemblances can be found in various socioeconomic characteristics of the country. Such as, GDP per capita, the purchasing power parity in current international dollars of Turkey is $28,133.088, which is above the $25,000 threshold. The infant mortality rate is 8.6 per 1,000 live births, which is better than the 12 death per 1,000 live births threshold for becoming a developed country (World Bank, 2019). Turkey is recognized as a developed country by UN Human Development Index (HDI), having 0.820 scores based on a 0 to 1 scale, where 0.800 or above is the threshold for developed countries (UNDP, 2019). However, despite these facts, the World Bank and IMF, with having their own criteria, declares Turkey as being a developing country. Hence, the results derived from this research can easily be replicated and modified for other countries.

3.1.2 Research Question

After studying the existing literature on food security and its affecting factors from various perspectives, a research question arises:

How do the macroeconomic variables affect food security in Turkey?

In order to answer this research question, the following data and methodology are employed for the empirical analysis.

3.2 DATA AND METHODOLOGY

Quarterly data from 2012 till 2020, which makes 36 periods, is selected for the quantile-on-quantile regression (QQR) analysis. Two thousand twelve as the beginning year is chosen because the food security data, which is retrieved from the Global Food Security Index, was developed in 2012 for the first time by the Economist, and they have been publishing data every year since then. Secondary time series data for eight variables are obtained and transformed for this purpose. Food security, per capita gross domestic product (GDP per Capita), interest rate, consumer price index (CPI), exchange rate, unemployment, export, and import are the variables analyzed in this thesis.

3.2.1 Data Descriptions

Turkey's food security is the dependent variable of the analysis. Annual food security data of 113 countries is published by the GFSI every year since 2012. In this thesis, the Overall Food Security column of Turkey from the index is used for analysis purposes. The data is annually converted to quarterly using the academic method of local quadratic with average matched to the source data. EViews 10 Statistical Package (IHS Global Inc., 1994) is used for the task. The local Quadratic Method fits a local quadratic polynomial for each data point of the low frequency, then uses this polynomial to interpolate the high-frequency series. The average matched interpolation method to convert the low-frequency data to high-frequency data works in such a way that the average of the interpolated points for each period is equal to the source data point for that period.

Macroeconomic variables of Turkey are used as independent variables. Data for these variables are retrieved from the (FRED, 2021) in the Economic Research Division of the Federal Reserve Bank of Saint Louis. Most of the data is retrieved quarterly, the only GDP per capita and gross domestic savings are retrieved annually, and interest rate is retrieved monthly. GDP per capita and gross domestic savings data are then converted to quarterly using local quadratic with sum matched. Similar to the average matched, in this method, the interpolated points will sum to the source data point for the period. Finally, the interest rate, which is retrieved monthly in high frequency, is converted to quarterly using the average observation method of converting high-frequency series to low-frequency series.

Table 3.1 Descriptive Statistics

	Food Security	GDP per Capita	Interest Rate	CPI	Exchange Rate (USD/TL)	Unemployment Rate	Exports (Billions USD)	Imports (Billions USD)
Mean	65.78	3,514.61	11.97	118.36	3.65	10.85	40.91	57.33
Median	65.90	3,506.17	10.25	107.48	2.96	10.39	40.58	56.89
Maximum	68.60	3,895.88	18.50	190.70	7.87	14.07	51.27	69.22
Minimum	61.70	2,934.36	8.75	77.91	1.78	8.23	32.40	43.27
Std. Dev.	1.75	273.40	3.63	33.70	1.78	1.78	3.87	6.27
Skewness	(0.75)	(0.42)	0.81	0.66	0.79	0.46	0.25	(0.14)
Kurtosis	3.44	2.00	2.06	2.17	2.42	2.10	3.53	2.15
Jarque-Bera	3.65	2.54	5.21	3.67	4.26	2.45	0.81	1.21
Probability	0.16	0.28	0.07	0.16	0.12	0.29	0.67	0.55
Observations	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00

Table 3.1 contains descriptive statistics of the data employed for the quantile on quantile regression (QQR) in this thesis. Each column of the table represents each variable, and the rows represent descriptive statistics of that variables. The variable Food Security in the first column is an overall food security score of Turkey in the Global Food Security Index developed by (The Economist Intelligence Unit, 2021). The scores vary from 0 to 100, where 100 is the highest score or the sustainably food secured country. Turkey's mean value is 65.78, and the series is slightly left-skewed, as is shown in the brackets. Std. Dev. is a short form for standard deviation that shows the average spread of data points from each other. When the data is symmetrically distributed around the sample mean, the value of skewness is zero. A negative value indicates left skewness, and a positive value indicates right skewness (Hao & Naiman, 2007). Skewness can be

interpreted that there is an imbalance between the spread below and above the mean. (It is used to describe the non-normality of a distribution). In the skewness row, the values for food security, GDP per capita, and imports are in brackets which indicates the negative value or left skewness.

Kurtosis is another measure of the normal distribution that shows the tailedness or shape of the arch of the probability distribution curve. The kurtosis value for a normal probability distribution curve is three. The kurtosis values for all of our variables in the table are around three, indicating a normal probability distribution curve. The Jarque-Bera test results show the normal distribution of the data with the null hypothesis of the data is normally distributed. Looking at the probability values of the test provided in Table 3.1, we cannot reject the null hypothesis because all the p-values are higher than 0.05. Hence, the data is normally distributed. The last row on the table shows the number of observations for each variable. As mentioned before, the data is from 2012 quarter one till 2020 quarter four, which makes it a total of 36 observations for each variable in the analysis.

Each of the remaining plots shows the distribution of the macroeconomic variables. In addition to other characteristics, the box and whiskers plot can also show the skewness of a series. For instance, (iii), (iv), (v), and (vi) plots are rightly skewed where the mean value is higher than the median. (vii) contains two plots for trade, the blue one plots (ln) values of export and the orange one plots (ln) values of imports of Turkey. The import plot is higher than the export plot, which means the total import values for the time period are higher than that of exports. That is why Turkey's net trade or balance of trade is negative.

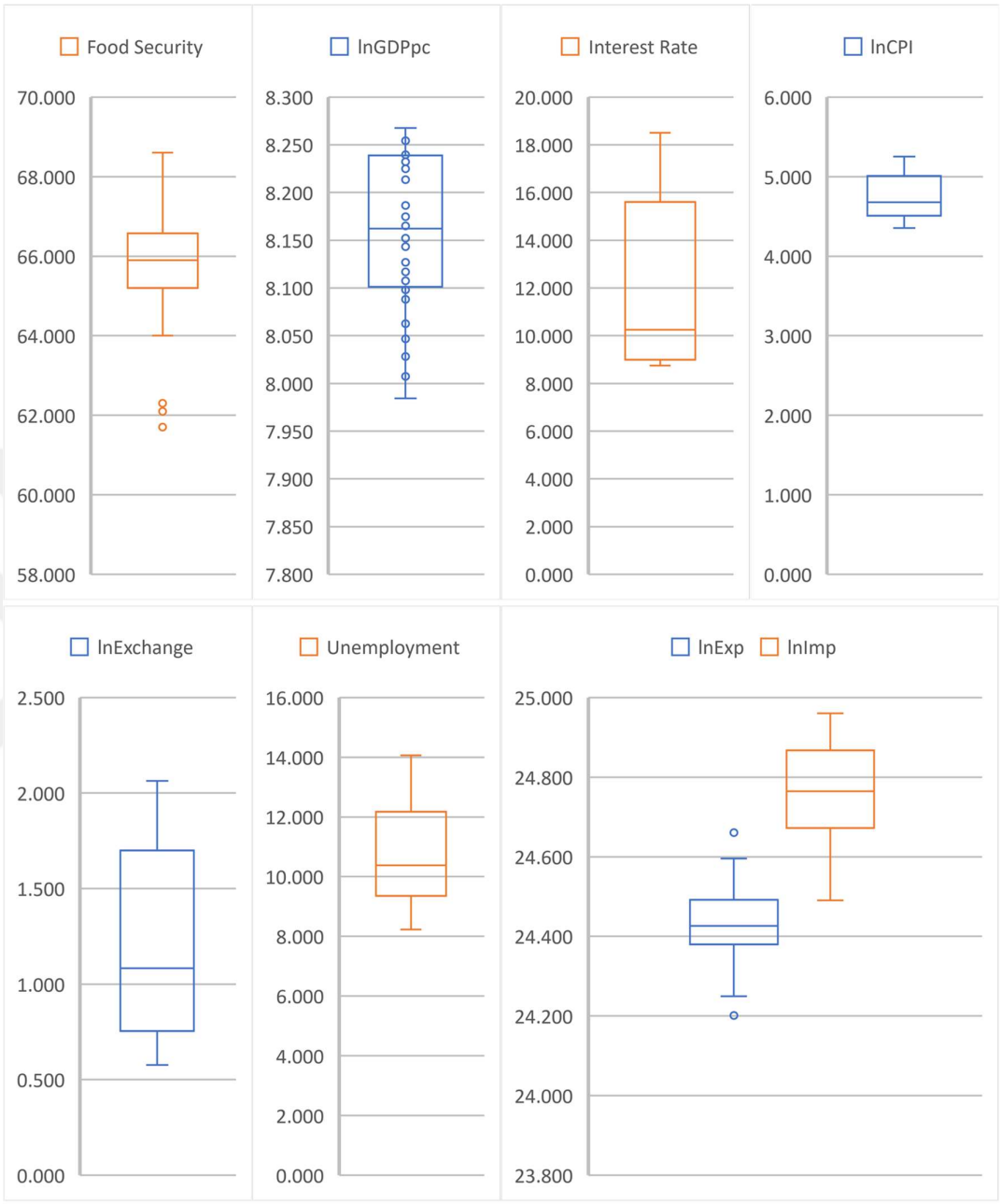
Figure 3.1 shows the box and whiskers plots for all the variables used in the analyzes. The lower end of the lower whisker shows the lowest value for that variable, and the upper end of the upper whisker shows the highest value for that certain variable. The box shows data around the median. The lower edge of the box is the 25^{th} percentile, and the upper edge of the box represents the 75^{th} percentile of the data. In the box, we can see a line and an X; the line denotes the median of the series, and the X denotes the mean of the series for each variable. The dots up or down the whisker lines denote outliers. Each of the remaining plots shows the distribution of the macroeconomic variables. In addition to other characteristics, the box and whiskers plot can also show the skewness of a series. For instance, (iii), (iv), (v), and (vi) plots are rightly skewed where the mean

value is higher than the median. (vii) contains two plots for trade, the blue one plots (ln) values of export and the orange one plots (ln) values of imports of Turkey. The import plot is higher than the export plot, which means the total import values for the time period are higher than that of exports. That is why Turkey's net trade or balance of trade is negative.

Figure 3.1 has seven plots numbered in Roman numbers from (i) to (vii). The dependent variable food security is plotted in the (i) plot, which shows that the data is distributed between 64.00 and 68.60 with 65.20 at the $.25^{th}$ quantile and 66.57 at the $.75^{th}$ quantile. The median of the series is 65.90, and the mean is 65.77. Also, the data has three outliers laying around 62.00 shown by the three dots.

Each of the remaining plots shows the distribution of the macroeconomic variables. In addition to other characteristics, the box and whiskers plot can also show the skewness of a series. For instance, (iii), (iv), (v), and (vi) plots are rightly skewed where the mean value is higher than the median. (vii) contains two plots for trade, the blue one plots (ln) values of export and the orange one plots (ln) values of imports of Turkey. The import plot is higher than the export plot, which means the total import values for the time period are higher than that of exports. That is why Turkey's net trade or balance of trade is negative.

Figure 3.1 Box and Whiskers Plots of all the Variables


Food Security
70.000
68.000
66.000
64.000
62.000
60.000
58.000
lnGDPpc
8.300
8.250
8.200
8.150
8.100
8.050
8.000
7.950
7.900
7.850
7.800
Interest Rate
20.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
lnCPI
6.000
5.000
4.000
3.000
2.000
1.000
0.000
lnExchange
2.500
2.000
1.500
1.000
0.500
0.000
Unemployment
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
lnExp
lnImp
25.000
24.800
24.600
24.400
24.200
24.000
23.800

3.2.2 Methodology

Regression analyses are used to expose the relationship between a dependent variable and independent variable(s). To easily predict the effect of the independent variable on the dependent variable, the average value, the middle value, or the most likely value (mean, median, and mode) – which are the measures of central tendency, are employed in various regression analyses. Linear Regression Models (LRM) predict the effect by using the conditional mean. But it has some limitations; first, the conditional mean only studies the central location. It cannot be extended to a non-central location. Second, the homoskedasticity assumption, which frequently fails in a real-world application. Third, the conditional mean ignores the scale, the skewness, the central location, and the higher-order properties of a distribution (Hao & Naiman, 2007). The Quantile Regression Models (QRM) estimate the effect of predictor variable over response variable using different quantiles of the series. The QRM is preferable because it does not have the curse of dimensionality or the three big assumptions of LRM: homoscedasticity, normality, and one-model assumption. The LRM creates only one regression line, which is running through the mean of the data. On the other hand, QRM has the ability to regresses multiple regression lines with different slopes that runs through various quantiles of the series.

Quantile-on-quantile regression analysis is employed in this study which was first developed by (Sim & Zhou, 2015). The idea of using quantile regression or median is not a recent one, but it goes up to the 18th century when in 1760, Roger Joseph Boscovich traveled to London to compute his newly developed median regression method. This way, the conditional median regression was firstly proposed by Boscovich in the mid-18th century and was subsequently investigated by Laplace and Edgeworth (Hao & Naiman, 2007). However, it was very challenging to compute the analysis at that time. With the recent technological development in computing and advanced statistical software packages, analyzing quantile regression has become a lot easy. The modern-day quantile regression, which is used in the different scientific research analysis, was first introduced by (Koenker & Bassett, 1978) and was eventually developed and advanced over time.

Quantile-on-quantile regression (QQR) is a non-parametric regression analysis originated and developed from the conventional parametric quantile regression analysis with a combination of the local linear regression model. The QQR estimates the local

effect of tau-quantiles of the independent variable on the theta-quantiles of the dependent variable. This estimation can only be done if we first choose some tau-quantiles of each independent variable by using local linear regression and implement a theta-quantile regression with the dependent variable. Before going to the model itself, first, we use the following quantile regression model's equation to find the theta-quantiles of food security as a function of the macroeconomic variables.

$$Y_t = \beta^\theta(X_t) + \alpha^\theta Y_{t-1} + v_t^\theta \quad \text{.......} (1)$$

In equation 1, Y_t stands for food security over time as the dependent variable. X_t stands for the macroeconomic variables as independent variables over time. The subscript small t denotes time; the superscript θ denotes the theta-quantiles of food security and the v_t^θ is an error term that has a zero θ-quantile. Furthermore, after some mathematical steps and modifications, the following equation is developed by (Sim & Zhou, 2015):

$$Y_t = \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(X_t - X^\tau) + \alpha(\theta)Y_{t-1} + v_t^\theta \quad \text{.......} (2)$$

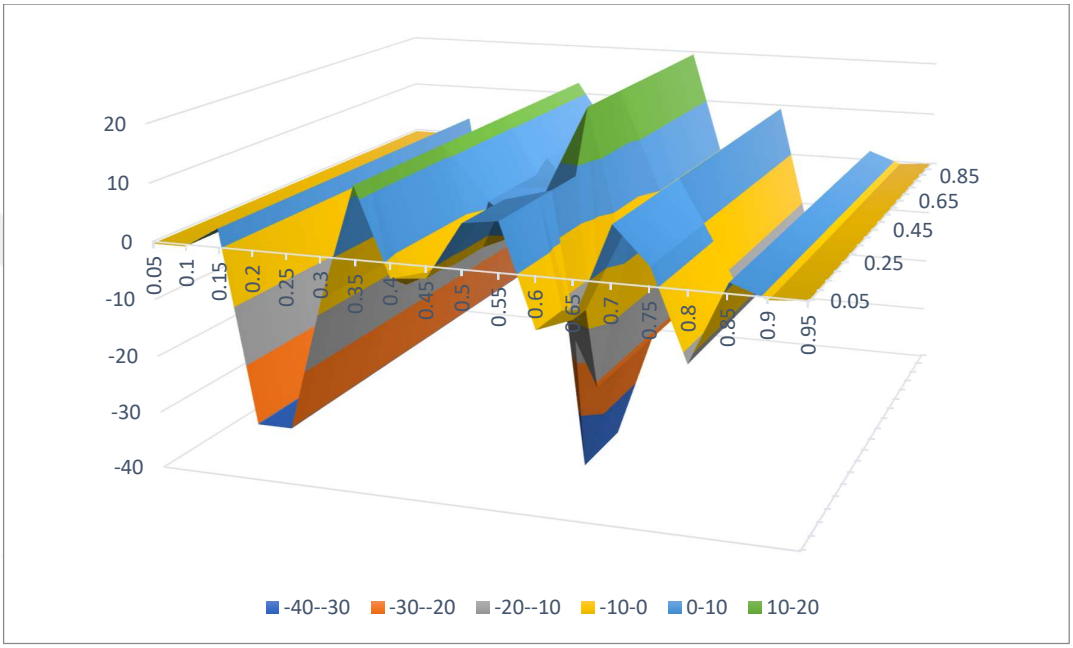
Where $\alpha(\theta) \equiv \alpha^\theta$ which is the error term that has a zero θ-quantile. $\beta_0(\theta,\tau)$ is the intercept term of the model in equation 2. Tau (τ) denotes the tau-quantiles of each macroeconomic variable used in the analysis. Plugin bandwidth of $h=0.05$ is selected for the empirical analysis of the regression analysis. The model is run in R language codes (R Core Team, 2021) using RStudio Software (RStudio Team, 2021) with the help of the *"quantreg"* package programmed by (Koenker, 2021). This way, all the required values for the different quantiles of both dependent and independent variables are acquired and saved in the matrix form. The data in the matrix is then used to plot 3D surface graphs for each model using Excel 365 (Microsoft Corporation, 2021). This process is repeated seven times for each macroeconomic variable as a predictor variable X_t and food security as a response variable Y_t.

3.3 ANALYSIS

The results of the QQR analysis between food security and macroeconomic variables of Turkey are present in this section. The QQR analysis can be done between two time series to explore the effect of the independent variable at each quantile on the dependent variable quantiles. The graphs from **Error! Reference source not found.** to **Error! Reference source not found.** show the results of every model analyzed separately one by one. In some of the analyzed models, the independent variable is transformed into

its natural log form to harmonize the data. For the interpretation of its coefficient $\beta_1(\theta, \tau)$ values, we first need to divide the $\beta_1(\theta, \tau)$ value by 100 and then interpret it as a percentage change in the τ – quantiles of an independent variable will change the θ – quantiles of the dependent variable by $(\frac{\beta_1(\theta,\tau)}{100})$ percent.

Figure 3.2 QQR Estimation of GDP per Capita and Food Security



In Figure 3.2, the 3D surface graph represents the results of QQR analysis of the model equation for the dependent variable food security and the independent variable GDP per capita with its natural log form. On the z-axis, the graph shows $\beta_1(\theta, \tau)$, on the x-axis, it shows quantiles of lnGDPperCapita (τ), and on the y-axis, it shows the quantiles of food security (θ). The dark blue or cobalt blue color shows the very dept of the graphed surface or the lowest values for $\beta_1(\theta, \tau)$ and the green color shows the very high peaks of the graphed surface or the highest values for $\beta_1(\theta, \tau)$. The graph represents a pretty interesting relation between the lnGDPperCapita and food security. It clearly shows that at the lower quantiles of lnGDPperCapita -from 0.15 till 0.3, all quantiles of the food security will decrease since the $\beta_1(\theta, \tau)$ is negative values. That means the lower GDP per capita has a negative effect on food security. The lowest point on the graphed surface is just above the median at the 60th quantile of lnGDPperCapita and at the lower quantiles of food security from the 20th quantile till the 40th quantiles. In the median of lnGDPperCapita, the impact of (τ) on (θ) is positively the highest only for the upper quantiles of food security (θ). Overall, the graph shows that mostly the impact of quantiles

of lnGDPperCapita (τ) on the quantiles of food security (θ) is positive from the 30th quantile upward.

Figure 3.3 QQR Estimation of Interest Rate and Food Security

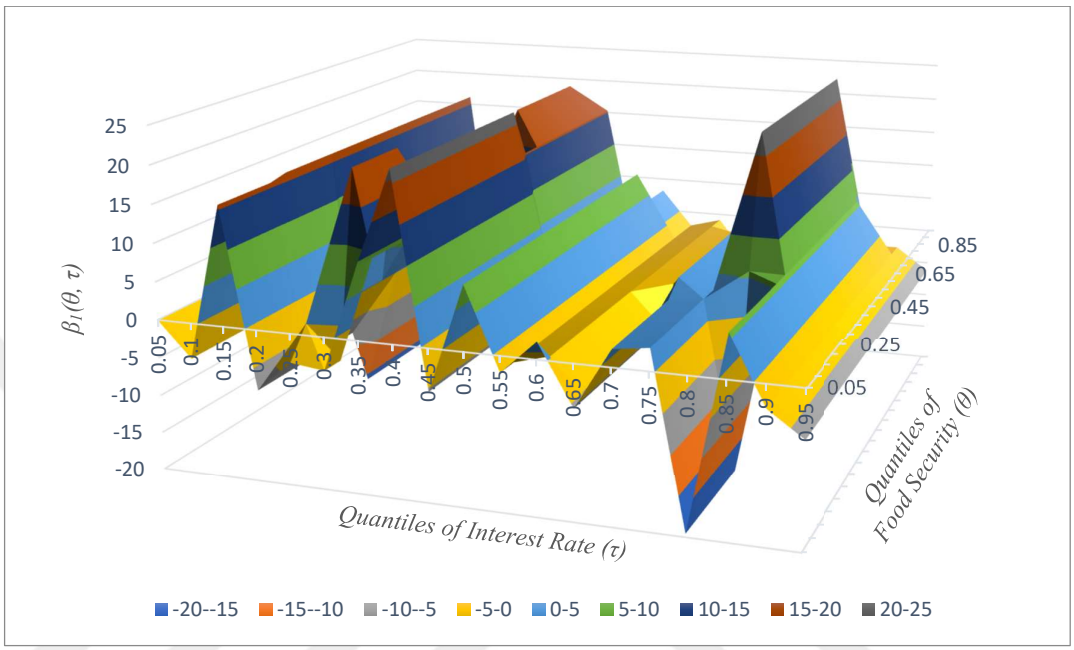
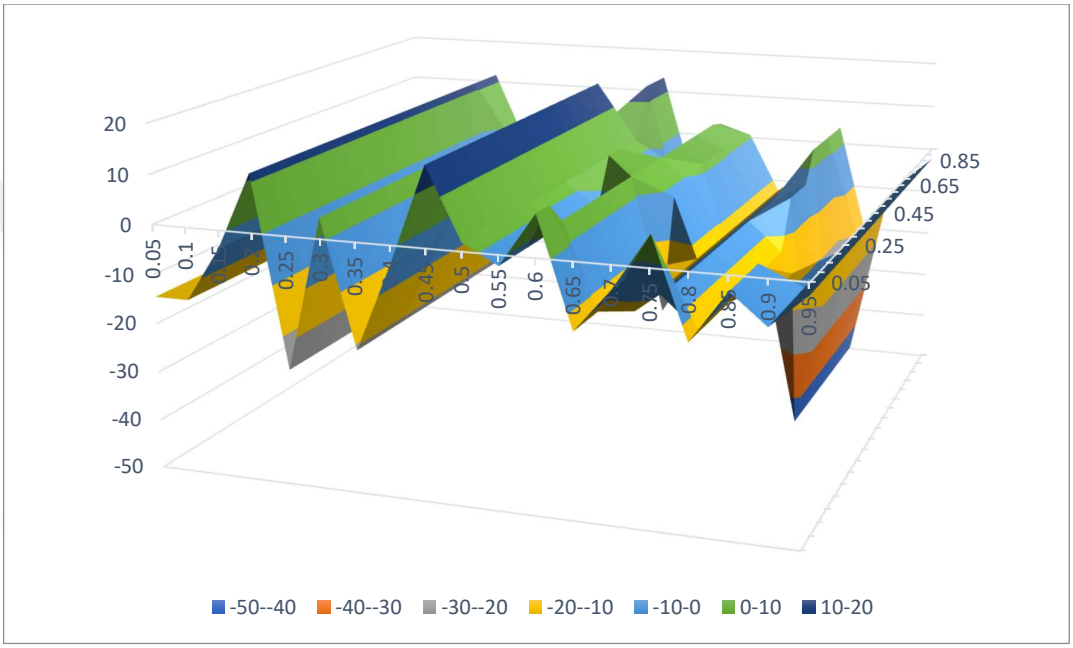


Figure 3.3 shows the QQR analysis results for the model equation with an interest rate as an independent variable (X_t) and food security as a dependent variable (Y_t). On the z-axis of the 3D surface-graph is the coefficient $\beta_1(\theta, \tau)$, on the x-axis we have quantiles of interest rate (τ), and on the y-axis, on the graph, we have quantiles of food security (θ). The dark grey color at the peaks shows the highest positive values for $\beta_1(\theta, \tau)$, lower than that but still very high is the garnet red color followed by the Persian blue color and the shamrock green color. The cobalt blue color represents the lowest possible values for $\beta_1(\theta, \tau)$ at the dept of the graphed surface. Followed upward by the orange and light grey colors, which also have negative values.

At the lower quantiles of interest rate (τ) below the median, the impact on the quantiles of food security (θ) is very high, which means that a lower interest rate is better for food security. A surprising fact in the graph is the highest peak at the 75th percentile of interest rate and above the median quantiles of food security. Where the $\beta_1(\theta, \tau)$ is in the dark grey color as high as approximately up to 22.5, one possible and strong justification for this high impact of high-interest rate can be as this: Since the interest rate is high and the food is relatively secured -since the effect is at the high percentiles only, then the people will tend to save, and those savings will contribute to investment in the

future eventually increasing the food security. The above argument is valid because we can see that at that same level of interest rate, the effect on food security is negative, which means that the high-interest rate will furthermore deteriorate the low food security situation. Based on the 3D surface graph in Figure 3.3, we can state that food security will increase when the interest rates are low.

Figure 3.4 QQR Estimation of CPI and Food Security



The 3D surface graph in Figure 3.4 shows the results of QQR analysis of the model equation for the natural logged values of CPI represented by (X_t) and the food security represented by (Y_t). The coefficient values for $\beta_1(\theta, \tau)$ are shown on the z-axis, the quantiles of lnCPI (τ) are shown on the x-axis, and the quantiles of food security (θ) are shown on the y-axis of the graph. The Persian blue color represents the highest possible value for $\beta_1(\theta, \tau)$, followed by the shamrock green color. All the remaining colors represent negative values for $\beta_1(\theta, \tau)$. In the dept of the graphed surface, we can see the lowest possible value for $\beta_1(\theta, \tau)$ colored with the cobalt blue color. Followed upward with the garnet red and light grey colors.

The QQR graph, which analyzes the effect of the quantiles of lnCPI (τ) on the quantiles of food security (θ), clearly shows a very high and significant effect. At the lower quantiles of lnCPI (τ) up to the 60th percentile, the effect is positive except for 25th and 35th percentiles. This means that the lower CPI will increase the overall food security. At the higher quantiles of lnCPI (τ), the graph shows a negative value for $\beta_1(\theta, \tau)$. It is

because as the inflation rate increases, the food becomes more and more insecure. This relation is more impactful in the 85th percentile of lnCPI (τ) and above the 45th percentile of food security (θ) where the value of $\beta_1(\theta, \tau)$ goes as low as negative 45 colored in cobalt blue. After studying the graph in detail, we can conclude that the high inflation will deteriorate the status of food security. As prices go high, food will become less affordable, and as prices go down, the food will become more affordable. Hence the increase of CPI has a negative effect on food security.

Figure 3.5 QQR Estimation of Exchange and Food Security

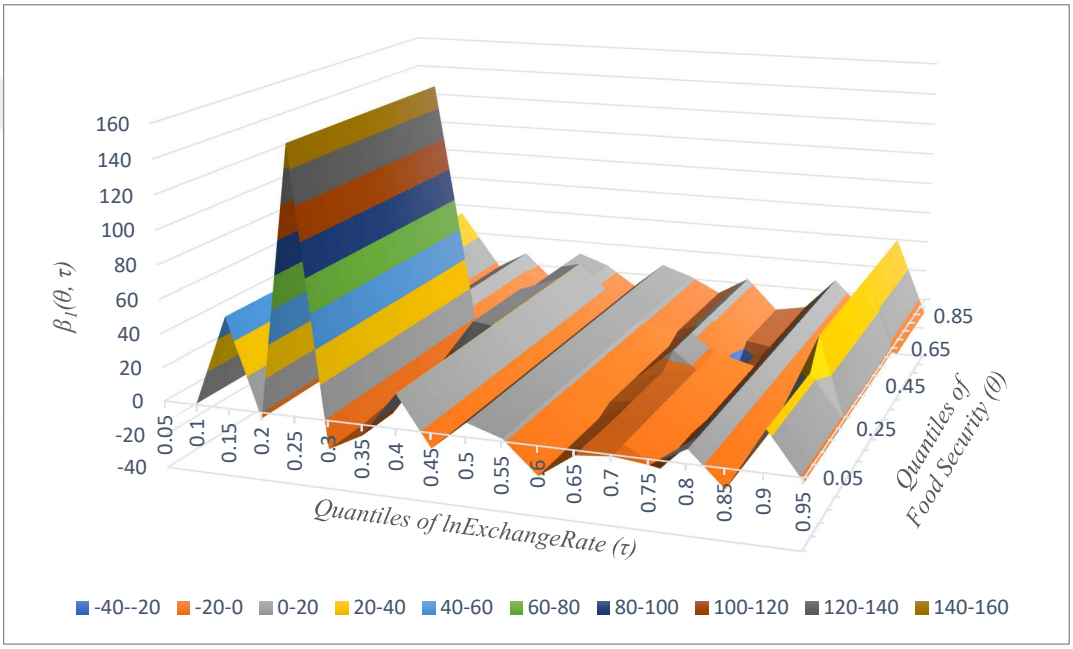


Figure 3.5 shows the QQR analysis results of the model equation for lnExchangeRate denoted by (X_t) and food security denoted by (Y_t). The z-axis on the graph represents the coefficient $\beta_1(\theta, \tau)$ values of the analysis. The x-axis and y-axis represent the quantiles of lnExchangeRate (τ) and food security (θ), respectively. The graphed surface is color-graded from high to low. Areas colored in the orange have low values of $\beta_1(\theta, \tau)$, which are below zero and the lowest dept of the graph is colored with cobalt blue at the 70th percentile of lnExchangeRate (τ) and 60th up to 70th percentiles of food security. The peak in the graph colored with dark yellow represents the highest possible value for $\beta_1(\theta, \tau)$.

This graph which shows the effect of quantiles of lnExchangeRate (τ) on the quantiles of food security (θ), presents an interesting result. We see that there is a positive

impact of exchange rate on food security at the lower quantiles of lnExchangeRate (τ) up to the 30th percentile. The effect becomes more and more negative towards the upper quantiles of lnExchangeRate (τ). The highest peak in the graph, which goes as high as 145, shows the powerful effect of exchange rate on food security at the .25 quantile of lnExchangeRate (τ) over the lower quantiles of food security (θ). Overall the graph shows that the low exchange rate will positively affect food security, and as the exchange increases, it will negatively affect the status of food security.

Figure 3.6 QQR Estimation of Unemployment Rate and Food Security

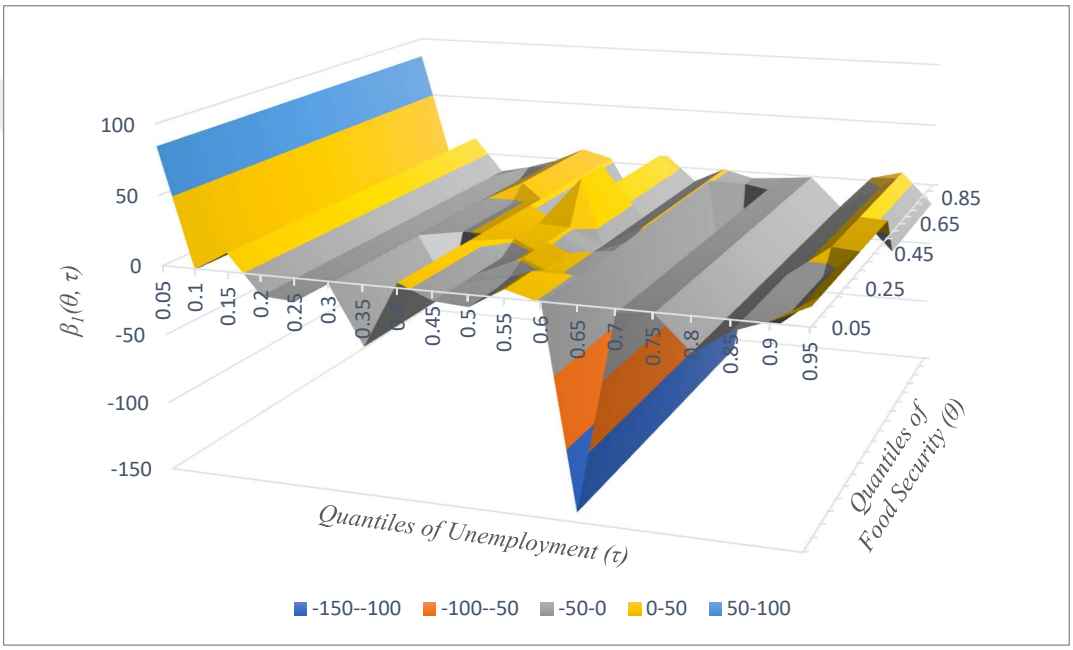


Figure 3.6 shows the QQR analysis results for the model equation with the unemployment rate as an independent variable (X_t) and food security as a dependent variable (Y_t). The z-axis represents $\beta_1(\theta, \tau)$, the x-axis represents the quantiles of the unemployment rate (τ), and the y-axis represents quantiles of food security (θ). The positive and high values of $\beta_1(\theta, \tau)$ are colored with the light blue and yellow colors in the 3D surface graph. The cobalt blue shows the very dept of the surface followed upward by the orange and light grey colors.

The surface of the graph peaks up at the lowest quantiles of the unemployment rate (τ) and peaks down at the 60th percentile. The impact of quantiles of the unemployment rate (τ) on the quantiles of food security (θ) after the 15th percentile is mostly negative throughout the graph. This clearly shows that food security is negatively affected by the increase in the unemployment rate.

Figure 3.7 QQR Estimation of Exports and Food Security

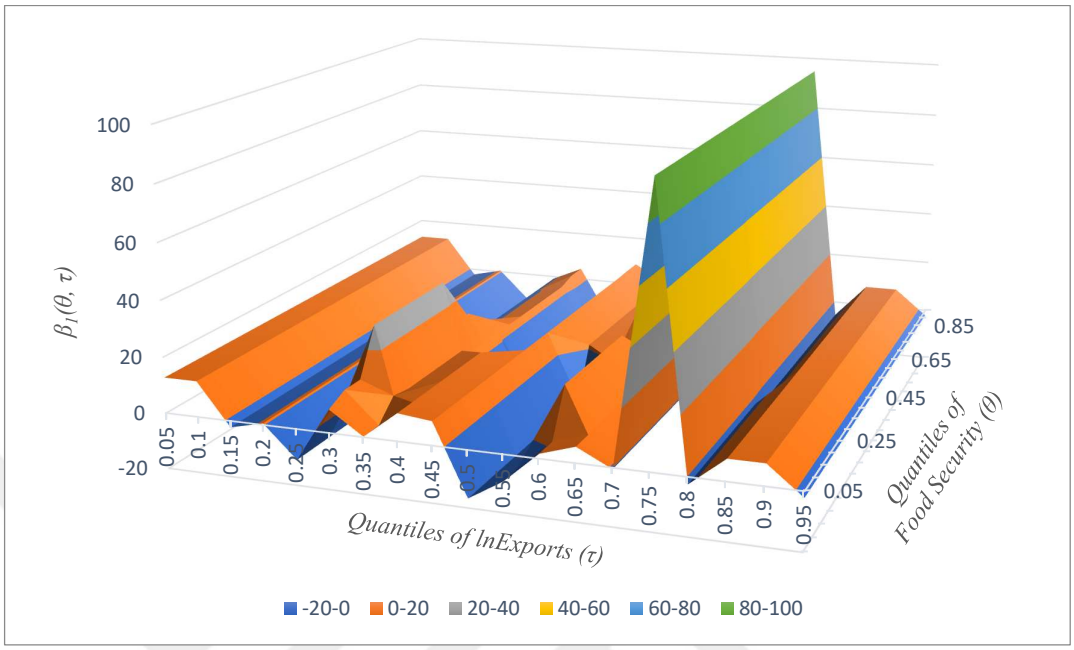
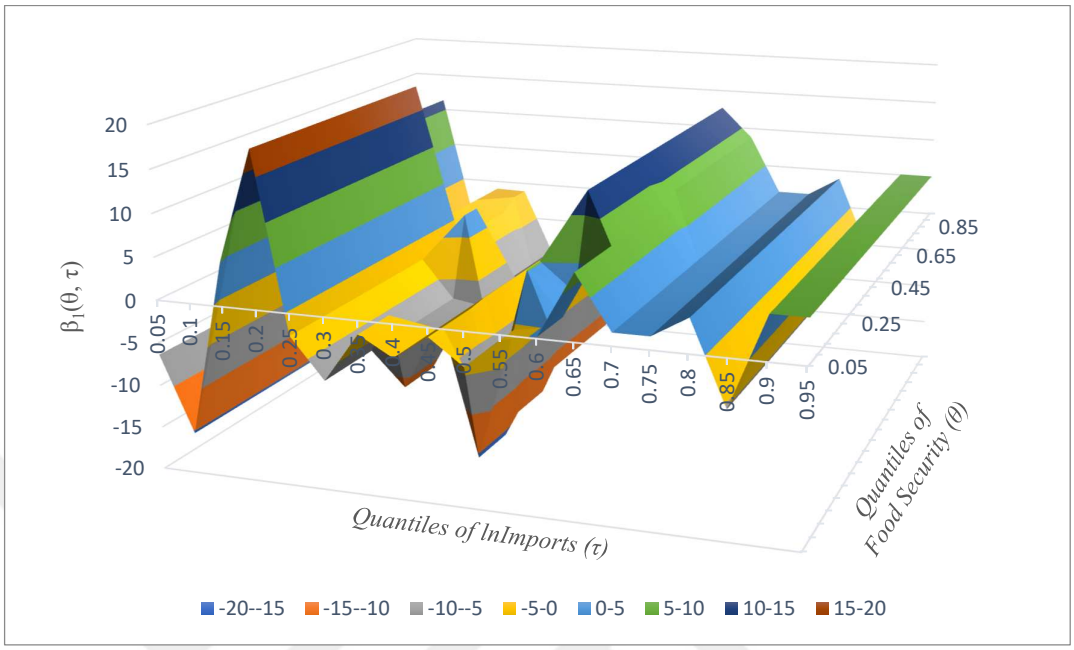


Figure 3.7 shows the results of QQR analysis of the model equation on the natural log form of exports as the independent variable (X_t) and food security as a dependent variable (X_t). QQR analysis examines the effect of τ – quantiles of lnExports over the θ – quantiles of food security. The z-axis of the graph represents $\beta_1(\theta, \tau)$, the x-axis represents the τ – quantiles of lnExports, and the y-axis represents the θ – quantiles of food security. The green color represents the highest possible values of $\beta_1(\theta, \tau)$ at the peak of the graphed surface. The cobalt blue color below zero represents the negative impact of quantiles of lnExports (τ) on the quantiles of food security (θ).

The graph shows a very neutral and mostly positive but practically insignificant effect of (τ) on (θ) until 70th percentile. The effect is very high where the surface peaks up at the 75th percentile of lnExports (τ), where the percentage change in exports will increase the food security by 0.95 percent. The relationship among the quantiles shows that the exports are almost always contributing towards a sustainable food security. Overall we can say that the high exports of Turkey will elevate the status of food security in Turkey.

Figure 3.8 QQR Estimation of Imports and Food Security



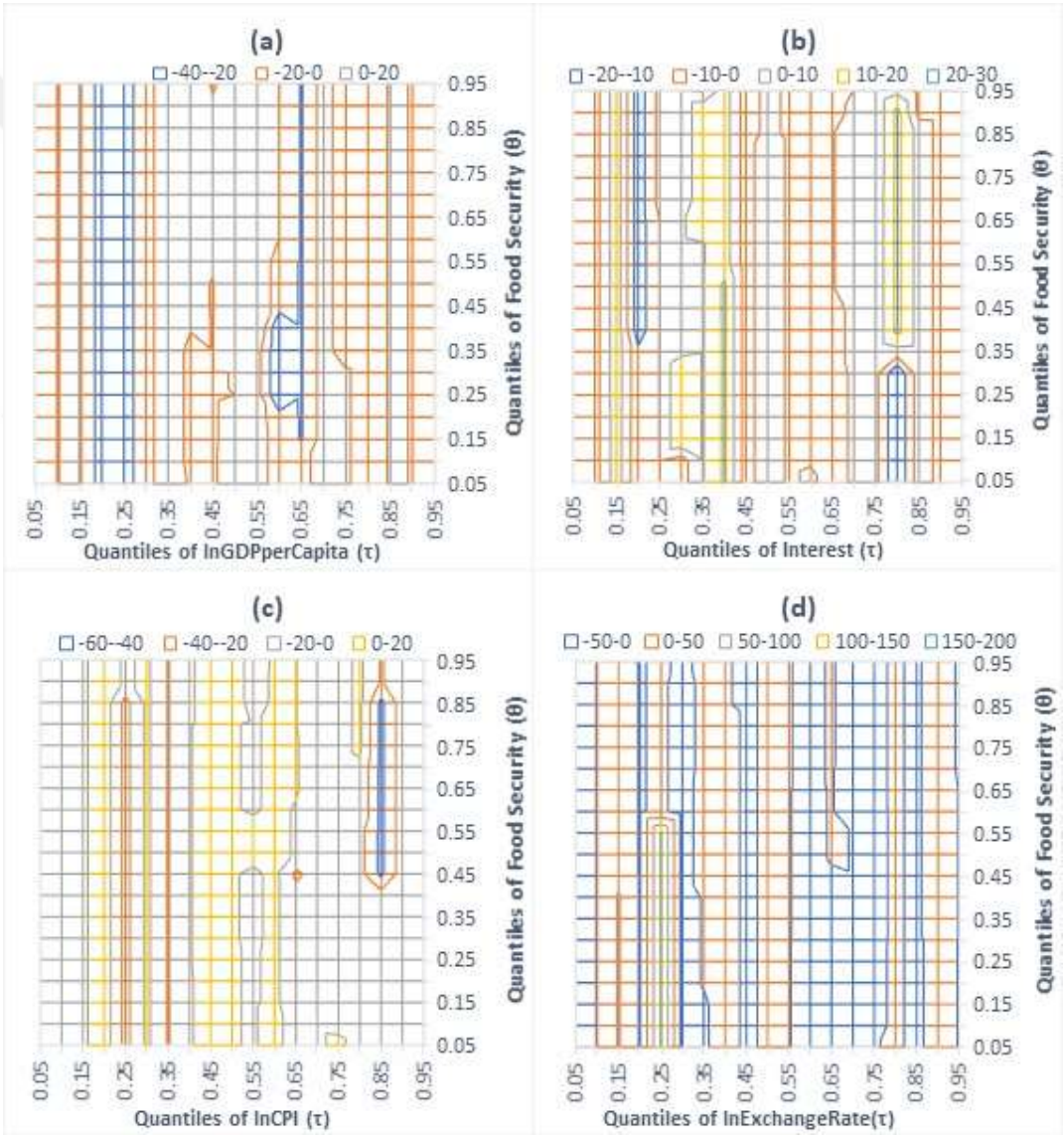
The 3D surface graph in Figure 3.8 shows the QQR analysis results of the model equation for the variables import as an independent variable and food security as a dependent variable denoted by (Xt) and (Yt), respectively, in the model equation. The QQR analyzes the effect of τ – quantiles of lnImports on the θ – quantiles of food security. The z-axis represents β1(θ, τ), the x-axis represents τ – quantiles of lnImports, and the y-axis represents the θ – quantiles of food security. The cobalt blue color followed by orange color represents the lowest possible values for coefficient β1(θ, τ). The garnet red color followed down by the persian blue colors in the peak of the graphed surface represents the possible most high values for β1(θ, τ). The effect is noticeably high at the 20th percentile and 65th percentile of lnImports on the quantiles of food security (θ). At the peak with one percentage change in the imports the food security will increase by around 0.17 percent. In the median of lnImports (τ), the surface peaks down to the dept of the graph where a percentage change in lnImports will decrease the food security by around 0.17 percent.

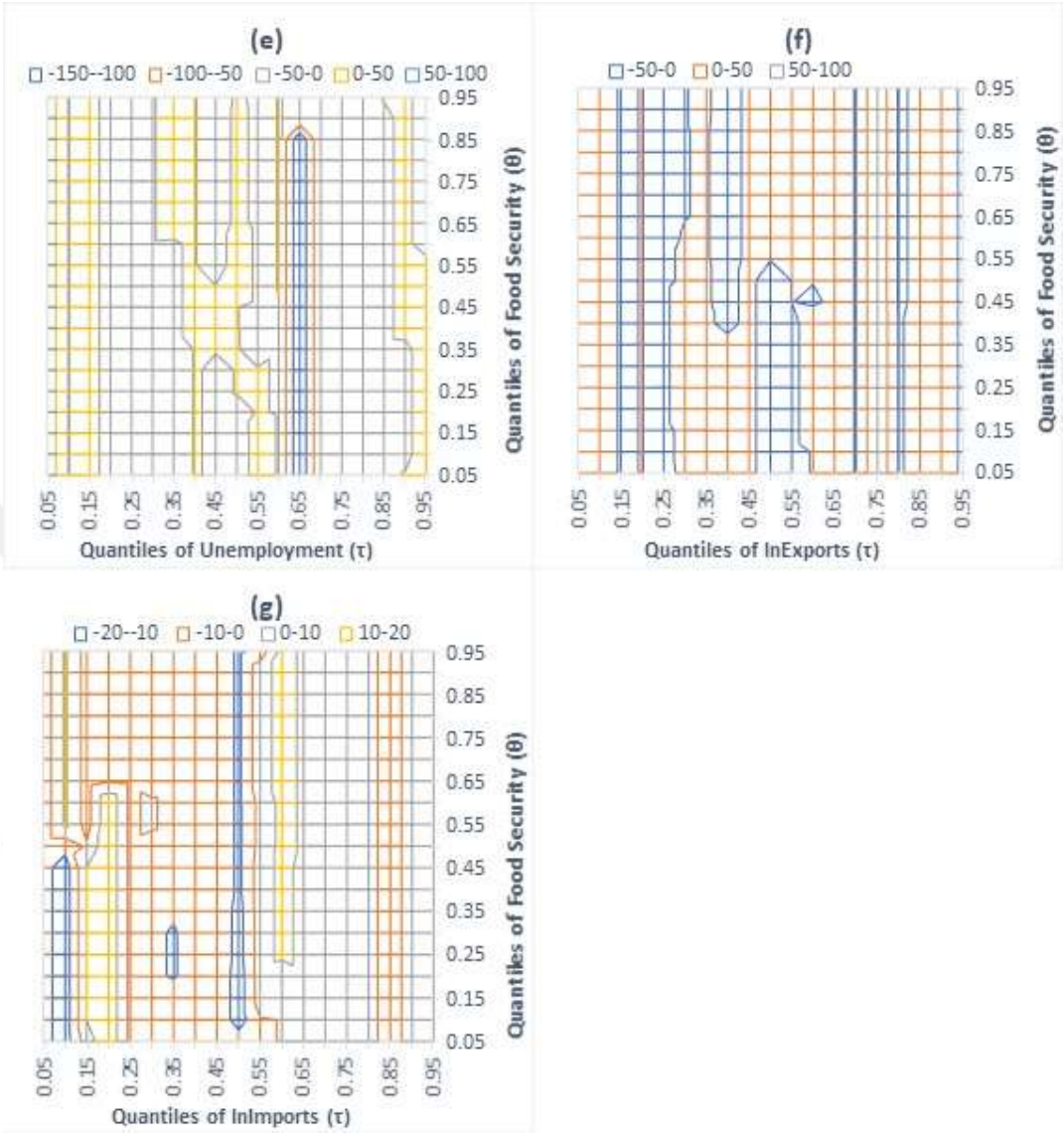
3.3.1 Contours of the 3D Graphs

In order to understand the effect better and the other side of the 3D surface graphs, we have to see it from another perspective. Figure 3.9 shows contour maps of each individual model's results shown on the 3D graphs above. The seven contour maps

from (a) to (g) represent every single graph mentioned above in the same order. On the horizontal axis, we have the τ – quantiles of the independent variables (X_t), and on the vertical axis, we have θ – quantiles of food security as a dependent variable (Y_t). The different lines and various colors represent the depths and elevations of the surface. With the help of this bird's eye view of the results, we can see the effect of individual quantiles of independent variables on the individual quantiles of a dependent variable more clearly. The legend above the maps helps us understand the elevation values sets of each color.

Figure 3.9 Contour Maps of the QQR Analysis Results' 3D Surface Graphs





3.4 RESULTS AND DISCUSSIONS

This research study analyzes the effect of macroeconomic variables on food security in Turkey by employing the quantile-on-quantile regression analysis, which analyzes the effect of various quantiles of the independent variable on various quantiles of the dependent variable. To the current knowledge of the researcher, this thesis is the first research to study food security from a macroeconomic perspective. And it also is the first one to use the quantile-on-quantile analysis on food security. The results of the analyzed models reveal very detailed insight into the effect of the macroeconomic variable on food security. Following are some key findings of the empirical results and policy implications based on the key findings of the analysis.

3.4.1 Key Findings

- All affecting factors ceteris paribus, less GDP per capita will deteriorate the food security with a 0.35 percentage change. More GDP per capita will result in more food security.
- All the other affecting factors Ceteris paribus, lowering the interest rate can increase the food security by around 20 units, and the high-interest rate will decrease food security by approximately 17 units.
- A high inflation rate worsens food security. From the analysis results, we found that the last quantiles of lnCPI negatively affect food security. All things ceteris paribus, a percentage change in high quantiles of CPI will decrease food security by .45 percent.
- The effect of a high exchange rate is negative but highly minuscule; it's practically insignificant. However, at the lower quantiles, the effect of exchange rate on the lower quantiles of food security is highly practically significant. All things ceteris paribus, a lower exchange rate will increase food security by 1.45 percent.
- The effect of the unemployment rate on food security is practically insignificant until the 60^{th} percentile. Every other thing ceteris paribus, at the 65^{th} percentile of the unemployment rate, the food security will worsen by 145 units. Clearly showing that the high unemployment rate is bad for food security.
- Exports do not affect food security when it is low. However, the higher quantiles of lnExports have a significant effect on all the quantiles of food security. In the third quarter of export, a percentage change will increase the food security by around 0.95 percent.
- The result of our last model shows that imports do affect food security differently at different quantiles. All things ceteris paribus, food security will improve response increasingly by around 0.17 percent and 0.13 percent at a positive change in the 20^{th} percentile and 65^{th} percentile of imports. And it will decrease by around 0.16 percent in response to a positive change in median values of imports.

After empirically analyzing the data using seven different models where the macroeconomic variables were employed as explanatory variables to see their effect on

the dependent variable food security and after studying all the results thoroughly, we conclude that yes all of the employed macroeconomic variables do somehow affect the food security in Turkey. The relationship to how each variable affects it is clearly shown and explained by the results and findings of the analyzed models.

3.4.2 Policy Implications

From the results, we see that food security is highly dependent on macroeconomic variables on different levels with different relations. Some of the variables positively contribute to food security, and some negatively affect its status. Researchers, policymakers, and government officials should try to build policies, programs, and plans that will contribute towards a stable economy and sustainable development. Food security is not only the study of agriculture; it is a socio-economic phenomenon that needs to be addressed by policymakers and researchers. High-interest rates, CPI, exchange rates, and unemployment rates are affecting food security negatively. Hence, it is advised to make such policies where these macroeconomic variables will all decrease to its possible minimum rates. On the other hand, GDP per capita and trade both exports and imports, but especially exports contribute positively to food security; plans and agendas are to be made to enhance the situation. Low GDP per capita affects food security negatively. Hence, macroeconomists should always try to increase GDP per capita. Food is the foundation stone of life, and it should be at the center of every policy, long-term plan, and agendas to have sustainable food security for all.

3.4.3 Academic Contribution

Food security, food safety, food waste, and nutrition are vastly studied in the existing literature. However, most of it is focused on a microlevel employing data from the household surveys. Very little focus is given to a macro-level study of the topics, with a very vast gap to be filled by academic contributions. This thesis is one of the stones thrown to the lake from which a mountain will rise. Food security is not analyzed by the quantile-on-quantile regression analysis methods to this date. This thesis is the first research to undertake this method of analysis in studying food security.

3.4.4 Implications for Further Research

The empirical analysis of this thesis is limited only to Turkey. Still, researchers can expand the study area to other individual countries, or it can even be extended to a regional level. In addition, with the help of QQR analysis, food security can be studied from other macro-level perspectives, for instance, its relationship with financial development, political stability, and economic growth.

CONCLUSION

This thesis was aiming to find that how the key macroeconomic variables affect food security in Turkey? In order to answer this research question, we did an empirical analysis on seven key macroeconomic variables as independent variables and food security as the dependent variable. The result from the empirical analysis indicates that food security is highly affected by macroeconomic variables. The results of the specific regression models show that GDP per capita, exports, and imports impact food security positively when they are high. In contrast, interest rates, CPI, exchange rates, and unemployment rates will deteriorate the state of food security when they are high. Food security will improve if interest rate, inflation rate (CPI), exchange rate, and unemployment rates are kept at their possible minimum low rates.

The quantile-on-quantile regression (QQR) approach was chosen for the empirical analysis. (Sim & Zhou, 2015) first developed the models based on the quantiles regression analysis developed by (Ma & Koenker, 2006). This approach is effective and significantly practical in analyzing the effect of different quantiles of the explanatory variable on the different quantiles of the response variables. Seven models in total, one for each key macroeconomic variable was developed and analyzed to the kind of effect these variables how on food security. The results were in many ways aligned with the expectations based on the theoretical knowledge and assumptions.

This thesis is an important contribution to the existing literature in the related academic research field. The existing literature on the issue of food security and nutrition only focuses on the agricultural perspective of food. There is a gap in research in the macroeconomics of food and nutrition. Most focus is given to the production of food. However, the economics of food, the utilization, distribution, and ability to acquire the food are of the same importance. Based on the empirical results, it is recommended that macroeconomic policy and decision-makers consider the significance of the effect macroeconomic variables have on food security. To better understand the implication of the results, future research studies could address the effect of some other country's macroeconomic variables on food security.

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