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The Future of Food Supply in the Middle East: Case Studies of Iran, Turkey, and Iraq

Ph.D. Dissertation

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Abbreviations

Acronyms	Explanation
AIDS	Acquired Immunodeficiency Syndrome
ANFIS	Adaptive Network-Based Fuzzy Inference System
ANN	Artificial Neural Network
BMI	Business Model Innovation
CI	Customer Intimacy
CO_2	Carbon Dioxide
CVS	Convenience Store
FAO	Food And Agriculture Organization
FSC	Food Supply Chain
GBELL	Generalized Bell-Shaped
HIV	Human Immunodeficiency Viruses
ICT	Information And Communication Technology
IOT	Internet Of Things
ISO	International Organization for Standardization
MF	Membership Functions
MLP	Multilayer Perceptron
OEM	Original Equipment Manufacturer
PL	Product Leadership
R	Determination Coefficient
RMSE	Root Mean Square Error
SDI	Spatial Data Infrastructure
TRAP.	Trapezoidal-Shaped
TRI.	Triangular-Shaped
TSP	Targeted Subsidies Policy
UN	United Nation
VAFI	Variable Alternate Furrow Irrigation
WHO	World Health Organization

1. INTRODUCTION

1.1. The importance of the topic

Food security is one of the most important challenges of the current century specially in the developing countries as 15% of the population of developing countries face chronic hunger. However, human societies encounter crucial challenges ahead that could remarkably make the current worrying situation worse. The world population is expected to reach more than 9 billion by 2050 in which the share of developing countries in this population increase is approximately 100% (DIVISION 2020). In addition, RUANE & SONNINO (2011) argue that 70% of the world's population will be urban by 2050. Residents in urban areas are just food consumer while most agricultural activities take place in rural areas and the villagers are mainly engaged in agricultural activities and feed production and the rural areas play a vital role in food provision for the cities. On the other hand, urbanization and anti-poverty activities are expected to increase income. This increase in income and new lifestyle (i.e., urbanization) has changed people's demand for food as such demand for meat, oil and fish and dairy products increase and replaces demand for grains. Hence, FAO (2009) expects that the Global demand for food will increase by 70% in 2050.

The other challenge that affects the food security in the developing countries is the effect of climate change on the agriculture. Hazards and extreme events affect the crop yield (NOSRATABADI et al. 2020) changes the growth patterns and global warming have altered the pest distribution patterns leading to spreading disease among crops and livestock. The negative influence of climate change on food security is increasing and vulnerable areas already suffer from droughts and food insecurity in serious danger. The Global South, especially those are in Asia which are suffering from lack of land availability, experience a severe problem in both food production and food availability. It is worth mentioning that the World Bank introduced the term of Global South, contrasts to the Global North, that refers to the low- and middle-income countries in Asia, Africa, and Latin America. According to the United Nation (UN) organization, however, there are sufficient food for all the current population of the world and the main problem of food security currently is in the food accessibility (RUANE & SONNINO 2011).

1.2. Problems to solve: Food Security

Food Security means that all humans will always have the ability and access to the nutrition and the food preference they need for a healthy life (SCHMIDHUBER & TUBIELLO 2007). Food security constitutes four pillars: 1) food availability, 2) food accessibility, 3) food utilization, and 4) food system stability (Ruane and Sonnino 2011). Food availability refers to the availability of high quality and nutritious food produced and processed from various sources from local to international whether have produced or processed in the local or international regions. For a region, for example, that produces, exports and imports food the availability of food is not an issue. Three major factors affect the food availability within a country: 1) local food production, 2) food stocks, and 3) imported food production. Improving the national food production increases the food availability. To do so, investing on the infrastructure and transportation (NARROD et al. 2009, VAN DEN BROECK & MAERTENS 2016b), management of land use, water management, and management of labor resources are necessary (VAN DEN BROECK & MAERTENS 2016). Such investments decline the transportation costs of moving the product from rural areas to markets that may increase the farmers' incomes and food diversity which consequently improve food accessibility.

In addition, export of food surplus is one of the most important approach can increase the food availability, because it, firstly, transfers the food from a place encountering surplus of food supply to a place in which the food demand has not been seen by the local food production and secondly, it increases the economic power of the parties engaging in export of food such as the farmers, the processors, distributors etc. There is evidence that increasing the food price not only does not affect the food security, but also it increases the food export and food availability (VERPOORTEN et al. 2013).

Food accessibility means that people should have both physical and economic access food, in order to have a healthy life. This dimension of food security covers different aspects such as purchasing power the right food, food distribution systems, transportation infrastructure, appropriate school meals for children. Food accessibility refers to the ability of people to access to adequate food and food nutrition which are necessary for a healthy life. In other words, the economic state of individuals is very determinant. Of course, access to food can be direct also it means that the farmers, for example, can consume his/her own production. Therefore, in addition to the economic power/purchase power, accessing to productive resources increase the food access. There is ample evidence indicating that income influence the access to food in developing countries (e.g., NARAYANAN 2014; CARLETTO et al. 2011; BECCHETTI & COSTANTINO 2008). Hence, VAN DEN BROECK & MAERTENS (2016) believe that engaging the farmers in export chain increases the farmers' income which enhances their purchase power subsequently, it amends access to food.

The third pillar of food security is food utilization that implies the access to the safe and healthy food with proper nutritious for all age groups. This pillar of food security comprises food safety and accessing to clean water also. Food system stability refers to a food system that is able to supply the adequate food to the society and this system is so stable that economic and climate shocks do not affect its performance (RUANE & SONNINO 2011). To reach food security, the objective of all the four pillars should be meet simultaneously. In other words, lack of even one of these 4 pillars for food security will lead to food insecurity in which people does not access to the adequate safe healthy food and nutrition due to either poverty or improper distribution and lack of infrastructure to supply the food.

Based on the Food and Agriculture Organization (FAO) report, 2014 million of the world population are undernourished (see Table 1) while 51.5% of undernourished people are in Asia. Besides, there are 704 million people in the world that encounter the severe food insecurity in which 50% of them are in Asia too (FAO et al. 2019).

Table 1. Distribution of people facing with moderate or severe food insecurity in 2018

	World	Asia	Africa	Northern America and Europe	Latin America
Total Population	7633 million	4545 million	1288 million	1106 million	608 million
Moderate or severe food insecurity	2014 million	1039 million	676 million	89 million	188 million
Severe food insecurity	704 million	354 million	277 million	11 million	55 million

Source: Author's compilation

1.3. The importance of food security in the Middle East

According to the FAO annual report on food security and nutrition in the world, the number of people in Western Asia facing undernourishment has increased from 20.1 million to 33.7 million from 2010 to 2018. Western Asia is the only region in Asia in which malnutrition is increasing, especially in countries experiencing a popular uprising (see Figure 1). It is worth mentioning that in this report Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, United Arab Emirates and Yemen are categorized in Western Asia.

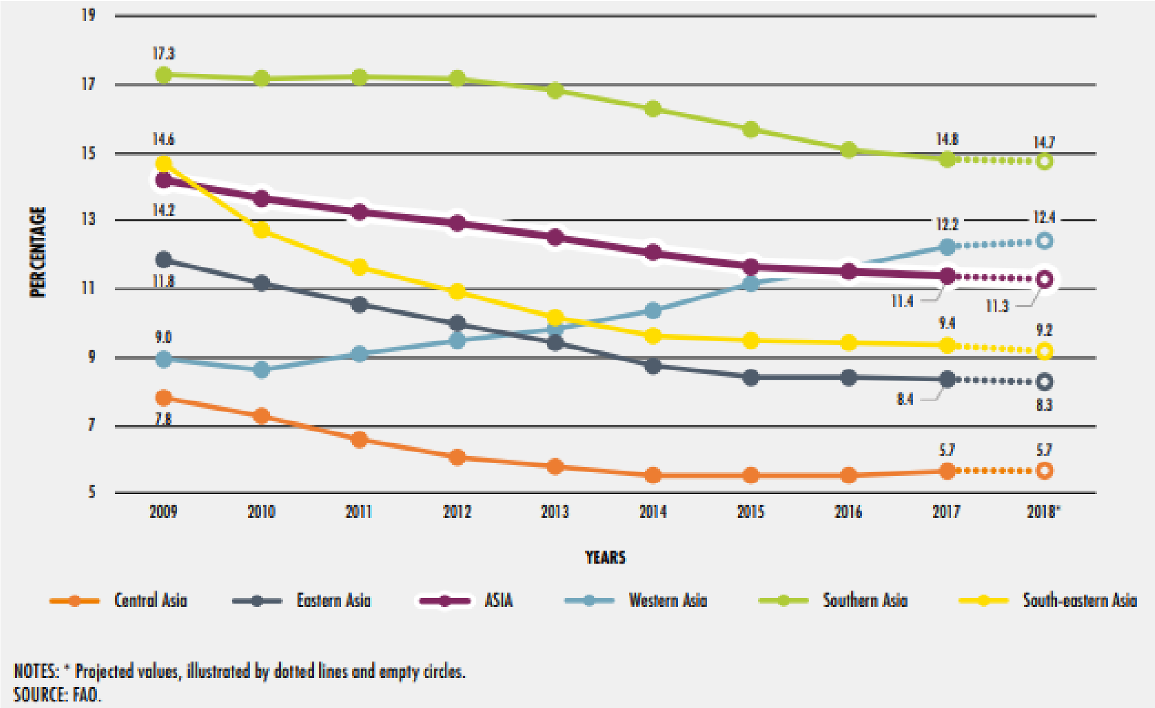


Figure 1. Undernourishment status in different regions of Asia

Source: Adapted from World Health Organization (WHO) (2019)

Globally, 2013.8 million were exposed to moderate food insecurity in 2018, an increase of 317.5 million compared to 2014, in which 704.3 of them are in severe food security, 119.3 million more than in 2014. Figure 2 also discloses that 80.2 million encountered with food insecurity in 2018 in western Asia that this number increased by 6.5 million compared with 2014. The number of people faced severe food insecurity also increased by 5.1 million from 2014 to 2018.

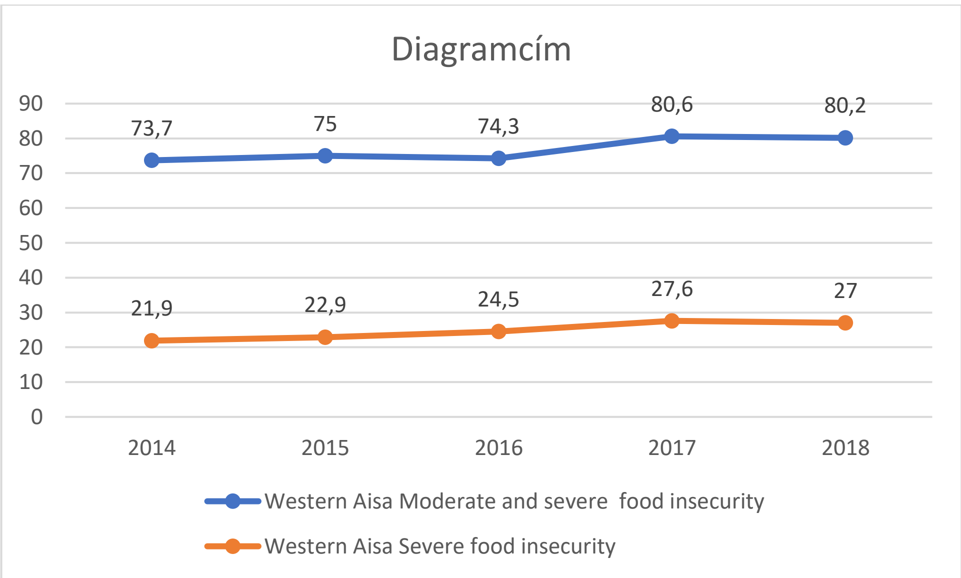


Figure 2. The increase of food insecurity in Western Asia from 2014-2018

Source: Adapted from WHO (2019)

Although the number of people encountering sever food security reported 27 million in 2018, which is only 0.03% of people in the world are at risk of severe food security, the percentage of people are exposed to moderate and severe food security in Western Asia is higher than the world (see Figure 3). Figure 3 shows that the percentage of people are in the risk of food insecurity have been always higher the world average where 29.5 percent of the population of Western Asia are exposed to the food insecurity in 2018.

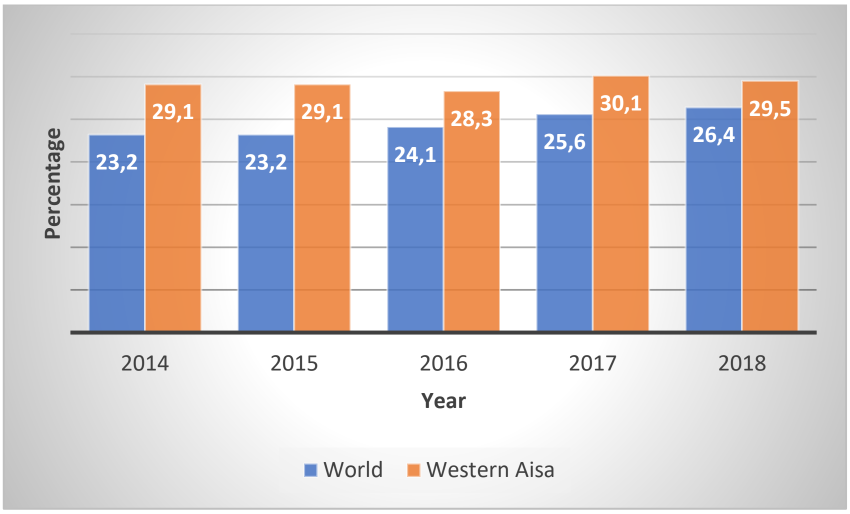


Figure 3. Comparison of food insecurity in Asia and the world

Source: Adapted from WHO (2019)

There are many reasons for the increase food insecurity, one of which is urbanization. Urbanization is expected to accelerate in the next few decades, with two-thirds of the world's population living in metropolitans by 2050 (BREARS 2016). Urbanization and related demographic changes in developing countries result in problems in food insecurity. Therefore, the pressure to adjust food systems in developing countries, where urbanization is occurring faster, is increasing substantially as urbanization will occur in some of the world's most fertile agricultural land (SETO et al. 2012; D'AMOUR et al. 2017). Hence, the impacts and consequences of urban dispersion on agricultural production in developing countries have been recognized and food security issues have increasingly attracted the attention of researchers (SONNINO 2016). According to HATAB et al. (2019) population growth in developing cities is steadily increasing, leading to employment problems, urban population nutrition and environmental protection. Due to the scarcity of freshwater resources, farmers are increasingly turning to wastewater for irrigation, which in turn presents a wide range of health risks (FANG et al. 2007; GOBER 2010).

In addition, one of the consequences of urbanization and economic development is the increase of demand for animal-based foods, while ranching intensifies the impact of agricultural production on natural resources (THORNTON 2010; HERRERO et al. 2009) and MAXWELL & SLATER (2003) argue that food security issues are intertwined with the loss of agricultural land.

According to MAXWELL & SLATER (2003), the food system in developing countries affected by industrialization, urbanization, and technological transformations is undergoing a change that requires new and different food policies. Therefore, they believe that new appropriate food policies are necessary to secure food and to pace with the global food system transformations.

1.4. How to achieve global food security

There are many solutions available to tackle food insecurity, including investing in agriculture and increasing access to feed. 500 million small farms comprising about two billion people operate in the agriculture sector. Indeed, the agriculture sector is responsible for more than fifty percentage of employment across developing countries. According to RUANE & SONNINO (2011) governments' budgets for agriculture around the world have been cut. From 1980 to 2002, for example, the total government expenditure on agriculture decreased from 14.8 to 8.6% in Asia. Therefore, an increase in the investment on the agriculture can be a giant step in diminishing hunger and food insecurity. On the other hand, many scientists believe that food accessibility is also the most important issue on the road to realizing food security. RUANE & SONNINO (2011) believe that designing programs that provide safe foods to the poor and vulnerable people is a suitable solution to food security. They recommend safety net policies such as food price subsidies, in-kind transfers (e.g., school meals), food stamps, etc. are very effective to eliminate the food insecurity as FAO reports that such policies have been successfully implemented in Brazil and Ethiopia.

There are many actors in the global food supply chain, and each of them plays an important role in the production and provision of food. Innovation of business models of active businesses in the food supply chain can play an effective role in optimizing food supply and ultimately food security. For this reason, in the present study, the role of business model innovation in food security is also discussed in detail. In addition to businesses, people themselves can play a role in reducing food security. Studies have shown that the social capital created in communities can offer many benefits to members of that community. These communities can play an effective role in reducing food insecurity and providing food to their members in different ways. Therefore, the present study deals in detail with how social capital can provide solutions to reduce food insecurity.

2. OBJECTIVES TO ACHIEVE

FAO (2019) introduces climate shocks, economic slowdowns, and conflicts as the main driving forces of food insecurity specially in the low and middle-income countries. To evaluate the "conflict", FAO (2019) considers if a country has suffered at least 500 war casualties for five consecutive years. Climate variability is also defined if the cereal yield of a country affected by the climate factors. According to FAO (2019), the Economic downturns refer to the negative economic growth that a country experience. In 2018, conflict faced 74 million people with severe food insecurity and climate shocks and Economic shocks were respectively driver of severe food insecurity for 29 and 10.2 million people. Economic shocks elongate and worsen the effect of have also prolonged and ed the impact of conflict and climate events on food insecurity. Due to the high importance of food security in Western Asia, where most countries are developing and food insecurity in this area is increasing every year, the present study seeks to provide appropriate solutions to counter food insecurity in the countries of Iraq, and Turkey, of Western Asian countries, and of Iran, of Southern Asian countries. To do so, the current study is going to address the following research questions (RQs) and Hypotheses:

RQ1: Do the machine learning models have the ability to predict domestic food production?

RQ2: What will be the domestic livestock production in Iran in the next ten years?

RQ3: What will be the domestic agricultural production in Iran in the next ten years?

RQ4: What will be the domestic livestock production in Turkey in the next ten years?

RQ5: What will be the domestic agricultural production in Turkey in the next ten years?

RQ6: What will the domestic livestock production in Iraq in the next ten years?

RQ7: What will be the domestic agricultural production in Iraq in the next ten years?

RQ8: How does business model innovation contribute to the food supply chain?

RQ9: How does social capital improve food security?

Based on the research questions and objectives, the hypotheses are:

H1: Machine learning models are able to predict the food production.

H2: Machine learning models have the ability to predict the future trend of domestic livestock production in Iran.

H3: Machine learning models have the ability to predict the future trend of domestic agricultural production in Iran.

H4: Machine learning models have the ability to predict the future trend of domestic livestock production in Turkey.

H5: Machine learning models have the ability to predict the future trend of domestic agricultural production in Turkey.

H6: Machine learning models have the ability to predict the future trend of domestic livestock production in Iraq.

H7: Machine learning models have the ability to predict domestic the future trend of domestic agricultural production in Iraq.

3. LITERATURE OVERVIEW

3.1. Introduction

The overall objective of the current study is to provide individual solutions to Iran, Turkey, and Iraq, to deal with food security for the next generation. Therefore, the wide literature is reviewed to figure out how current the research deal with food security issues in these regions. To do so, a systematic literature review named PRISMA is conducted to maximize and optimize to find the most relevant publications. This methodology includes four main stages to make a database for review and analysis. The first stage of this method is identification in which the documents are found based on the primary search on the databases and other possible sources. The second stage is screening in which the documents found in the first stage are screened for duplications and those documents are found in more than one database are eliminated. In addition, the title and abstract of the remain documents are carefully read to check if they are eligible and relevant to the focus of the study or not. Only the relevant documents go to the next stage that is eligibility. In this stage the full text of the documents is precisely read, and the irrelevant documents are deleted. The last stage of the PRISMA model called included in which documents from the previous stage are considered as the database of the study and all the final analyses done on these documents (LIBERATI et al. 2009). Accordingly, terms of "food security" was inquired on Scopus database. The search inquiry limited to the Title-Abstract-keyword and then the publications were categorized based on the country of origin. Results of initial search emerged 20001 documents (the identification stage). Only the articles related to Iran, Turkey, and Iraq considered. Hence, 19511 documents are eliminated from the primary search and only 459 relevant articles considered for further analysis. Figure 4 illustrates that the search query resulted in 258 documents related to food security in Iran, 174 documents that addressed food security in Turkey, and 27 documents that investigated food security issues in the context of Iraq (the screening stage).

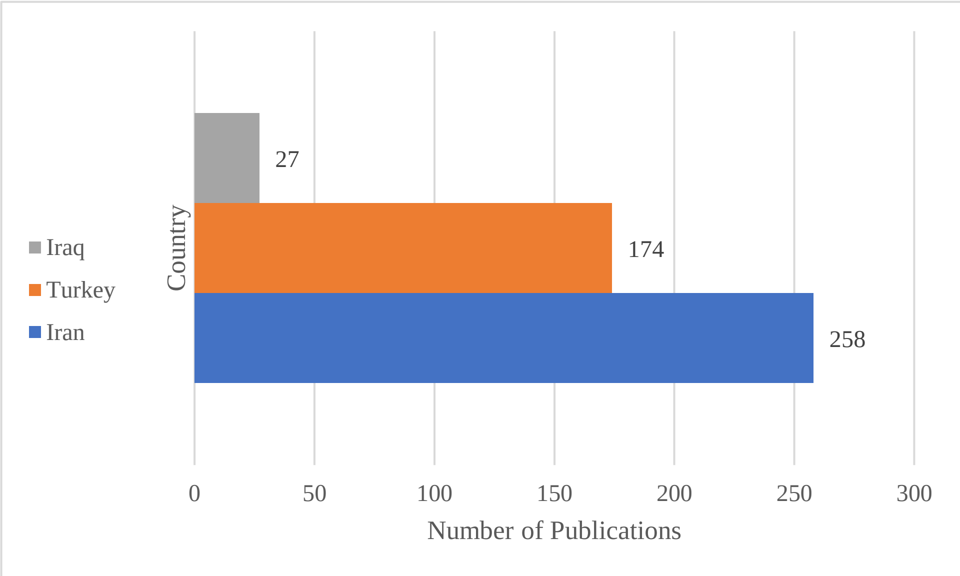


Figure 4. Results of primary search on food security and three countries of Iran, Iraq, and Turkey

Source: Author's framework

After reading the full text of the documents 459 documents omitted (the eligibility stage) and 46 documents considered suitable for the final analysis. In other words, the database of this study comprised 46 articles (the included stage). All the stages of PRISMA model are presented in Figure 5.

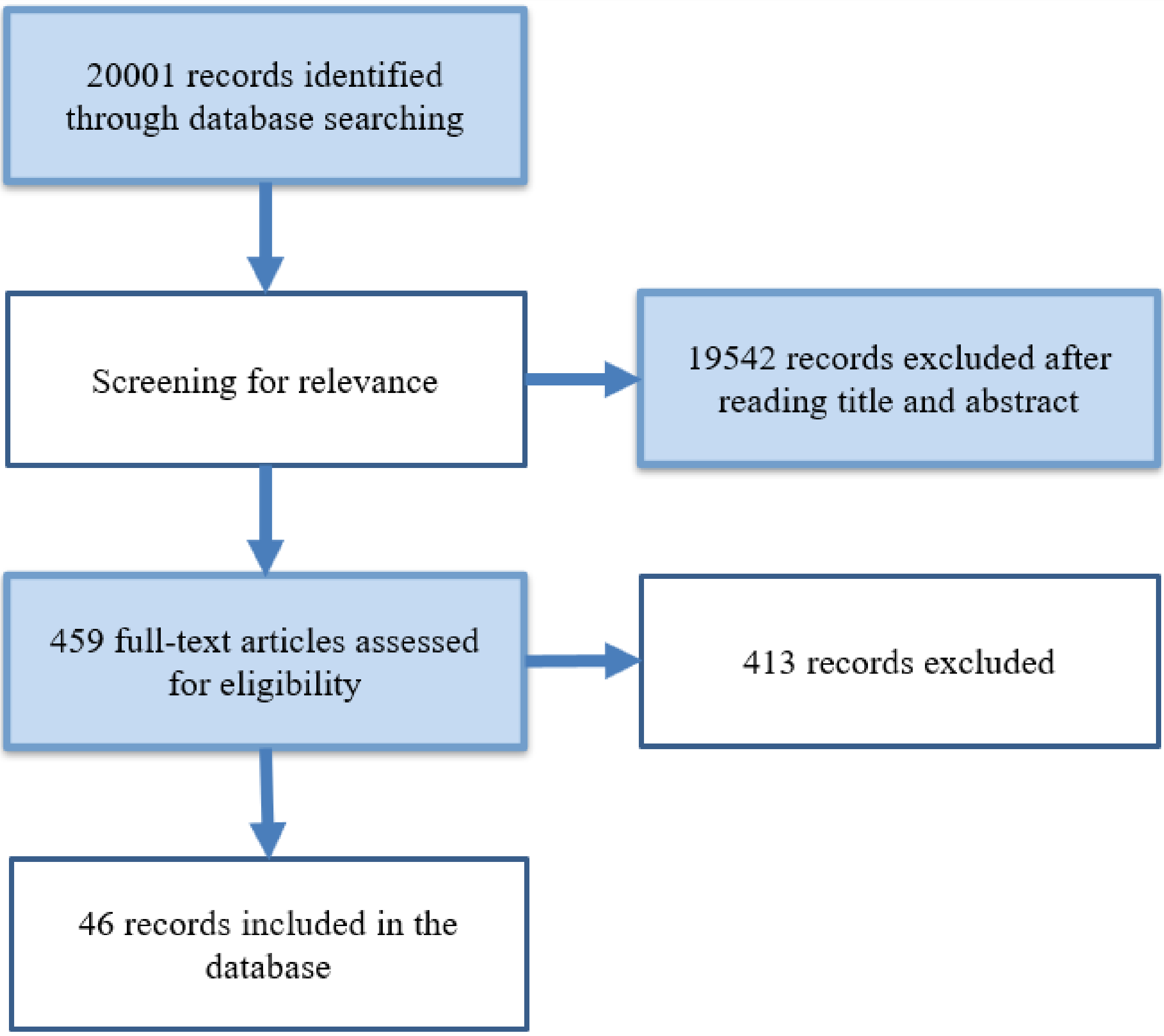


Figure 5. The Prisma model applied to form the database of the current study

Source: Author's framework

All the 46 documents of the database of the study were analyzed in details and it revealed that Iran, Turkey, and Iraq with respectively 29, 15, and 2 publications have the most publications addressing food security issues (see Figure 6). All the following analyses are based on this database and documents.

Figure 6. Geographical map of the number of published articles on food security in the countries under study

Source: Author’s framework

3.2. Food Security in Iran

Iran means the land of the Aryans by the official name of the Islamic Republic of Iran is a country located in southwest Asia and in the Middle East. According to world bank statistics the population of Iran was 81.16 million in 2017. With a total area of 1,648,195 square kilometers, Iran is seventeen largest country in the world. Tehran, the capital city of Iran, with the population of 9 million is the largest and most populous city. Tehran has been also considered the cultural, economic, political, and administrative center of Iran. Iran has large reserves of fossil fuels, which include the largest natural gas field in the world and the fourth largest discovered and confirmed oil reserves.

The database of the study includes 29 documents addressing food security issues in Iran. Figure 7 shows that the concern on this topic is exponentially increasing in Iran as the number of publications increased in the last decade.

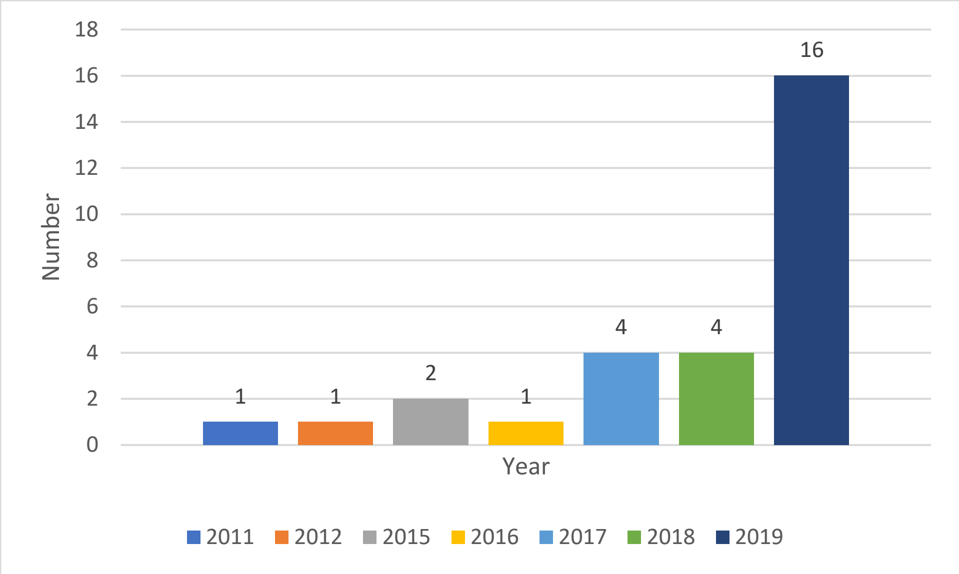


Figure 7. Published articles on food security in Iran by year

Source: Author's framework

Table 2 implies that these documents are publish through 22 different sources (journals, books, proceedings, etc.) in which Agricultural Water Management and Iranian Journal of Public Health with 3 publications and Ecology of Food and Nutrition, Progress in Nutrition, and Water (Switzerland) with 2 publications contributed the most in this area.

Table 2. Journals publishing food safety research in Iran

Journal title	Numbers
Agricultural Water Management	3
Iranian Journal of Public Health	3
Ecology of Food and Nutrition	2
Progress in Nutrition	2
Water (Switzerland)	2
African Journal of Biotechnology	1
Agriculture and Food Security	1
Bulgarian Journal of Agricultural Science	1
Cities	1
Current Research in Nutrition and Food Science	1
Energy Policy	1
Environmental Science and Pollution Research	1

Iranian Journal of Nutrition Sciences and Food Technology	1
Journal of Cleaner Production	1
Koomesh	1
Medical Journal of the Islamic Republic of Iran	1
Networks and Spatial Economics	1
Shiraz E Medical Journal	1
Sustainability (Switzerland)	1
Theoretical and Applied Climatology	1
Waste Management	1
Water Resources Management	1

Source: Author’s compilation

The 29 articles have contributed to the food security in the context of Iran are analyzed based on data collection methods and research types. Figure 8 displays that the vast majority of the articles have utilized a quantitative empirical research design (i.e., 90%) and 10% of the articles have used a qualitative research design. Figure 8 also discloses that questionnaire has been the most applied data collection tool among the articles, using secondary data, field experiment, and interview are respectively data collection methods have been frequently used among these articles.

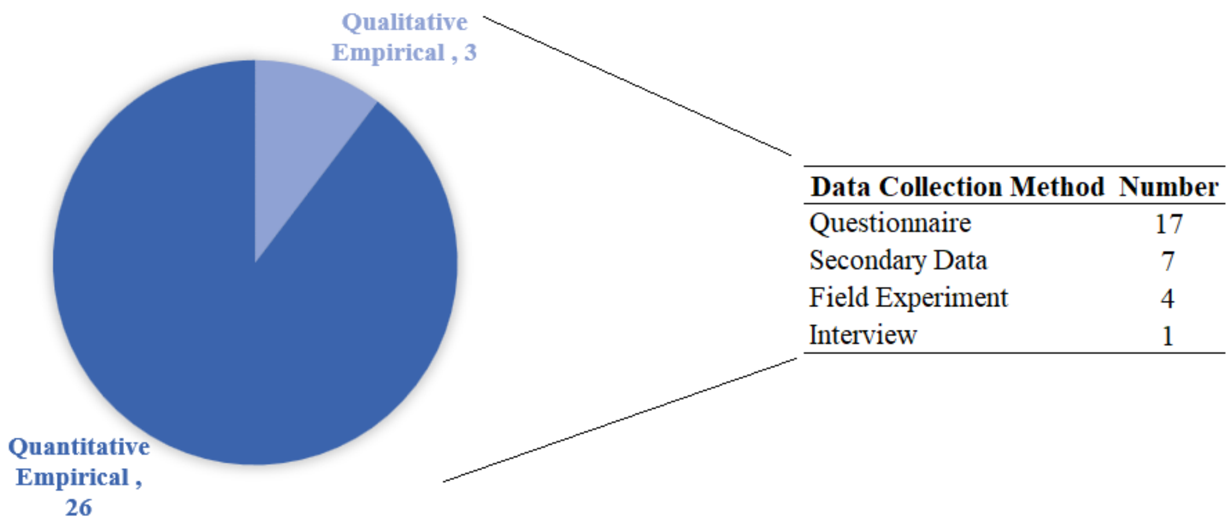


Figure 8. Research Type and Data Collection Method Qualitative

Source: Author’s framework

3.2.1. Food supply chain

The Food Supply Chain (FSC) includes various processes during which food move from farmers to end consumers (WUNDERLICH & MARTINEZ 2018). The FSC is the network of different players in which the food productions are produced and offered to meet the needs of end-customers. The FSC includes farmers, processors, distributors, retailers and consumers (e.g., HIGGINS et al. 2010; PLÀ et al. 2014). In such an FSC, farmers harvest raw materials, processors produce and pack end products, distributors deliver final goods to retailers, and ultimately, retailers are the final destination in which customers buy end products (WUNDERLICH & MARTINEZ 2018). Accordingly, the articles reviewed in this project were divided into four categories of agricultural, production, distribution, sales and consumption activities based on the focus of the article on each of these stages of the FSC. However, articles that did not focus on any of the FSC steps were moved to the fifth category called *general*. This classification sets out to determine at what stage of the supply chain the solutions provided by each of these articles to achieve food security. In Table 3 the articles that are categorized based on their focus on the FSC.

Table 3. Classifying the reviewed articles based on their focus on the food supply chain (FSC)

Explanation	Agricultural Activities	Consumption	General
Sources	PAYMARD et al. (2019), MEHRABI & SEPASKHAH (2019), RAEISI et al. (2019), TAGHIZADEH-HESARY, RASOULINEZHAD, & YOSHINO (2019), ESFAHANI et al. (2019), QASEMIPOUR & ABBASI (2019), AKHOUNDI & NAZIF (2018), EMAMI et al. (2018), MORSHEDI et al. (2017), KARANDISH & HOEKSTRA (2017), KARANDISH et al. (2015), KARIMI et al. (2012).	EKHLASPOUR et al. (2019), ESFARJANI et al. (2019), SOORANI & AHMADVAND (2019), FATHI BEYRANVAND et al. (2019), NAJAFI ALAMDARLO, et al. (2019), MOTLAGH et al. (2019), BARZEGAR et al. (2019), SIAHIPOUR et al. (2019), ASADI-LARI et al. (2019), HEIDARI et al. (2019), TABRIZI et al. (2018), CHERAGHI & KAZEMI (2018), HOSSEINI et al. (2017), YADEGARI et al. (2017), SHAHRAKI et al. (2016).	ABOLHASSANI et al. (2015), LASHGARARA et al. (2011).
Numbers	12	15	2

Source: Author’s compilation

Findings reveals that 15 out of 29 articles that addressed food security problems in Iran have concentrated on the consumption parts where the food security issues related to the households are mainly studied. 12 articles address food security issues related to agricultural activities such as water management, land use management, yield management, and so forth. There are four articles that fall into the general category because they focus on none of the stages of the FSC.

3.2.2. Solution Areas

After reading precisely the articles it turned out that the 65 articles have mainly addressed 7 different areas. In other words, the solutions that these articles have considered to tackle with food security issues are categorized in 7 areas including Socio-economic Features with 33 articles, Water Management with 12 articles, Food Security Strategies with 10 articles, Yield Management with articles 7, Land Use Management, Nutrition Management, and Overseas Cultivation each with 1 article (see Table 4). Socio-economic Features refers to the articles which investigated the relationship between socio-economic features with food security especially household food security. The water management category includes articles that have considered the topics related to the management of water as solutions to food security. The category of food security strategies comprises articles presents general strategies to food security in Iran. The categories of yield management, land use management, and nutrition management respectively include the articles to address the issues related to crop yield, land use and nutrition.

Table 4. Solution areas emerged from the literature for food security in Iran

Solution Area	Number
Household Food Security	11
Water Management	9
General Strategies	6
Waste Management	2
Overseas Cultivation	1

Source: Author's compilation

3.2.3. Food Security

Food Security means that all humans will always have the ability and access to the nutrition and the food preference they need for a healthy life (Schmidhuber & Tubiello 2007). Food security comprises four pillars: 1) food availability, 2) food accessibility, 3) food utilization, and 4) food system stability (RUANE & SONNINO 2011). Food availability refers to the availability of high quality and nutritious food produced and processed from various sources from local to international whether have produced or processed in the local or international regions. Food accessibility outlines that people should have both physical and economic access food, in order to have a healthy life. This dimension of food security covers different aspects such as purchasing power the right food, food distribution systems, transportation infrastructure, appropriate school meals for children. Food accessibility refers to the ability of people to access to adequate food and food nutrition which are necessary for a healthy life. The third pillar of food security is food utilization that implies the access to the safe and healthy food with proper nutritious for all age groups. This pillar of food security comprises food safety and accessing to clean water also. Food system stability refers to a food system that is able to supply the adequate food to the society and this system is so stable that economic and climate shocks do not affect its performance (RUANE & SONNINO 2011).

The database research solutions are then categorized and presented according to each of the food security pillars. Since only one out of 65 articles was related the food accessibility pillar, this pillar is presented with food availability. Two other categories also created. The first one labeled food security as the articles of this category present general solutions for food security in Iran and they don't address one of the pillars of food security. The second category includes only the articles referring household food security instead.

3.2.4. Food Availability and Food Accessibility

There is only one research has addressed food accessibility in the context of Iran. In this study, HOSSEINI et al. (2017) investigate the impact of Targeted Subsidies Policy (TSP) on various food commodities on the household food security in Iran. TSP increases the economic power of households that subsequently lead to improve in food accessibility of the households. Their results reveal that TSP had a positive impact on the household food security of some food items such as red meat and fish and it affected negatively other items such as poultry and cereals.

20 out of 65 articles worked on food security in Iran provided solutions to food availability. A close look at these articles reveals that the solutions of these 20 articles are centered around five main axes, namely water management, yield management, food security strategies, nutrition management, overseas cultivation (see Table 5). In addition, all the 20 articles have focused on the agricultural activities in the FSC. The solutions presented for each of the five areas are described below.

Table 5. Articles and solutions to address food availability in Iran

Solution Area	Source
Water Management	PAYMARD et al. (2019), MEHRABI & SEPASKHAH (2019), RAEISI et al. (2019), QASEMIPOUR & ABBASI (2019), AKHOUNDI & NAZIF (2018), KARANDISH & HOEKSTRA (2017), KARANDISH et al. (2015), KARIMI et al. (2012)
General Strategies Food Security	MORSHEDI et al. (2017)

Source: Author’s compilation

2.2.4.1. Water Management

According to KARANDISH & HOEKSTRA (2017), crop production, water footprint of crop production, and the blue water footprint respectively increased by 175%, 122%, and 20%, over the period 1980-2010, in Iran. They explain that not only has Iran's population increased by 90%, but also crop consumption per capita has increased by 20%. Such increases in population and consumption patterns have increased the total food consumption and the total water footprint of national crop consumption by 130% and 110%. Therefore, KARANDISH & HOEKSTRA (2017) articulate policies to reduce water footprint of crop production and adjust cropping patterns based on water availability and consumption patterns should be adopted to achieve food security and water management. QASEMIPOUR & ABBASI (2019) evaluate the virtual water trade and the water footprint in South Khorasan Province, a semi-arid area, Iran for crops and livestock products. Virtual water trade refers to the hidden flow of water if a product is traded from one place to another. Water footprint outlines the total amount of water used in production of a product. The results of their study disclose that despite the aridity of the area, eight out of 11 counties have been net exporters of virtual water and only Birjand is a net virtual water importer. QASEMIPOUR & ABBASI (2019) also figured out the average water footprint per capita in this region is 115 percent higher than the average national per capita in which crop production is responsible for 82.16% of the total water footprint. They argue that such intensive agricultural practices led in a water scarcity of 206%.

There are studies that provide solutions for managing water resources for agriculture to food security in Iran. RAEISI et al. (2019), for instance, recommend greenhouse cultivation in Tashk-Bakhtegan Basin, Fars, Iran to maximize saving water in irrigation. They evaluate the performance of three saving water systems naming deficit irrigation, replacing surface irrigation with drip irrigation and greenhouse cultivation. According to their results, although the deficit irrigation and drip irrigation respectively resulted in saving up to 12% and 8% water consumption, these approaches increase up to 94% more salt accumulation than surface irrigation. While greenhouse cultivation approach reduced the water consumption up to 24% reduction without salt accumulation. AKHOUNDI & NAZIF (2018) consider wastewater reuse applications as the solutions for water management for achieving food security goals. AKHOUNDI & NAZIF (2018) develop a mathematical algorithm based on the evidential reasoning (ER) approach which is a multi-criteria decision-making method to evaluate the sustainability of wastewater reuse alternatives. They this model in Tehran, Iran and according to the results industrial application, artificial recharge of groundwater, and agricultural irrigation are the potential wastewater reuse alternatives. They also claim that food security is the most important criteria affecting prioritization of the wastewater reuse alternatives. KARANDISH et al. (2015) consider the optimization of cropping patterns as a solution for water resources management in Sistan and Blouchestan province, Iran. Since this region is an arid area water management plays a critical role in food security in this region. They applied a virtual water trade assessment to design the optima cropping pattern in this area. KARANDISH et al. (2015) classify the productions in 6 classes of cereals, legumes, vegetables, oil crops, fruits, and potato. They found out incorrect distribution of crops in the current cropping pattern resulted in a high mean value of total virtual water. KARANDISH et al. (2015) accordingly, propose an optimal cropping pattern of potato followed by vegetables, legumes, fruits and cereals to minimize water use for irrigation. KARIMI et al. (2012) believe that groundwater is utmost important for food security and the use of groundwater for irrigated agriculture has increased over last decades in Iran. However, using groundwater for irrigation resulted in a reduction in groundwater reserves and it is a very energy consuming process to use such waters as it contributes to 3.6% of the total carbon emission in Iran. Hence, they come up with solutions such as developing better irrigation programs and improving the efficiency of field applications to increase water productivity without affecting the yields.

PAYMARD et al. (2019) believe that climate change leads to a higher temperature and drought in the future in Iran. Therefore, they tried to predict the impact of climate change on the rainfed wheat yield in Iran. According to their results, the mean monthly reference crop evapotranspiration and water requirement would likely increase. PAYMARD et al. (2019) claim that the northeastern part of Iran encounters drier climatic condition by 2100 and climate change decreases rainfed grain yield, water use efficiency, and precipitation use efficiency during that lead to wheat yield loss endangering food security in Iran. MEHRABI & SEPASKHAH (2019) propose to use partial root zone drying strategy, a water-saving irrigation strategy, for winter wheat. They recommend combining variable alternate furrow irrigation (VAFI), one of the Partial Root Zone drying approaches, with in-furrow planting and 150 kg N ha−1, to maximize the winter yield and water saving during the winter wheat growing season. Because VAFI increases leaf photosynthesis rate/ leaf transpiration (An/Tr) efficiency which leads to lower water supply.

3.2.4.2. General Strategies to Food security

MORSHEDI et al. (2017) Consider organic farming as a solution to improve food security in Iran. According to their results, using the modern technologies, considering the healthy and safe nutrition, and optimizing production are respectively the most important factors improving food security goals through the organic farming.

3.2.5. Food Utilization

Overall, 14 articles have provided solutions for food utilizations in Iran. Twelve of the 14 articles focused on the household food security in Iran and all of these articles have concentrated on the consumption part of the FSC. While the solutions of the other two articles are related to water management.

3.2.5.1. Household Food Security

Another trend in the literature of food security in Iran is evaluating of household food security and the effective factors on the household food security. In this research only articles providing solutions for and investigating effective factors on the household food security in Iran are considered. In this regard, 12 articles were found that mainly studied the effect of socio-economic features of family members on the households' food security (see Table 6) among which the food security related to women specially elderly women (e.g., CHERAGHI & KAZEMI 2018), pregnant women (e.g., FATHI BEYRANVAND et al. 2019; BARZEGAR et al. 2019; YADEGARI et al. 2017) has been more frequently studied. All these 12 articles introduce the economic status and the level of parental education, especially the level of education of mothers (e.g., EKHLASPOUR et al. 2019; ESFARJANI et al. 2019; FATHI BEYRANVAND et al. 2019; BARZEGAR et al. 2019), as factors that affect households' food security in Iran.

Table 6. Articles and solutions to address food utilization in Iran

Solution Area	Food Supply Chain	Source
Household Food Security	Consumers	EKHLASPOUR et al. (2019), ESFARJANI et al. (2019), FATHI BEYRANVAND et al. (2019), NAJAFI ALAMDARLO et al. (2019),

		MOTLAGH et al. (2019), BARZEGAR et al. (2019), SIAHIPOUR et al. (2019), ASADI-LARI et al. (2019), TABRIZI et al. (2018), CHERAGHI & KAZEMI (2018), YADEGARI et al. (2017), SHAHRAKI et al. (2016)
Waste Management	Consumers	SOORANI & AHMADVAND (2019), HEIDARI et al. (2019)

Source: Author's compilation

3.2.5.2. Waste Management

SOORANI & AHMADVAND (2019) and HEIDARI et al. (2019) believe that reduction the food waste can be resulted in food security through food utilization. SOORANI & AHMADVAND (2019) introduce attitude, perceived behavioral control, feeling of guilt, subjective norm, and intention of not wasting food as the effective factors to management of food consumption and avoiding food waste in Iran. In this regard, HEIDARI et al. (2019) develop models to predict and explain the intention to reduce food waste in Iran.

3.2.6. Food System Stability

Food system stability refers to a food system that is able to supply the adequate food to the society and this system is so stable that economic and climate shocks do not affect its performance. Results of the study of TAGHIZADEH-HESARY et al. (2019) illustrate that food price is affected by the energy price in Iran. In other words, fluctuations in oil price make unstable the food system in Iran. Therefore, they come up with solutions such as replacing fossil fuels with renewable energy to make the food system less vulnerable to the oil price.

3.2.6.1. General Strategies

ESFAHANI et al. (2019) See overseas cultivation to develop food security in Iran. ESFAHANI et al. (2019) define overseas farming as a kind of direct foreign investment in agricultural sector. They believe that in addition to requirements such as political, economic, social, and cultural requirements, agronomic specialties play a vital role in success of implementation of this strategy. Results of their study discloses that overseas cultivation improves the food system stability.

EMAMI et al. (2018) articulate that economic problems, environmental threats, especially water scarcity, the lack of adequate mechanization fleet, and the lack of a unified system for agricultural equipment are the main impediments to agricultural development in Iran. In order to achieve agricultural development in Iran, they also offer suggestions including modification of country cropping pattern according to the climatic conditions, modernization of mechanization fleet, and investment in research development of agriculture.

ABOLHASSANI et al. (2015) and LASHGARARA et al. (2011) propose solutions to improve household food security in Iran. ABOLHASSANI et al. (2015) believe that a considerable percentage of society receiving less than 70% of daily energy requirement that is the most important factor leading to food insecurity among the households in Iran. They also found that to improve household food security in Iran the policies related to the indicators such as food prices, per capita of dietary energy supply, and provision of micro-nutrient supply requirement per capita should be reconsidered. LASHGARARA et al. (2011) believe that increasing the awareness of rural households increase food security in rural areas in Iran. Therefore, they recommend using information and communication technology (ICT) to increase rural households' knowledge of food security. LASHGARARA et al. (2011) explain that workshop, exhibition, scientific trips, and printed materials are tools that can be used alongside television and radio to educate rural families. The summary of these studies is presented in Table 7 as well.

Table 7. Articles and solutions to address food security in Iran

Solution Area	Food Supply Chain	Source
Food Security Strategies	Agricultural Activities	EMAMI et al. (2018)
Food Security Strategies	General	ABOLHASSANI et al. (2015), LASHGARARA et al. (2011)
Overseas Cultivation	General	ESFAHANI et al. (2019)

Source: Author's compilation

3.3. Food Security in Turkey

Turkey, officially known as the Republic of Turkey, is a Eurasian country with a large part of the country, Anatolia, in northwest Asia and the Middle East, and a small part called Thrace in the Balkans (a region in Southeast Europe). Turkey with the total area of 783,356 km^2 is thirty-seventh largest country in world. Turkey is a mountainous and relatively fertile country. Turkey has a population of about 82 million (estimated 2018). Ankara, with the population of 4,338,620, is Turkey's second largest city after Istanbul.

At the final stage of screening the articles, it was revealed that 15 articles addressed Food Security in Turkey. It should be noted that only articles were selected that somehow provided a solution to Food Security. Figure 9 shows that the trends in addressing food security issues in Turkey is on the rise.

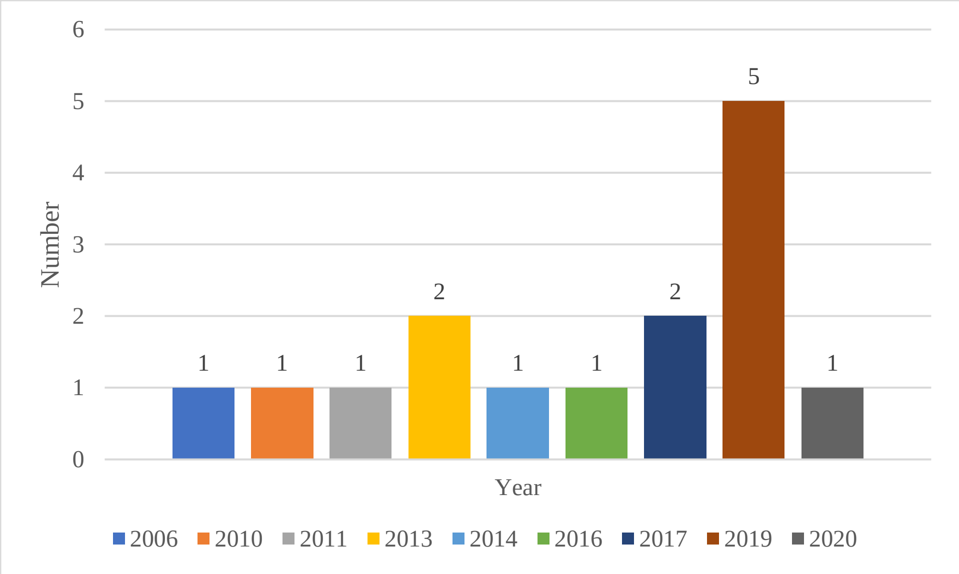


Figure 9. Numbers of publications on food security in Turkey

Source: Author's framework

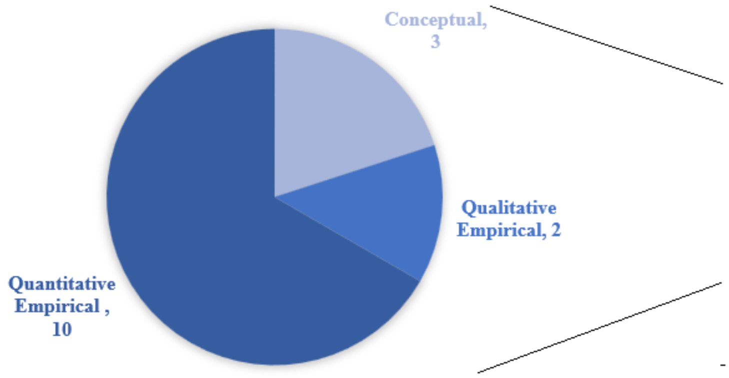
Fourteen of these 15 articles have been published in journals, and only one of them has been presented at an international conference. The list of these articles and their source is listed in Table 8.

Table 8. The sources of articles on Food Security in Turkey

Source title	Document Type	Source
Agronomy Research	Article	66
Ecological Indicators	Article	6
Environmental Monitoring and Assessment	Article	1
Environmental Science and Pollution Research	Article	7
Food Policy	Article	77
Forum for Development Studies	Article	17
Innovation and Knowledge Management: A Global Competitive Advantage	Conference Paper	150
Journal of Food, Agriculture and Environment	Article	157
Land Use Policy	Article	26
Pakistan Journal of Nutrition	Article	120
Plant and Soil	Article	16
Public Health Nutrition	Article	166
Tarim Bilimleri Dergisi	Article	131
Turkish Journal of Field Crops	Article	128
Turkish Journal of Veterinary and Animal Sciences	Article	59

Source: Author's compilation

Data collection method and research type of the articles are analyzed. Figure 10 shows that field experiment has been the data collection tools of 7 articles, 4 articles used secondary data, 3 articles that have been conceptual research used literature synthesis to develop their concept, and only one of the articles administered a questionnaire for data collection. It was also found that 10 of the articles applied a quantitative research design and 3 of them used qualitative research method to address the objective their research.



Data Collection Method	Number
Field experiment	7
Secondary Database	4
Literature Synthesis	3
Questionnaire	1

Figure 10. Data collection method and research type of the articles addressing food security in Turkey

Source: Author's framework

3.3.1. Food supply chain

The focus of the paper's proposed solutions on the food supply chain is another factor that has been analyzed in this study. Table 9 shows that food security solutions of 11 out of 15 articles are related to the agricultural activities in Turkey and the rest article focused on food distribution, food production, and consumption respectively with 2, 1, and 1 article.

Table 9. Classifying the reviewed articles based on their focus on the food supply chain (FSC)

Explanation	Agricultural Activities	Production	Distribution	Consumption
Sources	SEVIK et al. (2020), MURATOGLU (2019), VANLI et al. (2019), ASIF et al. (2019), IBAN & AKSU (2020),	YÖRÜK & GÜNER (2017)	GÖRMÜŞ (2019), ÖZKAN-	Esturk & Oren (2014)

	KONUKÇU et al. (2017), DEMIRDÖĞEN et al. (2016), CAGIRGAN et al. (2013), ŞIMŞEK & ÇAKMAK (2012), OZCATALBAS & AKCAOZ (2010), PEKCAN (2006)		GÜNAY & FEDA (2011)	
Numbers	11	1	2	1

Source: Author's compilation

3.3.2. Solution Areas

After reading precisely the articles it turned out that the 15 articles have mainly addressed 5 different areas. In other words, the solutions that these articles have considered to tackle with food security issues are categorized in 5 areas including General Strategy with 7 articles, Yield Management with 4 articles, Land Use Management with articles 2, Water Management, and Household Food Security each with 1 article (see Table 10).

Table 10. Solution Area of articles addressing food security in Turkey

Solution Area	Number
General Strategy	7
Yield Management	4
Land Use Management	2
Water Management	1
Household Food Security	1

Source: Author's compilation

3.3.3. Food Security

The solutions of the article are also checked and it was found that there is only one article that presents a general solution for the food security in Turkey and 9 articles address food availability issues, 3 articles deals with food accessibility problems, and 2 articles cope with food utilization issues in Turkey (See Table 11).

Table 11. Classification of the articles based on their focus on the food security pillars

Food Security	Source	Number

Food Availability	MURATOGLU (2019), VANLI et al. (2019), ASIF et al. (2019), IBAN & AKSU (2020), KONUKÇU et al. (2017), DEMIRDÖĞEN et al. (2016), CAGIRGAN et al. (2013), ŞIMŞEK & ÇAKMAK (2012), OZCATALBAS & AKCAOZ (2010)	9
Food Accessibility	GÖRMÜŞ (2019), ÖZKAN-GÜNAY & FEDA (2011), ESTURK & OREN (2014)	3
Food Utilization	SEVIK et al. (2020), YÖRÜK & GÜNER (2017)	2
Food Security	PEKCAN (2006)	1

Source: Author's compilation

PEKCAN (2006) provides a sort of solutions to deal with food security issues in Turkey. From her point of view the government and policy makers should firstly focus on policies increasing the income of vulnerable groups so that increase food accessibility. She also recommends policies and should support farmers, especially young farmers, to increase the productivity of animal and agricultural production. PEKCAN (2006) argues that providing the adequate nutrition for the society should be in the priority of agricultural policies. Finally, she proposes to extend training programs, such as Tele Food activities, that increase awareness and knowledge of all players in a food system to improve food security in Turkey.

3.3.4. Food Availability

3.3.4.1. Yield Management

Although CAGIRGAN et al. (2013) presents evidence that climate change and global warming have a positive impact on crop yields by removing sesame phyllody at West Mediterranean region of Turkey, there are studies have shown that climate change significantly threatens the food security in Turkey. There are three study in the literature investigated the impact of climate change on the wheat yield. VANLI et al. (2019) predict the impact of climate change on wheat yields in the two cities of Islahiye and Nurdagi in southeastern Turkey. The results of their study show that climate change and global warming will be resulted in a 16.3% reduction in the wheat yield in Islahiye and in a 13.0% reduction in the wheat yield in Nurdagi by 2050. Vanli et al. (2019) expect the wheat yields to decline more in the year 2100 in the provinces of Islahiye and Nurdagi, while Islahiye and Nurdagi will face a 16.8% and 14.4% drop in wheat yield, respectively. ASIF et al. (2019) believe that climate change, rising temperatures, and rising carbon dioxide dramatically affect wheat growth stages and cause irreparable damage to wheat yields. Thus, they recommend using macro (e.g., nitrogen: N) and micro (e.g., zinc: Zn) nutrients in chemical fertilizers to minimize the effect of climate change on the wheat yield. ŞIMŞEK & ÇAKMAK (2012) study wheat yield in different scenarios where temperature, solar radiation and precipitation vary. Their research results show that wheat yields have fallen by between 13.2% and 18.2% in different scenarios. It implies that climate change, however, will reduce wheat yields in Turkey (see Table 12).

Table 12. Summary of articles addressing food availability in Turkey

Solution Area	Food Supply Chain	Source
Yield Management	Agricultural Activities	VANLI et al. (2019), ASIF et al. (2019), CAGIRGAN et al. (2013), ŞIMŞEK & ÇAKMAK (2012)
Food Security Strategy	Agricultural Activities	Demirdöğen et al. (2016), OZCATALBAS & AKCAOZ
Land Use Management	Agricultural Activities	IBAN & AKSU, KONUKÇU et al. (2017)
Water Management	Agricultural Activities	MURATOGLU (2019)

Source: Author's compilation

3.3.4.2. General Strategy

DEMIRDÖĞEN et al. (2016) believe that there is a contradiction between food and fiber industry led to endangering food security in Turkey. Thy explain that the input supports, such as subsidies to agricultural activities, affect significantly crop productions. Subsidies to cotton significantly reduced the intention to grow food crops and policy makers should consider such intensives to increase the food crops than focusing on supports on farms outputs.

OZCATALBAS & AKCAOZ (2010) describe the importance of the role of women in food security in Turkey. They recommend that policymakers should focus on education activities to empower women so they can contribute more to the Turkish food system.

3.3.4.3. Land Use Management

IBAN & AKSU (2020) develop a Spatial Data Infrastructure (SDI) model to manage the land use in rural areas in Turkey. They claim that the novelty of their model in compare the existed SDI models in rural areas is that their proposed model integrated with Internet of Things (IoT) that allows the use of smart sensors to collect data to monitor natural events and other related parameters to land use management.

KONUKÇU et al. (2017) believe that land use management has been inadequate in Turkey for the last two decades, as poor management has threatened Turkey's food security. The results of their study reveal that industrial development and new reservoirs construction has increased the artificial area by 39.4% and 47.9%, while agricultural areas decreased by 32.1% in Ergene River Basin in Western Turkey. In this regard,

3.3.4.4. Water Management

Muratoglu (2019) studies the blue and green water footprint for Upper Tigris River Basin, Turkey. His finding discloses that 79% of total water footprint goes to crop production that 2% of which is dedicated to wheat production. After crop production, livestock farming and domestic plus industrial had the highest share of water consumption by 16% and 5%, respectively.

3.3.5. Food Accessibility

Three articles provide solutions to enhance food security in Turkey through food accessibility. Each of these articles have targeted different dimension of food accessibility. GÖRMÜŞ (2019) considers food banks as a solution to food security as making healthy food accessible to the poor is the main purpose of such entities. According to GÖRMÜŞ (2019) food banks are an example of targeted social provisioning of neoliberal economic policies that challenges the universalists. They articulate that food banks are part of progressive social policies that deals with the root causes of hunger in Turkey. ÖZKAN-GÜNAY & FEDAI (2011) argue that climate change affects the agricultural trade capability of Turkey. They explain that particulate emission damage declines agricultural trade capability of Turkey in the European food market, while, carbon dioxide emission level increases the agricultural trade capability, because it enhances the efficiency of agricultural production. ESTURK & OREN (2014) evaluate the household food security among the families in Adana, Turkey. Their finding reveals that the income level of the family has a significant positive impact on the food security of households. Therefore, to make accessible food in this region, they recommend the policy makers to consider the economic status of the family member to increase the food security among the households in this region (see Table 13).

Table 13. Summary of articles addressing food accessibility in Turkey

Solution Area	Food Supply Chain	Source
Food Security Strategy	Distribution	GÖRMÜŞ (2019), ÖZKAN-GÜNAY & FEDAI (2011)
Socio-economic Features	Consumption	ESTURK & OREN (2014)

Source: Author’s compilation

3.3.6. Food Utilization

Food utilization is about using healthy and safe food containing the adequate nutrition while, the results of SEVIK et al. (2020)'s research show that the heavy metal concentrations (such as Ni, Co) in fruits and vegetables grown in industrial zones and urban centers are higher than standards ones in Turkey that can be harmful to the public health. In addition, YÖRÜK & GÜNER (2017) proves that the production of 6 different companies, producing fermented sausage, salami, sausage, and hamburger meatballs, contains pathogen contamination. They argue that all these companies had the ISO 22000. Therefore, YÖRÜK & GÜNER (2017) recommend that to enhance food security and provide healthy food containing required nutrition, the hygiene of all the food supply chain, from growing animals to delivering product for consumption, should be seriously considered (see Table 14)

Table 14. Summary of articles addressing food utilization in Turkey

Solution Area	Food Supply Chain	Source
Food Security Strategy	Agricultural Activities	SEVIK et al. (2020)
Food Security Strategy	Consumption	YÖRÜK & GÜNER (2017)

Source: Author's compilation

3.4. Iraq

Iraq, officially known as the Republic of Iraq, is a country in the Middle East and Southwest Asia. Iraq with the area of is 437,072 km^2 is the fifty-eighth largest country in the world. Most of the land of Iraq is lowland and tropical. West of Iraq is a desert and east of it is fertile plains, but part of Iraqi Kurdistan (northeast) is mountainous and cold. Iraq is also one of the largest oil-rich countries. It has 5 billion barrels of confirmed oil reserves. According to world bank statistics in January 2014 Iraq is the 40th most populous country in the world, with a population of 32,585,692. Baghdad is the capital and one of the most important cities in the Arab world, with a population of 9.5 million reported in the census of 2008.

A preliminary search result in the Scopus database provides 27 articles on food security in Iraq. During the screening and after reading the title, the abstract and the full text of the articles finally found that only two articles provided solutions for food security in Iraq and the rest were irrelevant and were excluded from further investigation.

Table 15 illustrates that both of these articles have applied a quantitative empirical research method to address their problem and one of the articles administered a questionnaire to collect data and the other one used the secondary data. Table 15 also includes the title of the journals in which the articles are published.

Table 15. Summary of the articles addressing food security in Iraq

Journal title	Data Collection	Document Type	Research Type	Source
Plant Archives	Questionnaire	Article	Quantitative Empirical	AL-FATLAWI & AL TAIY (2019)
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	Secondary data	Article	Quantitative Empirical	WEICHENG et al. (2014)

Source: Author's compilation

3.4.1. Food Security

Table 16 shows that both articles on food security in Iraq focus on food access. The presented solutions of both articles are about agricultural activities in the food supply chain. AL-FATLAWI & AL TAIY (2019) present a general solution for food security in Iraq while the solution of WEICHENG et al. (2014) is related to land use management in Iraq.

Table 16. Summary of articles addressing food security in Iraq

Solution Area	Food Supply chain	Food Security	Source
General Strategies	Agricultural Activities	Food Availability	AL-FATLAWI & AL TAIY (2019)
Land Use Management	Agricultural Activities	Food Availability	WEICHENG et al. (2014)

Source: Author's compilation

3.4.2. General Strategies

AL-FATLAWI & AL TAIY (2019) consider greenhouses as tools for achieving food security and improving the incomes of farmers in Iraq. Results of their study reveals that due to two main reasons the farmers are reluctant to use greenhouses: 1) agricultural systems weakness and 2) institutional factors. AL-FATLAWI & AL TAIY (2019) elaborate that the local production does not have the adequate power to compete with imported production due to the lower prices of imported production. Greenhouses, on the other hand, do not have sufficient support to procure and manage greenhouses for the purchase of quality materials, plant protection against pests and the construction of agricultural warehouses.

WEICHENG et al. (2014) believe that Soil salinity is the main issue has affected crop production and food security in Mesopotamia, Iraq. Therefore, they develop a model based on remote sensing method to predict the salinity of the soil. WEICHENG et al. (2014) argue that the advantage of their proposed model with the other existed models is that this model minimize the problem caused by crop rotation and soil moisture content.

3.5. Business Model Innovation for Food Security

The world population is increasing by 3 billion by 2050 (WUNDERLICH & MARTINEZ 2018) which will be subsequently led in an increase in the demand for the food productions. On the other hand, the research has revealed that the calories consumption per person is increasing from 2250 kcal in 1960s to 2880 kcal in 2015 (PARDEY et al. 2014). Despite the acceptable performance of global food system in supplying food and decreasing the numbers of undernourished people, one in eight people were constantly suffering from undernourishment in 2014 (KEATING et al. 2014) and 815 million people in 2018 (UNITED NATIONS 2018).

In addition to the demand side, the research shows that the food supply is facing serious problems due to climate changes. Draught, rising temperatures, changes in precipitation regimes, increase of Carbon dioxide (CO_2) levels are named of the most critical issues have affected the yields of agricultural productions and it is predicted that the severity of these issues will be more in the next 50 years (PARRY et al. 2004). Such change will be subsequently resulted in socio-economic factors such as the increase of the prices (POPP et al. 2019). Hence, to meet this steady increasing food demand the current food supply chain system and activities should be reconsidered.

The FSC consists of a chain of activities elaborating how a product is produced and delivered to the final consumers. At each stage of the chain, value or values are added to the product by each player of the FSC (i.e., farmers, processors, distributors, and retailers). Therefore, along with the supply chain there is a chain so called value chain explaining the value/values are added to a product in each step. In other words, numerous actors perform in each stage of the FSC to produce a final product from a raw material and deliver it to the final consumers. Each of the entities have their own objectives which may be contrasted with the other actors as the activities of each entity influence the performance of the whole supply chain (HIGGINS et al. 2010). The concept of business model provides the ability to design and analyze the value a business is offering and delivering to its customers (NOSRATABADI et al. 2019). The business model explains the position of a business in the value chain (MOSLEH & NOSRATABADI 2015). All the FSC actors have their own business models, and they try to do their best to design elegantly and accurately their own business models so that improve their competitiveness. Moreover, factors such as social factors (BUSBY et al. 2016), economic and the environmental factors (BORODIN et al. 2016) affect the design of business models of businesses in the food supply chain. Therefore, survival in the FSC is hard to manage (AHUMADA & VILLALOBOS 2009) and it depends on the uniqueness of the business model.

Hence, analyzing the business model of all the FSC players can provide the answers for many questions related to food supply. In addition, any action to increase the food supply for meeting the future demand for food can be related to the business model of the FSC players.

The food supply chain (FSC) comprises a number of stages in which food travels from the farmers to the final consumers (WUNDERLICH & MARTINEZ 2018). In other words, a network of different actors in each stage of the FSC produces and delivers a final product to meet final customers' needs. Much research is conducted to investigate and analyze the FSC, while the general consensus is that the main FSC actors are farmers, processors, distributors, retailer and consumers (e.g., HIGGINS et al. 2010; ZONDAG et al. 2017). Where the farmers harvest the initial production, processors produce the final products and packages them, distributors supply the final products to the retailers and finally the retailers are the ultimate places that consumers purchase the products (WUNDERLICH & MARTINEZ 2018). To analyze the FSC in the current study the proposed model of VAN DER VORST (2014) is admitted. According to VAN DER VORST (2014) the FSC consists of farmers, food processors, distributors, retailers and consumers handling.

The concept of business model provides the opportunity for the entrepreneurs and organizational decision makers to analyze the logic of their businesses (ZOTT et al. 2011). Indeed, the business model simply explains what values a business creates, to whom, and how it can make money through this value creation and value delivering processes (ZOTT et al. 2011). many frameworks and models are offered in the literature to analyze a business model but all the models strive to explain four main aspects of a business: 1) value proposition, which refers to the product and services the business is providing, 2) value delivering, which implies the mechanisms the business is connected with its final customers to deliver the products and services to them, 3) value creation, points out the main activities which are necessary to create and deliver the values to the customers, and 4) value capturing, which indicates the ways a business makes money through the value creation and delivering processes (CHESBROUGH 2010).

According to GAMBARDELLA AND MCGAHAN (2010) business model innovation (BMI) is the adoption of novel approaches to commercialize underlying assets. In other words, when a BMI happens that value proposition and the business logic are changed. AMIT AND ZOTT (2012) believe that BMI can be occurred in three ways: 1) doing the current business and bonding the current activities in new ways, 2) innovation in the ways the current activities are performing, and 3) formulating new activities. Many driving forces are mentioned in the literature that induces the businesses to innovate their business model. New inventions, human capital, and new technologies are spelled as the most frequently reasons imposing the businesses to reconsider their business models (GRABOWSKA 2015). BMI is just not a passive response to the environmental changes, but also it has been considered as a strategy to take advantages of the changes and create competitive advantages for the business (ULVENBLAD et al. 2019).

Concluded from the aforementioned, the active firms in the FSC encounter with five strategies to innovate their business model: 1) innovating the value proposition, 2) reconsidering the value delivering mechanisms, 3) innovating the value creation processes, 4) providing new value capturing models, and 5) proposing a quite new business model.

There are studies which have provided solutions to BMI of the firms and entities of the FSC. Table 17 classifies these 25 documents based on their focus on the FSC and the business model strategies. It means that the documents are firstly classified according to which part of the supply chain is focused on the purpose of the article. On the other hand, the position of each document in each row of Table 17 reflects the business model strategy that the document has applied to BMI. Each of these articles is described below in detail on the basis of their position in the value chain.

Table 17. Business model innovation and value chain and Business model strategies

Explanation	Farmers	Processors	Distributors	Retailors	Consumers	The entire supply chain
Value Proposition		KÄHKÖNEN (2012)		DI GREGORIO (2017), HUANG et al. (2009),	MARTINOVSKI (2016)	
Value Creation	PÖLLING et al. (2017b)					
Value Delivering			SHIH & WANG (2016), KIM et al. (2014)	KAUR & KAUR (2018), PEREIRA		

				et al. (2018)		
Value Capturing						
Business Model	PÖLLING et al. (2017a), VARELA-CANDAMIO et al. (2018)	LIBERTI et al. (2018), VOJTOVIC et al. (2016), GIACOSA et al. (2017), JOLINK & NIESTEN (2015)	BERTI et al. (2017), MARTIKAINEN et al. (2014)	CHEAH et al. (2018), FRANCESCHELLI et al. (2018), RIBEIRO et al. (2018), LU et al. (2010)		ADEKUNLE et al. (2018), BARTH et al. (2017), PAHK & BAEK (2015), ULVENBLAD et al. (2018)

Source: Author's compilation

3.6. Social Capital and Food Security

Food security can be realized by accessing a balanced diet and essential nutrition for a healthy life (SCHMIDHUBER & TUBIELLO 2007). Achieving food security has become one of the most important goals of governments and international organizations. The number of people exposed to food insecurity is on the rise at a fast-paced. Vulnerability to food security has significantly risen from 1693.3 million, in 2014, to 2013.8 million in 2018 (FAO 2019). It is estimated that around 704.3 million people had faced severe food insecurity in 2018 (FAO 2019). Rapid population growth, changing lifestyles, and international institutions' efforts to alleviate poverty are factors that have fueled the growing demand for food. It is estimated that the world's population will exceed 10 billion by 2050 (WUNDERLICH & MARTINEZ 2018), while the number of undernourished people has been increasing since 2015 (FAO 2019) as it has reached 815 million in 2018 (RICKARDS & SHORTIS 2019).

According to SCHMIDHUBER & TUBIELLO (2007), there is food security when all human beings have access to the nutrition and food preferences needed for a healthy life. To measure food security, RUANE & SONNINO (2011) consider four criteria: Food availability, food accessibility, food utilization, and food system stability. As food availability indicates that high quality and nutritious food should be available in a region, regardless of whether it is produced or processed locally or internationally. Food access means that people need to be able to access food both physically and economically. Food utilization refers to the fact that all age groups should have access to healthy food that includes proper nutrition to live a healthy life. Ultimately, food system stability explains a system that provides enough food to the community and is also resilient to economic and climate shocks.

On the other hand, there is ample evidence that climate change has had a negative impact on crops and food productions. Climate change has led to droughts that have dramatically diminished agricultural yields as temperatures rise and changes in precipitation regimes, and it is expected that the impacts will be even exacerbated by 2050 (PARRY et al. 2004).

Social capital can contribute to food security through the synergy that is created from the interrelationship among community members at every stage of the food supply chain from production to consumption. In fact, social capital is the benefits that society derives from the interaction between different networks and groups (KANSANGA et al. 2020). Interpersonal relationships within social networks provide benefits to individuals through trust and social support (i.e., bonding capital). On the other hand, the interrelationship between these social networks will bring benefits to each of these networks by exchanging information, resources, and support (i.e., bridging capital) (XU et al. 2020). In the literature, the total benefits that individuals receive from membership in social groups and the benefits that society and each of these groups get from interacting with one other are called social capital (XU et al. 2020). Social capital, the synergy resulting from members of a community's interactions, brings benefits to community members and is a tool that members of a community can use as a solution to problems, such as food security. KANSANGA et al. (2020) believe that social capital is the resources that are created in human networks with common norms that facilitate social transactions and facilitate achieving the common goals of society for members. Social capital is identified through social organization characteristics, such as trust, norms, and networks.

without giving reasons why such a comprehensive definition is useful to our understanding of the social world. Several authors have defined social capital in an even more inclusive way, where even attitudes towards others, for example, appear: Social capital outlines trust, concern for others, desire to live according to the norms of one's society and to punish those who oppose it (BOWLES & GINTIS 2002). The literature proves that social capital and the synergy resulted from interactions among community members improve food security status, both directly and indirectly.

4. MATERIALS AND METHODS

4.1. Introduction

This chapter describes the methodology of this research in detail. This chapter includes the data source, a description of the machine learning models employed in this research and their applications, as well as accuracy metrics. It should be noted that these accuracy metrics are the criteria by which the predictive accuracy of the models used is examined. In this study, to predict a country's food production, the performance of two models, Adaptive Network-Based Fuzzy Inference System (ANFIS) and Multilayer Perceptron (MLP), are compared.

4.2. Data

To find the most appropriate predictive model for the prediction of domestic food supply for the next two decades in Iran, Turkey, and Iran MLP and ANFIS models are applied. Agricultural production and Livestock production of a country considered as domestic food supply of the country. To measure Livestock production, three variables of livestock yield, live animals, and animal slaughtered were evaluated. And to evaluate the agricultural production, two variables of agricultural production yields and losses were considered. It should also be added that the related data collected from the FAO database, i.e., FAOSTAT, that can be accessed on http://www.fao.org/faostat/en/#home. Since this database consists only of data related to the period 1961-2017, the analysis is based on this available data.

4.3. Multilayer Perceptron (MLP)

A multilayer perceptron (MLP) is a category of artificial neural network (ANN) that benefit from a Supervised learning technique called Backpropagation in the training phase (ROSENBLATT 1961). An MLP model uses a three-layer architecture which is composed of an input layer, a hidden layer and an output layer (see Figure 11). Hidden and output layer neurons apply a nonlinear activation function that enable the model to separate nonlinear data, which distinguishes this model from a linear perceptron. MLPs are universal function approximators (CYBENKO 1989) generating mathematical models using regression analysis. Therefore, MLP is widely used to design classifier algorithms. Hence, this model is widely used in applications such as speech recognition (ZHU et al. 2005), image recognition (CODRESCU 2014; GREENBERG et al. 1995), and machine translation (SHIMANAKA et al. 2019), Pattern-based forecasting (PEŁKA & DUDEK 2019) etc.

Research in agriculture and food has also benefited from MLP and this method has been used to solve various research problems such as yield prediction (e.g., ZHANG et al. 2019; BHOJANI & BHATT 2020; KALE & PATIL 2019), food quality assessment (e.g., LAM et al. 2020; CONCEPCION et al. 2019; PAREWAI et al. 2020), food contamination evaluation (e.g., URBINATI 2019; BUDIATI et al. 2020; BAGHERI et al. 2020), food image (e.g., UDAYANA et al. 2020; TAHIR et al. 2020), semantic analysis for costumer behavior prediction (e.g., SINGH & VERMA 2020), soil temperature prediction (e.g., SHAMSHIRBAND et al. 2020), and etc.

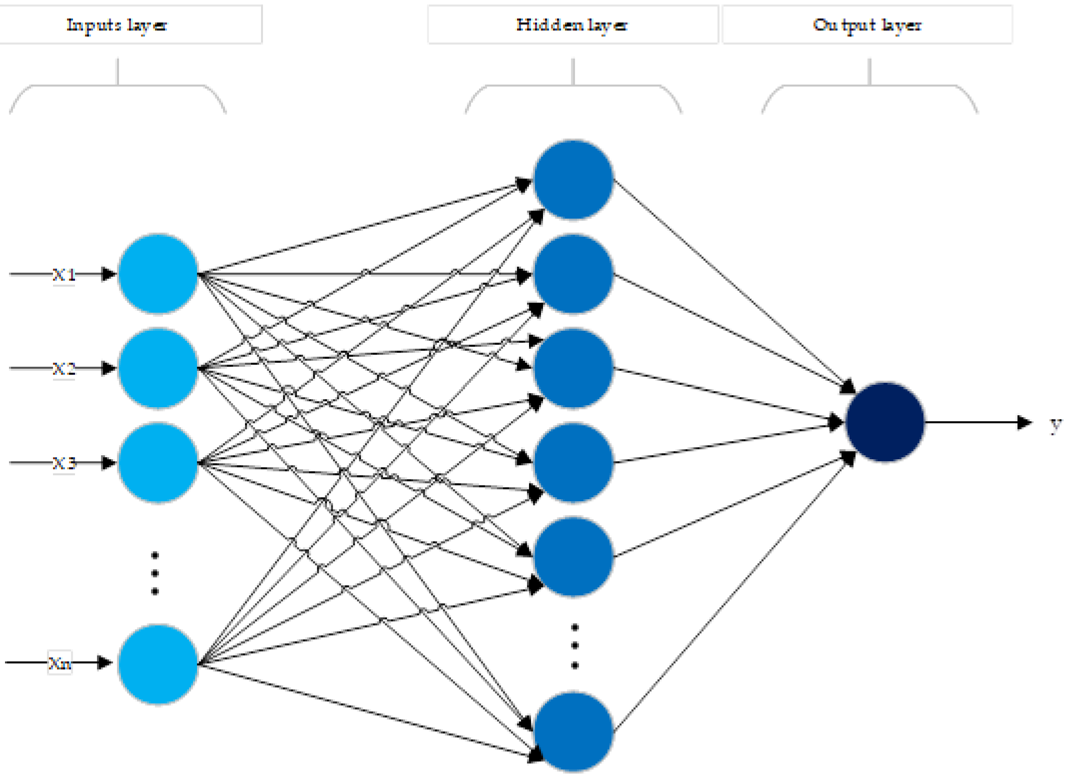


Figure 11. The architecture of the Multilayer Perceptron neural networks

Source: Author's framework

Equation (1) shows how the output of input variables, bias values, and input values are calculated:

$$S_j = \sum_{i=1}^{n} \omega_{ij} I_i + \beta_j \tag{1}$$

Where I represent the input layer, I_i is the input variable i, n shows the total number of inputs, βj is a bias value, ω_{ij} is the weight of connections in j level. The sigmoid function is mostly used as the activation functions in MLP, and it can be calculated through Equation (2):

$$f_j = \frac{1}{1 + e^{-S_j}} \tag{2}$$

Therefore, the ultimate output neuron j can be measured Equation (3):

$$y_i = f_j\left(\sum_{i=1}^{n} \omega_{ij} I_i + \beta_j\right) \tag{3}$$

4.4. Adaptive Network-Based Fuzzy Inference System (ANFIS)

To enhance the performance of machine learning models, some researchers suggest hybrid models in which either two models of machine learning are integrated, or one model of machine learning is integrated with an optimization model. An adaptive neuro-fuzzy inference system, which is also called adaptive network-based fuzzy inference system (ANFIS), is a hybrid model in which a model of ANN is developed based on Takagi–Sugeno fuzzy inference system, in early 1990s (JANG, 1991; JANG, 1993). ANFIS is a universal estimator, as the inference system of this model follows fuzzy IF–THEN rules, the performance of this model in approximate nonlinear functions is very high (ABRAHAM 2005).

Research in the field of food and agriculture has also benefited widely from this model, and researchers have used this model to solve problems such as food drying (e.g., PRAKASH & KUMAR 2014; JUMAH & MUJUMDAR 2005; AL-MAHASNEH et al. 2013), prediction of food properties (e.g., SAGDIC et al. 2012; TAGHADOMI-SABERI et al. 2014; SHAHBAZIKHAH et al. 2011), microbial growth and thermal process modeling (e.g., ESCANO et al. 2009; YOLMEH et al. 2014; QIN & YANG 2011), food quality control (e.g., ZHENG et al. 2011; RUSSO et al. 2012; DAVIDSON et al. 2001), food rheology (e.g., TOKER & DOGAN 2013; GHOUSH et al. 2008; SAMHOURI et al. 2007), crop yield prediction (e.g., SHASTRY et al. 2015; KHOSHNEVISAN et al. 2014; MOHADDES & FAHIMIFARD 2018), soil compaction Modelling (e.g., ABBASPOUR-GILANDEH & ABBASPOUR-GILANDEH 2019), soil contamination estimation (e.g., TAN et al. 2014), and etc. ANFIS architecture constitutes of 5 layers in which the first layer is called fuzzification layer where the input values are taken, and the membership functions are determined. The second layer is called rule layer in which the firing strengths for the rules generates here. In the third layer the firing strengths are normalized. In the fourth layer the normalized values are defuzzificated and go to the last layer to generate the output (KARABOGA & KAYA 2019).

For example, if in an ANFIS model includes two inputs (x, y) and one output (f_i), the two rules for a first-order two-rule are:

Rule 1: if x is A_1 and y is B_1 then z is $f_1(x, y)$

Rule 2: if x is A_2 and y is B_2 then z is $f_2(x, y)$

Where x and y are the ANFIS inputs, A and B are the fuzzy sets, $f_i\ (x, y)$ is the outputs of the first order Sugeno fuzzy. The architecture of an ANFIS model constitutes adaptive nodes and fixed nodes (see Figure 12). The first layer of the model includes adaptive nodes that can be calculated through Equations 4, 5 and 6.

$$O_{1,i} - \mu_{A_i}(x) \quad for\ i = 1,2 \qquad (4)$$

$$O_{1,i} - \mu_{B_i}(y) \quad for\ i = 1,2 \qquad (5)$$

$$\mu(x) = \frac{1}{1 + (\frac{x - c_i}{a_i})^{2b_i}} \qquad (6)$$

Where x and y are the inputs, A and B are the linguistic labels, $\mu(x)$ and $\mu(y)$ are membership functions that take values between 0 and 1, and a_i, b_i and c_i are the parameter sets.

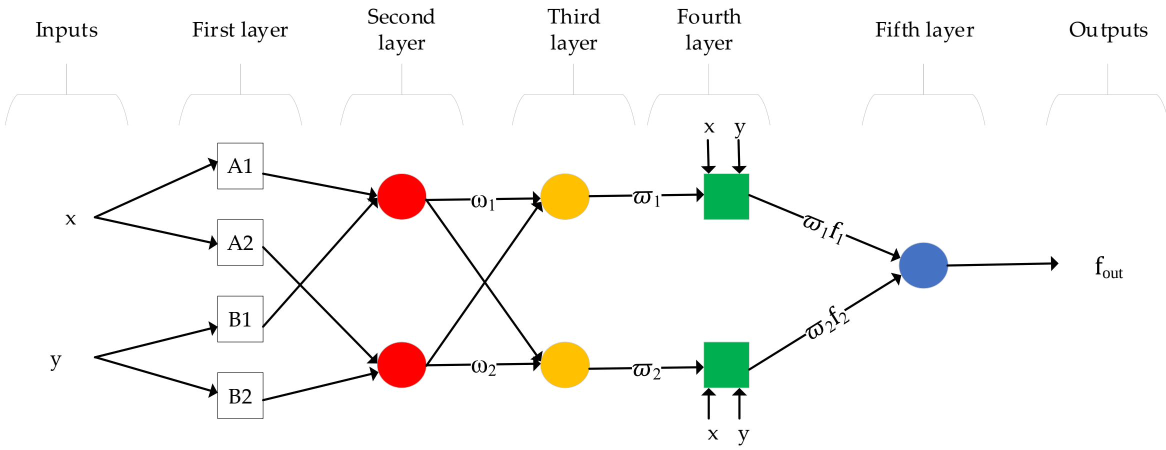


Figure 12. The architecture of Adaptive Network-Based Fuzzy Inference System

Source: Author's framework

The second layer, which is shown in red circles in Figure 12, is a fixed node and can be calculated through Equation 7. It is worth mentioning that ω_i is the firing strength of a rule.

$$O_{2,i} = \omega_i = \mu_{A_i}(x) \,.\, \mu_{B_i}(y) \qquad for\ i = 1,2 \qquad (7)$$

The third layer, which is presented in yellow circles in Figure 12, is also a fixed node. Its main goal is to normalize the firing strength by using Equation 8.

$$O_{3,i} = \varpi_i = \frac{\omega_i}{\sum \omega_i} = \frac{\omega_i}{\omega_1 + \omega_2} \qquad for\ i = 1,2 \qquad (8)$$

The fourth layer is an adaptive node as well and depicted as green squares. Equation 9 is used to measure the fourth layer.

$$O_{4,i} = \varpi_i . f_i \quad for\ i = 1,2 \tag{9}$$

Rule 1: if x is A_1 and y is B_1 then $f_1 = p_1x + q_1y + r_1$

Rule 2: if x is A_2 and y is B_2 then $f_2 = p_2x + q_2y + r_2$

Where p_i, q_i, and r_i are the parameters sets.

The fifth layer is also a fixed node presented in the form of a blue circle in Figure 12 and can be calculated through Equation 10.

$$O_{5,i} = f_{out} = \sum_i \varpi_i . f_i = Overal\ output \quad for\ i = 1,2 \tag{10}$$

The final output of an ANFIS structure, which is shown as F_{out} in Figure 12, can be calculated through Equation 11:

$$cf_{out} = \varpi_1 f_1 + \varpi_2 f_2 = \frac{\omega_1}{\omega_1 + \omega_2} f_1 + \frac{\omega_2}{\omega_1 + \omega_2} f_2 =$$

$$(\varpi_1 x)p_1 + (\varpi_1 y)q_1 + (\varpi_1)r_1 + (\varpi_2 x)p_2 + (\varpi_2 y)q_2 + (\varpi_2)r_2 \tag{11}$$

4.5. Accuracy Metrics

To compare the predictive power and accuracy performance of MLP and ANFIS two evaluation criteria namely Root Mean Square Error (RMSE) and determination coefficient (R) are measured for both models. RMSE is the difference between the value predicted by the model or statistical estimator and the actual value. Therefore, it is very desirable if the RMSE is lower. In other words, lower the RMSE, higher the predictive power of the model. This metric is a good tool for comparing forecast errors by a data set. Hence, this metrices is used in this study to evaluate the predictive performance of two models (i.e., ANFIS and MLP). In statistics, the coefficient of Determination, which is represented by R2, it is a ratio of variance in terms of a dependent variable that can be predicted from an independent variable (s). This coefficient is a statistic that has been used in the discussion of statistical models, so that its purpose is either to predict future outputs or to test a hypothesis based on other relevant information. Therefore, this metric is also used as one of the accuracy metrics to evaluate the soundness of the findings. Equations 12 and 13 respectively show how to calculate *RMSE* and R^2.

Two criteria of RMSE and determination coefficient (R) were used to evaluate the predictive accuracy of MLP and ANFIS models. How to calculate these accuracy metrics is given in equations 1 and 2.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(A-P)^2} \quad (12)$$

$$R^2 = 1 - \left(\frac{\sum_{i=1}^{n}(A-P)^2}{\sum_{i=1}^{n} A_i^2}\right) \quad (13)$$

5. RESULTS AND DISCUSSION

5.1. Introduction

The results of testing the hypotheses of this research in addition to addressing the research questions raised in this research are presented in this section. The results of quantitative analyses are firstly presented to address the first 7 RQs and 7 hypotheses which are related to the prediction of food production in Iran, Turkey, and Iraq. After forecasting the food products of the three countries, the results of the literature review are examined to determine the effects of business model innovation on the food supply chain as well as social capital solutions for food security.

5.2. Results of Food Production Prediction

The first research question and consequently the first hypotheses of this study were:

Do the machine learning models have the ability to predict domestic food production?

H1: Machine learning models are able to predict the food production.

To predict food production using machine learning models, models with 70% of the data are first trained and then their predictive performance is compared with the remaining 30% of the data. After the training phase, the models are tested, and predictive accuracy of models is evaluated by accuracy metrics RMSE and determination coefficient (R^2). Finally, the model with the highest performance in forecasting is used to predict food production and this model show a picture of the future of food production in the three countries under study.

5.2.1. Training results

The accuracy of the MLP model can be controlled by changing the number of neurons. In other words, it must first be determined which number of neurons in the proposed MLP model has the highest predictive accuracy. Therefore, in the training phase, the performance of the MLP model was tested in three stages and each stage with 10, 14, and 18 neurons, respectively. This test was performed to find the appropriate number of neurons for the MLP model for data from all three countries: Iran, Iraq and Turkey.

The results presented in Table 18 show that the MLP model with 10 neurons has the highest predictive power for predicting livestock production in Iran. On the other hand, this model with 18 neurons has the highest accuracy for predicting agricultural products in Iran. Similarly, for the case of Turkey, the MLP model with 18 neurons has the highest performance in both livestock production prediction and agricultural production prediction. It is also disclosed that the 14-neuron MPL model has the highest performance for both predicting livestock production and agricultural production, for the data collected from Iraq. It should be noted that the performance of these models is based on the amount of error measured by the RSME metric.

Table 18. Results for the training phase of the ML methods

Country	Variable	Neuron number	RMSE
Iran	***Livestock Products***	***10***	***275284878.3***
	Agri. Products	10	36325828
	Livestock Products	14	462563347.1
	Agri. Products	14	77746693.65
	Livestock Products	18	320412824.4
	Agri. Products	***18***	***35410107.42***
Turkey	Livestock Products	10	239577165.5
	Agri. Products	10	54972306
	Livestock Products	14	228289633.6
	Agri. Products	14	112062361.3

	Livestock Products	***18***	***63498693.14***
	Agri. Products	***18***	***12455144.81***
Iraq	Livestock Products	10	26805.78
	Agri. Products	10	68843.73
	Livestock Products	***14***	***23103.67***
	Agri. Products	***14***	***56667.16***
	Livestock Products	18	39332.54
	Agri. Products	18	61943.78

Source: Author's compilation

The ANFIS model has different membership functions (MF), each of which has a different predictive power. In other words, first the predictive performance of each of these membership functions is tested on the available data and then the membership function with higher predictive power and lower error level is selected. In the present study, the predictive performance of Triangular-shaped (Tri.), Trapezoidal-shaped (Trap.), and Generalized Bell-shaped (Gbell) built-in membership functions was compared, and the results are presented in Table 19.

The results of the training phase show that the ANFIS model with the Trap. membership function compared to other membership functions (see the last column of Table 19) has the lowest level of error both in the forecast of agricultural products (RMSE=987950.19) and in the forecast of livestock production (RMSE=4080579.79) in the data related to Iran. The result of the performance test of different membership functions of the ANFIS model on the data related to Turkey reveals that the ANFIS model with Gbell membership function has the lower RMSE both in the prediction of livestock product (RMSE=6643774.28) and in the prediction of agricultural product (RMSE=1920814.48) in comparison to the ANFIS model with other membership functions. The performance of different ANFIS model membership functions on Iraqi data was also tested and the results showed that the ANFIS model with Trap. membership function with a lower RMSE (RMSE=1867.43) has the highest accuracy in predicting livestock production and the ANFIS model with Gbell membership function has the highest accuracy (RMSE=8033.98) in predicting agricultural product (RMSE = 1920814.48) compared to ANFIS model with other membership functions. The results of comparing the performance of the ANFIS model with different membership functions in the data related to the three countries of Iran, Turkey, and Iraq are presented in Table 19.

Table 19. Results for the training phase of the ANFIS methods

Country	Variable	MF type	RMSE
Iran	Livestock Products	Tri.	17225511.04
	Livestock Products	***Trap.***	***4080579.79***
	Livestock Products	Gbell	6.75073E+14
	Agri. Products	Tri.	2144876.04
	Agri. Products	***Trap.***	***987950.19***
	Agri. Products	Gbell	9.75156E+12
Turkey	Livestock Products	Tri.	7599521.305
	Livestock Products	Trap.	22894177.28
	Livestock Products	***Gbell***	***6643774.28***
	Agri. Products	Tri.	1984235.22
	Agri. Products	Trap.	2265024.94
	Agri. Products	***Gbell***	***1920814.48***
Iraq	Livestock Products	Tri.	1996.15
	Livestock Products	***Trap.***	***1867.43***
	Livestock Products	Gbell	2003.67
	Agri. Products	Tri.	8034.15
	Agri. Products	Trap.	8041.52
	Agri. Products	***Gbell***	***8033.98***

Source: Author's compilation

5.2.2. Testing results

In the test phase, the predictive performance of the models was tested with the remaining 30% of the data. The results presented in Table 20 show that the MLP model with 10 neurons has the highest predictive power for predicting livestock production in Iran. On the other hand, this model with 18 neurons has the highest accuracy for predicting agricultural products in Iran. Similarly, for the case of Turkey, the MLP model with 18 neurons has the highest performance in both livestock production prediction and agricultural production prediction. It is also disclosed that the 14-neuron MPL model has the highest performance for both predicting livestock production and agricultural production, for the data collected from Iraq. It should be noted that the performance of these models is based on the amount of error measured by the RSME metric (see Table 20).

Table 20. Results for the testing phase of the ML methods

Country	Variable	Neuron number	RMSE
Iran	***Livestock Products***	***10***	***265590099.2***
	Agri. Products	10	40310186.93
	Livestock Products	14	457160675.6
	Agri. Products	14	82380698.29
	Livestock Products	18	311543277.9
	Agri. Products	***18***	***33575595.74***
Turkey	Livestock Products	10	232647138.7
	Agri. Products	10	58246984.17
	Livestock Products	14	211101750.5
	Agri. Products	14	116692375.1
	Livestock Products	***18***	***68401918.86***
	Agri. Products	***18***	***15763171.34***
Iraq	Livestock Products	10	33256.06

Agri. Products	10	75434.18
Livestock Products	***14***	***21504.22***
Agri. Products	***14***	***48901.38***
Livestock Products	18	34222.89
Agri. Products	18	51176.60

Source: Author's compilation

The results of the testing phase illustrate that the ANFIS model with the Gbell membership function compared to other membership functions has the lowest level of error both in the forecast of agricultural products (RMSE=1724426) and in the forecast of livestock production (RMSE=6052851.43) in the data related to Iran. The result of the performance test of different membership functions of the ANFIS model on the data related to Turkey reveals that the ANFIS model with Gbell membership function has the lower RMSE in the prediction of Livestock product (RMSE=5367841.52), and the ANFIS model with Tri. membership function has the higher accuracy in the prediction of agricultural product (RMSE=2201164.07) in comparison to the ANFIS model with other membership functions. The performance of different ANFIS model membership functions on Iraqi data was also tested and the results showed that the ANFIS model with Trap. membership function with a lower RMSE (RMSE=1908.30) has the highest accuracy in predicting livestock production and the ANFIS model with Gbell membership function has the highest accuracy (RMSE=2115.17) in predicting agricultural product compared to the ANFIS model with other membership functions. The results of comparing the performance of the ANFIS model with different membership functions in the data related to the three countries of Iran, Turkey, and Iraq are presented in Table 21.

Table 21. Results for the testing phase of the ANFIS methods

Country	Variable	MF type	RMSE
	Livestock Products	Tri.	11124369
Iran	Livestock Products	Trap.	17894505.8
	Livestock Products	***Gbell***	***6052851.43***

	Agri. Products	Tri.	2264668
	Agri. Products	Trap.	2415988
	Agri. Products	***Gbell***	***1724426***
Turkey	Livestock Products	Tri.	7107362.43
	Livestock Products	Trap.	22329660.3
	Livestock Products	***Gbell***	***5367841.52***
	Agri. Products	***Tri.***	***2201164.07***
	Agri. Products	Trap.	2955934.24
	Agri. Products	Gbell	2405773.6
Iraq	Livestock Products	Tri.	2101.26
	Livestock Products	***Trap.***	***1908.30***
	Livestock Products	Gbell	2100.59
	Agri. Products	Tri.	2115.46
	Agri. Products	Trap.	2138.51
	Agri. Products	***Gbell***	***2115.17***

Source: Author’s compilation

The best MSRE associated with both models (i.e., MLP and ANFIS) for each country is presented in Figure 13. It should be noted that the smaller the MSRE, the higher the performance of the model. Figure 13 represents that all the MSRE related to ANFIS models are lower than those related to MLP models. It is concluded that the ANFIS model has a higher performance in the current data which implies the higher ability of the ANFIS model both in predicting agricultural and livestock production. Therefore, the ANFIS model is selected for the prediction phase.

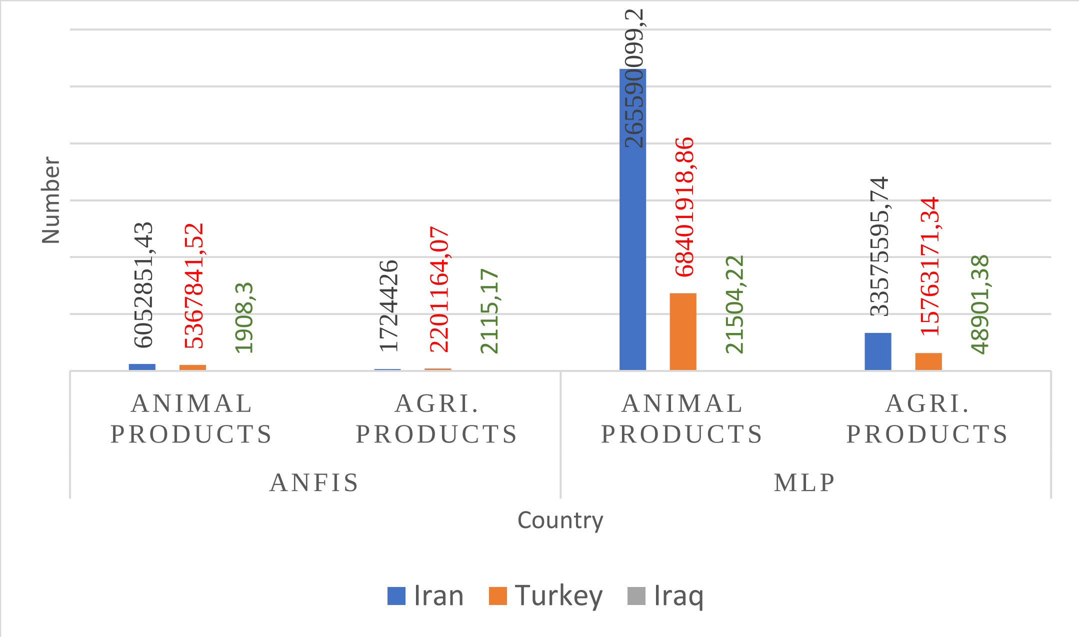
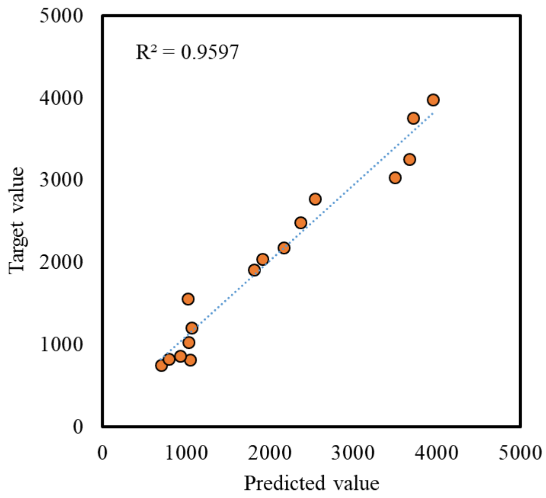
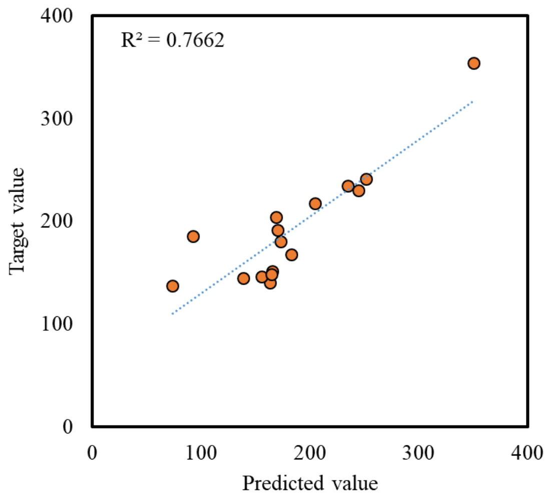


Figure 13. Comparison of RMSE for MLP and ANFIS models in data related to Iran, Turkey and Iraq

Source: Author's framework

To ensure the predictive power of the ANFIS model, the coefficient of determination (R^2) was also evaluated for this model. Figure 14 shows that the R^2 for all the tested models on the database of the current study is a considerable number as R^2=0.96 for livestock products and R^2=0.76 for the agricultural products for the data related to Iraq, R^2=96 for livestock products and R^2=0.92 for the agricultural products for the data related to Turkey, and R^2=0.99 for livestock products and R^2=0.94 for the agricultural products for the data related to Iran. In other words, in addition to the fact that the predictive power of the ANFIS model is higher than the MLP model in the data of this study, the predictive accuracy of the ANFIS model is significant and considerable. That is why, the ANFIS model is applied to predict the food production in this study.

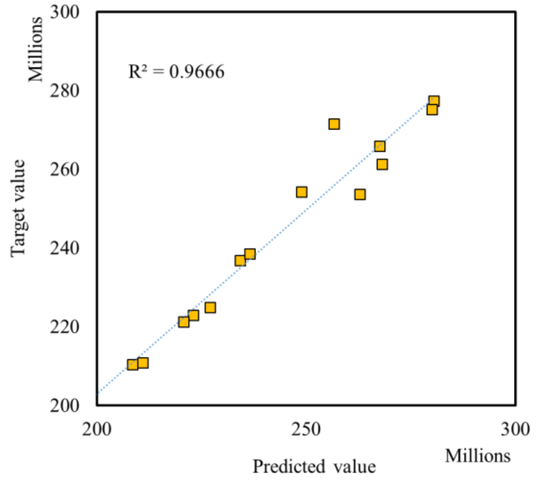


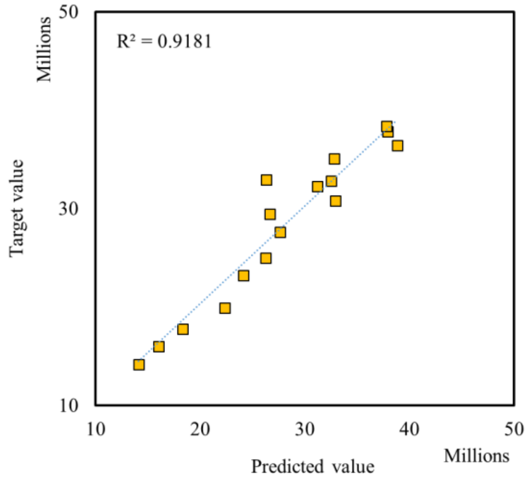


Livestock Products

Agri. Products

Iraq

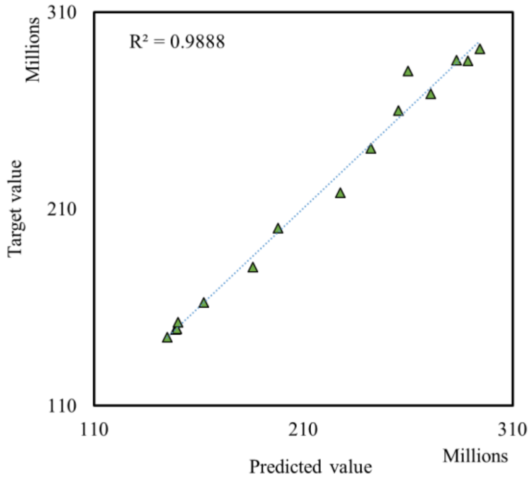


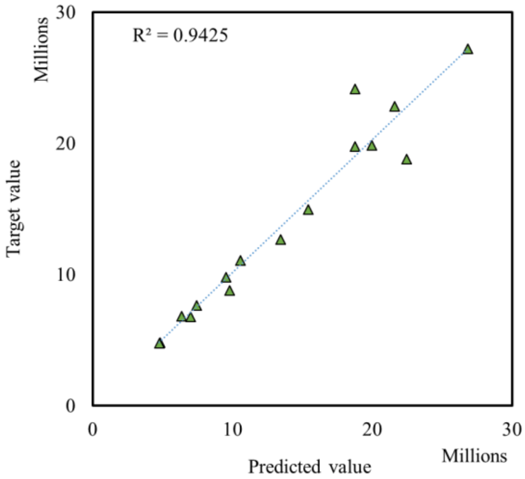


Livestock Products

Agri. Products

Turkey





Livestock Products

Agri. Products

Iran

Figure 14. The plot diagram for the selected models using predicted and target values

Source: Author’s framework

The results of equation metrics, i.e., MSRT as well as R^2, show that the ANFIS machine learning model has a high performance in predicting food products. Hence, the answer to the first research question of this research is yes. In other words, the first hypothesis of this research is confirmed.

5.2.3. Prediction results

5.2.3.1. Iran

In this section the second and third research question and the second and third hypothesis of the study are examined as they are:

RQ2: What will be the domestic livestock production in Iran in the next ten years?

RQ3: What will be the domestic agricultural production in Iran in the next ten years?

H2: Machine learning models have the ability to predict the future trend of domestic livestock production in Iran.

H3: Machine learning models have the ability to predict the future trend of domestic agricultural production in Iran.

Due to the low RMSE of the ANFIS model with the Gbell membership function (RMSE=6052851.43), this model was used to predict local food production in Iran. The result of forecasting agricultural and livestock production for the next ten years in Iran is presented in Table 22. Figure 15 illustrates that despite the decline in Iranian livestock production in recent years, the trend of livestock production in Iran is expected to increase. In other words, the output of the forecast model shows that livestock production will increase from 302028218.6 kg in 2014 to 397788163.4 kg in 2030.

Table 22. Retrospective prediction of agricultural and livestock production in Iran

Year	Gbell	Gbell
	Livestock products	Agricultural products
2014	302028218.6	24969177
2015	324548544.5	27300250
2016	341196828.8	29087504
2017	349110979.5	29981463
2018	351165674	30231125
2019	351393213.3	30242351
2020	351889340.6	30282632
2021	353044979.8	30413014
2022	355433096.5	30700922
2023	359042959.3	31147556
2024	363583520.4	31717244
2025	368812282	32374680
2026	374726642.9	33113468
2027	381123336.2	33906210
2028	387439028	34691535
2029	393045557.7	35395595
2030	397788163.4	35992727

Source: Author’s compilation

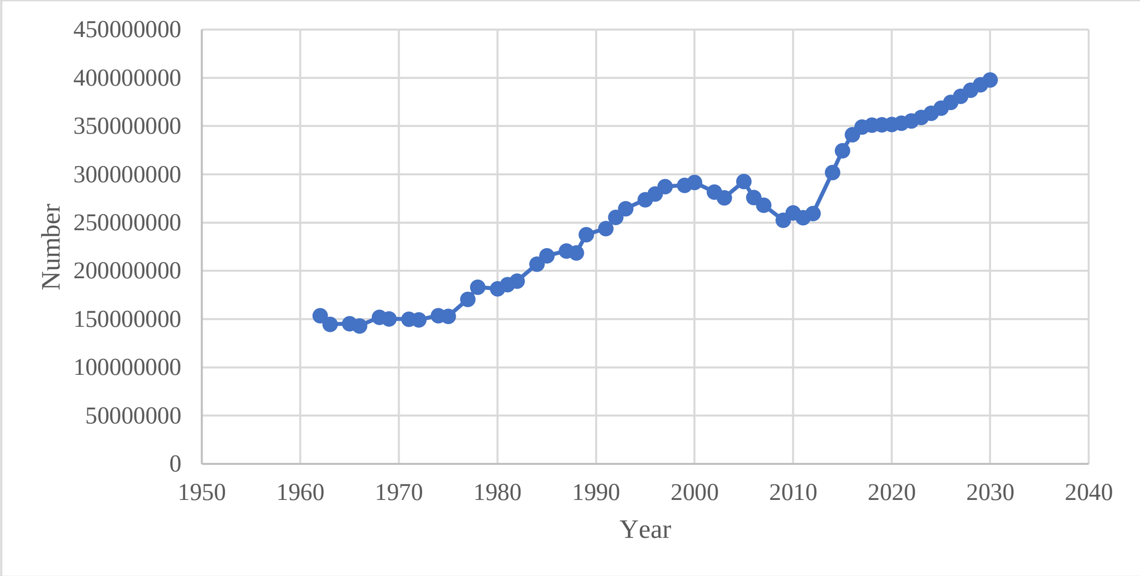


Figure 15. Livestock production in Iran, current data, and future trends

Source: Author's framework

The result of predicting Iran's agricultural production articulates that the production of agricultural products in Iran is on the rise and agricultural production in Iran will increase from 24969177 kg in 2014 to 35992727 kg in 2030 (see Figure 16).

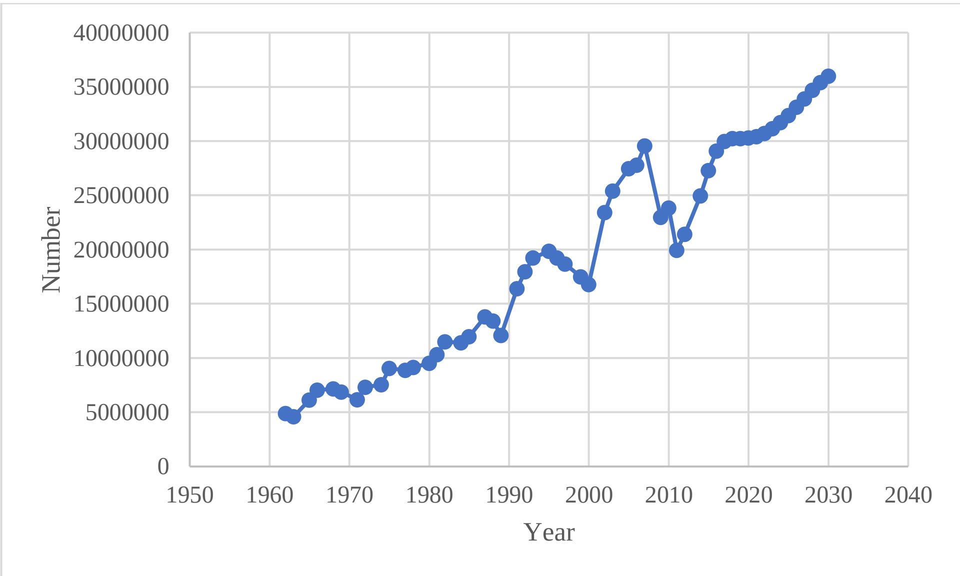


Figure 16. Agricultural production in Iran, current data, and future trends

Source: Author's framework

According to MSRT and R2, it is revealed that The ANFIS machine learning model with Gbell membership function has the ability to predict both agricultural and livestock production in Iran. Therefore, the second and the third hypothesis of this study (i.e., H2 and H3) are confirmed.

Comparison of agricultural and livestock production in 2020 with 2030 in Iran shows that livestock production in Iran increases in 2030 with a growth rate of 13% from 351889340.6 kg in 2020 to 397788163.4.4 kg in 2030. The forecast of a 13% increase in livestock production could result in a decrease in agricultural production. Because in practice, in order to increase livestock production, some agricultural lands are turned into pastures, and it is even possible to turn agricultural lands into places for keeping and raising livestock. On the other hand, with the increase of livestock production, a higher percentage of agricultural production goes to livestock consumption and this share is removed from the human food basket.

However, the output of the forecasting model discloses that agricultural production in Iran will increase by 18% in the next ten years. Since Iran is a country that is exposed to drought, water supply management and land use management are fundamental issues that macro management in Iran must make appropriate decisions in this regard. Technological infrastructure for optimizing agricultural production, facilitating the transportation system for the transfer of agricultural products is another infrastructure that should be considered in Iran. Predicting the increase of agricultural and livestock products in Iran can create many economic opportunities and many new jobs can be created in the food supply chain in Iran. Not only farmers and ranchers, but also food processing companies, distributors, wholesalers, and retailers can both benefit from this increase in production and contribute to facilitating food supply.

5.2.3.2. Turkey

In this section the fourth and the fifth research question and the fourth and the fifth hypothesis of the study are examined as they are:

RQ4: What will be the domestic livestock production in Turkey in the next ten years?

RQ5: What will be the domestic agricultural production in Turkey in the next ten years?

H4: Machine learning models have the ability to predict the future trend of domestic livestock production in Turkey.

H5: Machine learning models have the ability to predict the future trend of domestic agricultural production in Turkey.

Since the RMSE of the ANFIS model with the Gbell membership function was lower the other membership functions (RMSE=5367841.52), this model was used to predict livestock production in Turkey. The result of forecasting agricultural and livestock production for the next ten years in Iran is presented in Table 23 and Figure 15 and Figure 16. According to Figure 17, the trend of livestock production in Turkey is expected to decrease in the next decade. In other words, the output of the forecast model shows that livestock production will decrease from 255692892.2 kg in 2014 to 196830286.9 kg in 2030.

Table 23. Retrospective prediction of agricultural and livestock production in Turkey

Year	Gbell	Triangular
	Livestock products	Agricultural products
2014	255692892.2	42948684
2015	249186750.1	43774660
2016	233278907.8	44427670
2017	214158490.4	44877303
2018	202398028.3	45069582
2019	202938457.6	44958198
2020	208589414.1	44764210
2021	208579159.4	44900808
2022	204012069.8	45606259
2023	202112144.6	46741117
2024	204083811.2	47862075
2025	203291043.8	48681601
2026	199628802.4	49054696
2027	198151604.4	48702336
2028	198143600.8	48060244
2029	197192865	47998424
2030	196830286.9	48471123

Source: Author’s compilation

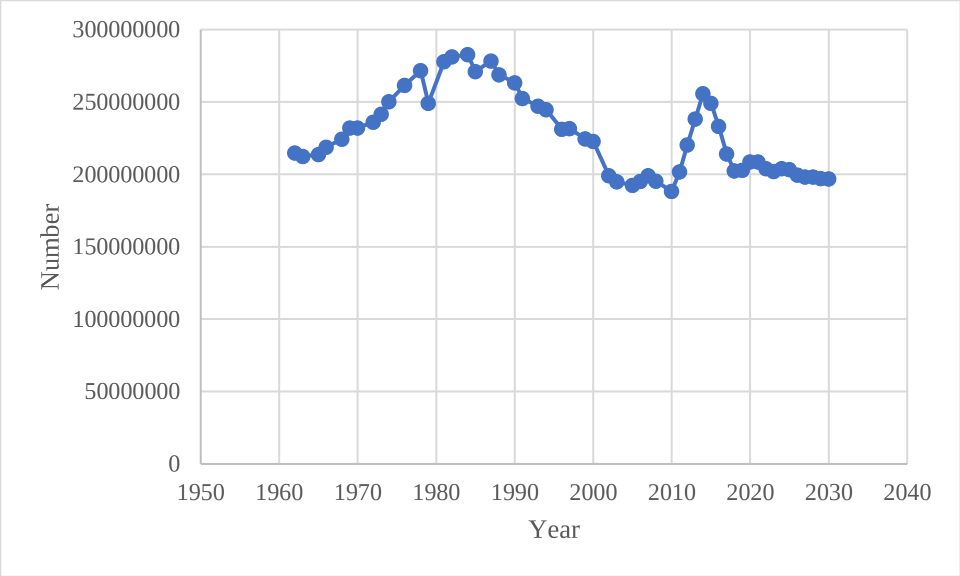


Figure 17. Livestock production in Turkey, current data, and future trends

Source: Author’s framework

According to MSRT and R2, it is disclosed that The ANFIS machine learning model with Gbell membership function has the ability to predict livestock production in Turkey. Therefore, H4 is confirmed.

Since the RMSE of the ANFIS model with the Tri. membership function is lower than the other membership models (RMSE=2201164.07), this model applied to predict the Turkey's agricultural production. It is disclosed that Turkey's agricultural production is on the rise and agricultural production in Turkey will increase from 42948684 kg in 2014 to 48471123 kg in 2030 (see Figure 18).

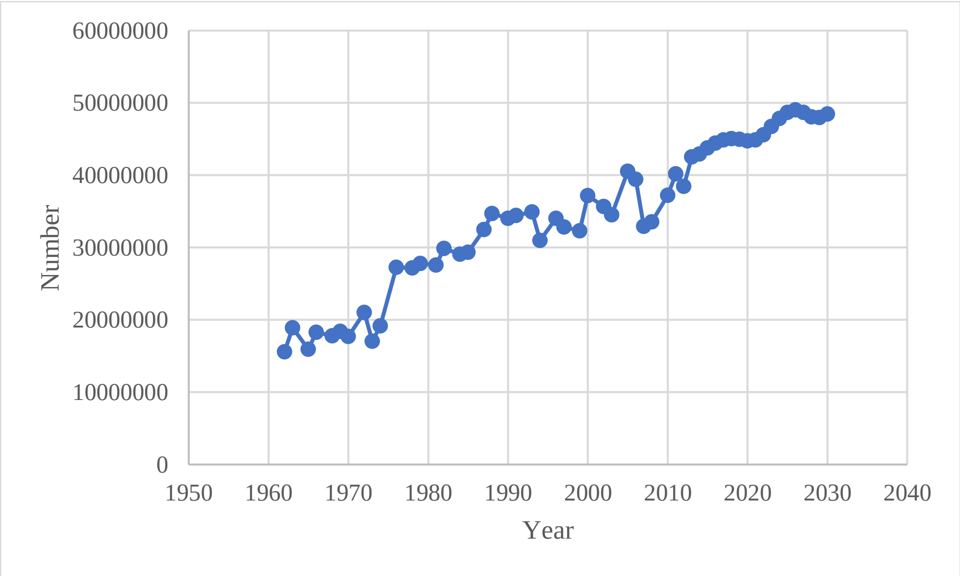


Figure 18. Agricultural production in Turkey, current data, and future trends

Source: Author’s framework

The results show that The ANFIS machine learning model with Triangular membership function has the ability to predict agricultural production in Turkey. Therefore, H5 is confirmed. It means that in 2030, compared to 2020, livestock production in Turkey will decrease by half a percent, and in contrast, agricultural production is expected to increase by 8% in the next ten years. In general, the climate of Turkey is more suitable for agriculture compared to the other two countries under study, namely Iran and Iraq, and it is not surprising that in both 2020 and 2030, Turkey's agricultural production was higher than the other two countries. The results shows that agricultural production in 2030 in Turkey, Iran, and Iraq is projected to be 48471123 kg, 35992727 kg, and 247.1713 kg, respectively.

5.2.3.3. Iraq

In this section the sixth and the seventh research question and the sixth and the seventh hypothesis of the study are examined as they are:

RQ6: What will be the domestic livestock production in Iraq in the next ten years?

RQ7: What will be the domestic agricultural production in Iraq in the next ten years?

H6: Machine learning models have the ability to predict the future trend of domestic livestock production in Iraq.

H7: Machine learning models have the ability to predict the future trend of domestic agricultural production in Iraq.

Due to the fact that the amount of RMSE of the ANFIS model with Trap. membership function was lower compared to other membership functions (RMSE=1908.30) in predicting Iraqi livestock production, this model was used to predict Iraqi livestock production. The result of the model forecast shows that despite the fact that livestock production in Iraq has been steadily declining in the past decades, livestock production will increase in the next decade and livestock production in Iraq will increase from 552.1903 kg in 2014 to 949.6233 kg in 2030 (see Table 24 and Figure 19).

Table 24. Retrospective prediction of agricultural and livestock production in Iraq

Year	Trap. Livestock products	Gbell Agricultural products
2014	552.1903	146.286
2015	554.548	157.6572
2016	597.2993	171.2183
2017	667.6741	182.2033
2018	741.8336	188.7279
2019	781.6264	191.68
2020	781.9615	193.1157
2021	756.469	195.1418
2022	717.5938	199.1618
2023	685.3931	204.405
2024	681.8519	209.7454
2025	712.171	215.1021
2026	769.1546	220.8816
2027	844.9736	227.026
2028	922.3446	233.5202
2029	971.749	240.2865
2030	949.6233	247.1713

Source: Author's compilation

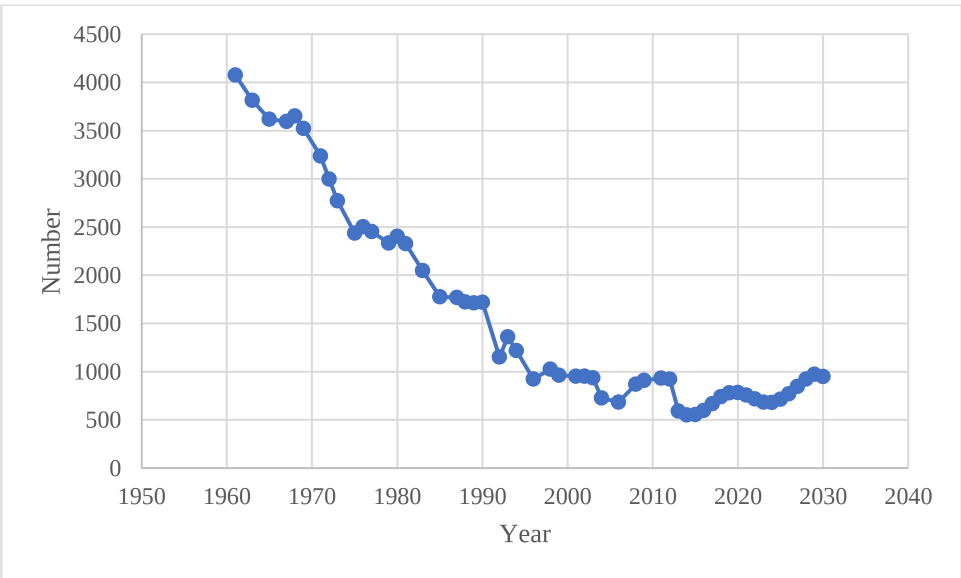


Figure 19. Livestock production in Iraq, current data, and future trends

Source: Author's framework

According to MSRT and R2, it is disclosed that The ANFIS machine learning model with Trap. membership function has the ability to predict livestock production in Iraq. Therefore, H6 is confirmed. The results of this study show that agricultural and livestock production in Iraq in 2030 will increase at a faster rate compared to the other two countries, namely Iran and Turkey; As it is predicted that livestock production in Iraq increases in 2030 compared to 2020 with a growth rate of 21% from 781.9615 kg to 949.6233 kg. The same for agricultural production in Iraq, so that agricultural production in Iraq is expected to reach 287.1713 kg in 2030 with a growth rate of 28% from 193.1157 kg in 2020.

Despite the fact that both livestock and agricultural production in Iraq is expected to increase at a higher rate compared to Iran and Turkey in the next ten years, the amount of production is very low compared to the amount of production in other countries. Due to the population of Iraq, which is almost half of the population of Iran and Turkey, the amount of food production in this country is very low, and the most important reason could be unfavorable climate for agriculture and animal husbandry, as well as drought in this country. Of course, with proper water management and proper selection of crops, they can achieve optimal production. Therefore, in addition to water management and land use management, it is suggested to pay attention to crop management in this country as well.

Since the RMSE of the ANFIS model with the Gbell membership function is lower than the other membership models (RMSE=2115.17), this model applied to predict the Iraqi agricultural production. It is disclosed that Iraqi agricultural production is on the rise and agricultural production in Iraq will increase from 146.286 kg in 2014 to 247.1713 kg in 2030 (see Figure 20).

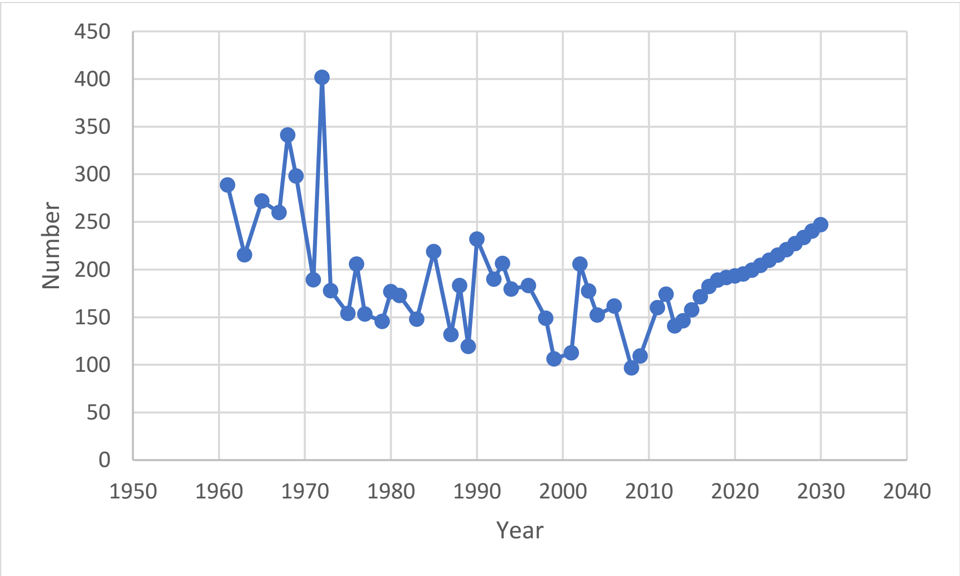


Figure 20. Agricultural production in Iraq, current data, and future trends

Source: Author's framework

Results show that The ANFIS machine learning model with Gbell membership function has the ability to predict agricultural production in Iraq. Therefore, H7 is confirmed.

5.3. Business Model Innovation and Food Supply Chain

In this section the eighth research question of this study, which is presented below, is addressed:

RQ8: How does business model innovation contribute to the food supply chain?

5.3.1. Farmers

According to Table 17 three of the documents have proposed solutions for BMI for the farmers in the FSC in which PÖLLING et al. (2017) consider innovation in the value proposition as a solution to BMI for the famers. Whilst VARELA-CANDAMIO et al. (2018) and PÖLLING et al. (2017) provide a new business model for the farmers in the FSC. Following a summary of these studies is provided.

1.5.1.1. Value Creation

PÖLLING et al. (2017) elaborate the importance of city-adjustment in success of urban farming. They sort a set of strategies such as high-value production, direct marketing, and tourism services and also, they introduce business models such as 'low-cost specialization', 'differentiation', and 'diversification' for adjusting the farms in the urban areas. The finding of PÖLLING et al. (2017)'s research, resulted from investigation of 180 urban farms in Ruhr Metropolis, Germany discloses that the city-adjusted farms reported a better economic performance and anticipated a more positive prospect in compare with the non-city-adjusted farms which have not used the mentioned strategies and business models.

1.5.1.2. Business Models

VARELA-CANDAMIO et al. (2018) propose a conceptual framework to design green business models in which rural women play critical multiple roles in generation-production-consumption of functional foods as producer, educator/advisor and buyer of such products. Where rural women are considered the main educators in the families to boost social-environmental awareness. In the production stage, rural women have a more proactive role in producing functional foods as farmers who are tied with academic institutions so as for transferring the knowledge and producing the functional foods. While, in the consumption stage, the role of rural women constitutes demanding the functional foods. Moreover, VARELA-CANDAMIO et al. (2018) debate that functional foods comprise elements, added naturally or processed, either to increase human health and well-being or mitigate the risk of diseases.

PÖLLING et al. (2017) develop new solutions to design urban farming business models, utilizing case studies. According to PÖLLING et al. (2017) farming and agriculture in the urban areas requires unique business models which are distinctive from rural areas. They have identified three business models for the urban farming called differentiation, diversification, and low-cost specialization. Where the business model of 'differentiation' is associated with niche production and differentiation. Differentiation business model recommend the urban farmers to analyze the whole value chain and utilize vicinity to the final consumers and by a vertical integration capture more values. PÖLLING et al. (2017) argue that to perform successfully a differentiation business model, not only the integration is matter, but also the product should possess specific features such as exotic species or traditional breeds.

PÖLLING et al. (2017) believe that 'diversification' in urban farming business model consists of the variety in the value proposition the farmer offers to the customers. They also articulate that agro-tourism, social events (i.e., education, therapy, health), horse services, and care farming are a sort of services that urban farms frequently offer to their clients as well.

To justify economically urban farming, since the farmland in and around urban areas are smaller than rural areas, higher added values crop production sounds necessity. Therefore, PÖLLING et al. (2017) explain that 'low-cost specialization' business model is an urban farming model in which only the products with high added values, high transportation costs, freshness and high perishability will produce, because the vicinity to the final consumers is a competitive advantage and makes the model feasible.

5.3.2. Processors

There are studies provide solutions for designing and performing the business models for the processors in the FSC where KÄHKÖNEN (2012) proposes strategies to innovate the value proposition in order to innovate a business model in the food industry and LIBERTI et al. (2018), GIACOSA et al. (2017), VOJTOVIC et al. (2016), and JOLINK & NIESTEN (2015) provide new business models for the processors in the FSC.

1.5.1.3. Value Proposition

KÄHKÖNEN (2012) studies the concept of value net in the context of the food industry. KÄHKÖNEN (2012) defines value net as "a dynamic, flexible network comprising the relationships between its actors who create value through collaboration by combining their unique and value-adding resources, competences and capabilities". The finding of her study reveals that the value net business model significantly affects the performance of food companies. The finding of the study also illustrates that the actors in the value net in the food industry are looking for competitive advantages through networking and joint projects. On the other hand, KÄHKÖNEN (2012) claims that since the main aim of value net is to provide a value/values to the customers through a collaborative process, shared knowledge leads in an innovative and powerful value proposition for the processors in the food industry.

1.5.1.4. Business Model

LIBERTI et al. (2018) work on an EU funded project called i-REXFO. The main objective of i-REXFO is to design a business model which is able to diminish landfilled food wastes through actions reducing food wastes and producing energy from the inevitable wastes. The i-REXFO model includes four phases. The first phase consists of providing a database to design a tool to analyze the feasibility of the i-REXFO approach in the desired area. The second phase focuses on strategies to minimizing the expired food in the retailers. LIBERTI et al. (2018) sort a set of strategies to reduce the expired food such as setting strategic prices and communication policies for pre-expiration food, increasing consumer awareness about food expiration label, collecting and distributing unsold pre-expired foods to charities, providing doggy bags among HORECAs. The third phase of i-REXFO business model to avoid landfilling is to generating energy from expired food in which the food wastes are collected from the retailers and HORECAs and processed to produce biomass biogas plant for electricity production. According to LIBERTI et al. (2018) to test replicability and transferability of the i-REXFO model, this model will be performed in Spain and Hungary.

GIACOSA et al. (2017) conduct a case study to investigate the approaches to strengthening the business models of family food businesses. They realize that tradition, the family's values and experiences in the food sector, and innovation, the creation of new values and opportunities by injecting new ideas, are two main pillars should be considered to strengthen the business model of a family food business. GIACOSA et al. (2017) explain that utilizing the customers' feedback will be resulted in the product innovation and it also presents the opportunity to increase the quality and product ranges and subsequently, it will lead in the customer satisfaction. Because they can offer a wider range of traditional products in old and new flavors utilizing both traditional approaches and the modern technologies. GIACOSA et al. (2017) provide evidence revealing that considering the tradition and innovation in the family food businesses improves and affects not only the value proposition and value creation processes, but also value delivering and capturing models.

VOJTOVIC et al. (2016) provide an innovative framework to design a sustainable business model for the processors in the food and beverage industry. By inspiring business model canvas, VOJTOVIC et al. (2016) propose a ten-pillar business model to develop a sustainable business model for the processors in the food and beverage industry.

They suggest that in the first step the business concept should be explained where key principles and values that the business offers to the costumers, sustainable benefits to the society and the environment, and the company vision and long-term goals should be clearly identified. After explanation of the business concept, the second step is to identify the customers. VOJTOVIC et al. (2016) divide the customers to three categories of early adopters, niche market and mass segment. The third pillar of this model is building relationships including branding, habit forming, and legislation issues. Designing a distribution channel is the next pillar of the proposed sustainable business model of VOJTOVIC et al. (2016). VOJTOVIC et al. (2016) articulate that planning for resources, designing the key activities (i.e., operating, support, and development) to run the business model, and developing a sophisticated support system are respectively fifth, sixth, and seventh pillar of this model. Developing the partners network with suppliers, manufacturers, service providers is named as the next action. Estimating the cost structure and selecting the income model are the last two pillars of this model.

JOLINK & NIESTEN (2015), utilizing the concept of Ecopreneurship, try to develop sustainable business models for the organic food industry. According to JOLINK & NIESTEN (2015), ecopreneurs are subcategory of sustainable entrepreneurs where the business operates in the mass markets and tries to meet the sustainability goals (i.e., economics', environment's, and society's benefits) at the same time. The result of their study exposes four ecopreneur business models among the organic food companies. The income business model, the subsistence business model, the growth business model, the speculative model.

JOLINK & NIESTEN (2015) argue that the income business model is adopted by small companies whose axial objective is to generate income through creating the opportunity to consumers to eat healthy foods. Providing the proper information to the consumers about eco-products plays a critical role in this model.

In accordance with JOLINK & NIESTEN (2015)'s findings, the objective of the companies applying subsistence business model "…is to survive and meet basic financial obligations". Although they try to make the world better, being ecologically sustainable is not in their priority, since they need to reach the mass markets lack of sufficient organic raw materials restricts them to present eco-product to their customers. Therefore, they need to make a compromise between being economically and environmentally sustainable.

The third ecopreneur business model discovered among the organic food companies is the growth model where the focal point is to invest and reinvest on the financial aspects and the relationship with the customers in order to be profitable in the long term. According to JOLINK & NIESTEN (2015) those companies implement such a business model have a relatively large impact on the market. These companies have turned being sustainable to a competitive advantage and have become profitable in this way.

JOLINK & NIESTEN (2015) express that the speculative model is the fourth ecopreneur business model they identified among the organic food companies. According to JOLINK & NIESTEN (2015), the speculative model focuses on making money by selling eco-products where the economic profits are set in the priority. Indeed, in this model, sustainability turned into a mean for profitability. These ecopreneurs concentrate on short-term goals with a large market effect.

5.3.3. Distributors

Among the research documents reviewed in the current study, four of them study business models of food distributors in which SHIH & WANG (2016) and KIM et al. (2014) investigate new solutions for delivering the food productions to the customers, and BERTI et al. (2017) and MARTIKAINEN et al. (2014) introduce new business models for the distributors in the FSC.

1.5.1.5. Value Delivering

One of the most important issues in the FSC is food distribution where cold chain management plays a vital role. Having a frozen storage with the risk of high-energy consumption and cool storage with the threat of bacterial decay is a dilemma the distributors in the food industry deal with. Hence, SHIH & WANG (2016) by means of an IoT architecture and International Organization for Standardization (ISO) 22,000, an international food standard, propose four solutions to overcome the aforementioned problems in the food distribution: cold chain home delivery service, convenience store (CVS) indirect delivery, CVS direct delivery, and flight kitchen service. According to their results, applying the above-mentioned business models can be resulted in a 1.36 million increase in annual sales of braised pork rice, generating extra revenue of US$6.35 million by creating new distribution channels, and also reducing 10% energy consumption.

SHIH & WANG (2016) elaborate that cold chain home-delivery service refers to free home delivery of the foods in 1–2 working days for orders exceeding a minimum purchase requirement at the off-peak hours (14:00–17:00). This approach not only provide the opportunity to use less the cold storage, but also expands brand recognition and facilitates market penetration. On the other hand, SHIH & WANG (2016) express that CVS indirect delivery refers to delivering fresh foods products that are processed in original equipment manufacturer (OEM) facilities by CVS companies. Convenience store companies prefer cool storage products than the products needed to be thaw where reheating them does not take more than 30–40 s in a microwave. In addition, SHIH & WANG (2016) argue that CVS direct delivery refers to the food products are processed, packed, and delivered by CVS. This approach is selected in the case the food quality and food safety are very important. According to SHIH & WANG (2016) the flight kitchen business model is quite similar to CVS indirect delivery business model where the only difference is the lower supply volume and fewer supply spots. In accordance with the flight kitchen business model, semi-processed food products are delivered to international catering companies via cool storage. Then they process and deliver it to the airplane flight kitchen, where they just need to re-heating it. In this approach, daily delivery is very important to maintain the food safety and quality.

To solve the urban agriculture’s problems, KIM et al. (2014) propose the Eco-M business model where organic fresh foods produced by suburban agriculture delivered daily to the local markets. KIM et al. (2014) claim that although this model has performed successfully, it cannot benefit from competitive price since, the risk of wasted food is high as the products are fresh foods and their expiration date is too close to the production date, and they should be consumed in 10 days after production.

1.5.1.6. Business Model

BERTI et al. (2017) propose a disruptive business model producing new values and new markets by redefining the food supply chain. They introduce a digital food hub, an online marketplace, facilitating efficient connections among local food producers and consumers. BERTI et al. (2017) argue that it is a sustainable business model as it increases the demand for the local food, and it also promotes healthy and sustainable food for the local communities. BERTI et al. (2017) believe that this digital food hub, indeed, provides a strategic network across the food supply chain to co-produce socio-environmental shared values.

5.3.4. Retailors

The Retailors play a very important role in the FSC as these are the places that the food products are delivered to the final customers. This part of the FSC attracted more researchers as 8 out 25 documents have focused on different aspects of the business model of the retailors. DI GREGORIO (2017) proposes strategies for the value Proposition the retailors are delivering, HUANG et al. (2009) focus on how retailors can create values, KAUR & KAUR (2018) and PEREIRA et al. (2018) study innovative solutions for retailors to innovate their business model by redesigning value delivering models. Finally, CHEAH et al. (2018), FRANCESCHELLI et al. (2018), RIBEIRO et al. (2018), and LU et al. (2010) identify new business models for the retailors in the FSC. Following a summary of all these studies are provided.

1.5.1.7. Value Proposition

DI GREGORIO (2017) proposes a creative business model for retailors, where the products are delivered to the customers, in the food industry. He applies the concept of placed-based business model to introduce a model in which location-specific resources are used to create and capture value. DI GREGORIO (2017) conduct case studies within slow food in Italy (Coop Italia and Eataly). According to his results, the placed-based business model in the slow food industry in Italy will subsequently lead in the resilience, sustainability and prosperity of the social context by reviving passion for traditional food cultures and increasing supply and demand for local food products.

1.5.1.8. Value Creation

HUANG et al. (2009) develop a e-business model for food souvenir industry in Taiwan, inspiring by e-commerce business model. The focus of their innovation is value creation. According to their model, the final customers are able to order online, and local providers are responsible for the supply and delivery of orders.

1.5.1.9. Value Delivering

Utilizing sensor-based measurement containers (SBMCs), an Android application, and cloud IoT-enabled grocery management system (CE-GMS), KAUR & KAUR (2018) provide a creative solution to business model innovation for retailors in the FSC. By designing an innovative approach to get the order and deliver it to the customers, they have created a new business model. According to proposed model of KAUR & KAUR (2018), when the retailers get the order from a customer, he will be subsequently gotten an alarm related to the quantity of the product in the store and the warehouses at the same time. This contribution helps them to manage the quantity of the products and make them able to maximize their potential to cover the customers' needs.

PEREIRA et al. (2018) run a case study to investigate a sustainable business model for delivering fresh milk. PEREIRA et al. (2018) compare traditional channels and vending machines for supplying the fresh milk. Their finding discloses that utilizing vending machines shortens supply chain therefore, it has a lower impact on the environment due to the elimination of mediators and transportations activities. PEREIRA et al. (2018) also realized that the success of vending machines remarkably depends on the consumer behaviors. As their finding exposes that when the consumption of environment friendly products is very important to the consumers, the vending machines were more profitable.

1.5.1.10. Business Model

CHEAH et al. (2018) provide empirical evidence that business model innovation provides competitive advantages to the retailors in the food industries. Their finding illustrates that the retailors acting in a high turbulence environment have a more chance to get sustainable competitive advantages by re-innovating of their business model.

RIBEIRO et al. (2018) strive to test the sustainability of a retailing strategy so called ugly business model in which the wastes resulted from the fresh fruit and vegetables that are not sold through the conventional distribution channels due to the appearance of these product, has been minimizing. According to their results, this project, in addition to the economic benefits, has had social benefits (i.e., "increasing waste awareness and healthy food consumption and community engagement in reduction of the waste", etc.) and environmental benefits (i.e., "prevent food wastes and climate change mitigation benefits).

LU et al. (2010) provide solutions for designing a business model for sustainable agricultural products utilizing internet of things (IoT). Aided by IoT, the new business model provides products through networks and e-commerce via electronic data interchange and e-mail online sales contract along with the traditional marketing channels. The convenience of online shopping and instant messaging interoperability are mentioned of the new value propositions that IoT can offer for the sustainable agriculture. LU et al. (2010) also claim that IoT designs a sophisticated information system in the organizations which arms the businesses to design a customer-centric structure collecting the data and customers' feedbacks and also provides the adequate information to the customers.

5.3.5. Consumers

Consumers are the most important part of the FSC as without the consumers all the supply chain will be meaningless. Handling customers' issues and studying their behavior is of the utmost importance during managing the FSC. MARTINOVSKI (2016) has an innovative approach to design value propositions based on the customers' behavior.

1.5.1.11. Value Proposition

MARTINOVSKI (2016) has a different perspective to design a business model for an entity performing in the FSC. MARTINOVSKI (2016) believes that consumer behavior is the key determinant in designing a business model. Therefore, he proposes the concept of modelling a business model according to consumer behaviors while purchasing food products. His finding reveals that this approach is a tool for the decision makers to design a sustainable business model in which on the one hand, the businesses are able to utilize this customer centric approach to get the customers' feedbacks so as for developing corresponding value propositions for their target market and on the other hand, the benefits of society and customers are considered, and healthy safe food productions are delivered to them based on their feedback.

5.3.6. The Entire Supply Chain

In addition to the studies that targeted a specific stage of the FSC, there are many studies have focused on the whole supply chain and have provided solutions to create values for the whole FSC. Designing solutions for value creation and value delivering for the entire supply chain, indeed, implies that the researchers have tried to provide innovative solutions that affects the whole supply chain from the farmers to the retailors and customers. For instance, ADEKUNLE et al. (2018) and BARTH et al. (2017), ULVENBLAD et al. (2018) and PAHK & BAEK (2015) recommend frameworks to innovate the business models in the FSC.

1.5.1.12. Business Model

ADEKUNLE et al. (2018) design a business model for small millets value chain in India. According to their result, a mixed CI–PL business model is appropriate for small millets value chain in India where CI-business model refers to customer intimacy business models in which the customer is placed in the center of the business model and PL business model points out to the product leadership business models in which the quality of the product is of the utmost importance. According to the proposed business model of ADEKUNLE et al. (2018) there should be an interactive collaboration among farmers, technologists, processors, and researchers to produce and deliver high-quality small millets through innovation, creating and sharing knowledge. This collaboration will lead in increase yield, improve marketing, and reduction of drudgery.

BARTH et al. (2017) develop an approach to design an innovative sustainable business model for the businesses performing in the agri-food sector statements. Based on a deep literature review they design questions for development of each pillar of the business model. According to BARTH et al. (2017) the business model constitutes four main pillars of 1) value proposition, 2) value creation and delivery, 3) value capture, and 4) value intention.

ULVENBLAD et al. (2018) study the barriers to business model innovation in the agri-food industry. To do so, they run a systematic literature review where they reviewed 570 research articles published between 1990 to 2014. They, ultimately, categorize the barriers to BMI in the agri-food industry to two classes of internal barriers and external barriers. Where the internal barriers to BMI include: 1) individual barriers (e.g., perceptions, values, behavior), 2) organizational barriers (e.g., lack of competencies, insufficient resources, and unsupportive organizational structure). On the other hand, ULVENBLAD et al. (2018) articulate that the external barriers to BMI comprise 1) resistance and lack of support from specific actors and 2) restrictive macro-environment. It is worth mentioning that they provide another layer of analysis for these barriers and for each of the mentioned barriers they provide sub-variables.

PAHK & BAEK (2015) develop the concept of ‘considerate design approach’ to design a sustainable business mode in which value propositions have considered to meet the benefits of all the stakeholders. PAHK & BAEK (2015) develop four business models includes: 1) neighboring producer community, a collaboration platform between the local farmers/producers and the customers for direct sale, 2) local food café, a mediator between local farmers/producers and the customers where the local foods are served, 3) farm mentoring institute, a mentoring platform transferring the farmers’ knowledge to the others and students, and finally 4) food community, including cuisine researchers and educators training the locals to utilize local ingredients to cook professionally in order for either their own consumption or selling their foods.

5.3.7. Lessons from business model innovation in food supply chain

The literature provides recommendations to redesign the value propositions in the business models. Where, KÄHKÖNEN (2012) introduce the concept of value net which suggest collaboration among the different stakeholders to shape the value. MARTINOVSKI (2016) also have a similar recommendation to design the value proposition. He recommends that to engage the customers in the value shaping processes. Whilst DI GREGORIO (2017) has an innovative solution for the value proposition as he considers the location and the place as a source of value.

Whist two of the documents including PÖLLING et al. (2017) and HUANG et al. (2009) consider innovation in value creation processes as the strategy to BMI for the food industry. PÖLLING et al. (2017) sort out solutions to adjust the urban farms according to the cities' constraints. On the other hand, HUANG et al. (2009) provide empirical evidence proving that applying e-commerce models facilitates the value creation processes. Reconsidering the value delivering processes is another strategy are considered by the author to BMI in the FSC. SHIH & WANG (2016) and KAUR & KAUR (2018) recommend applying IoT to optimize the management of delivering the food production. PEREIRA et al. (2018) offer vending machines to delivering the fresh milk product in the urban areas and KIM et al. (2014) introduce the concept of Eco-M business model to facilitate delivering fresh foods to the urban areas (see Figure 21). These strategies are summarized in Figure 21 as the strategies are applied in the FSC to innovate the business model.

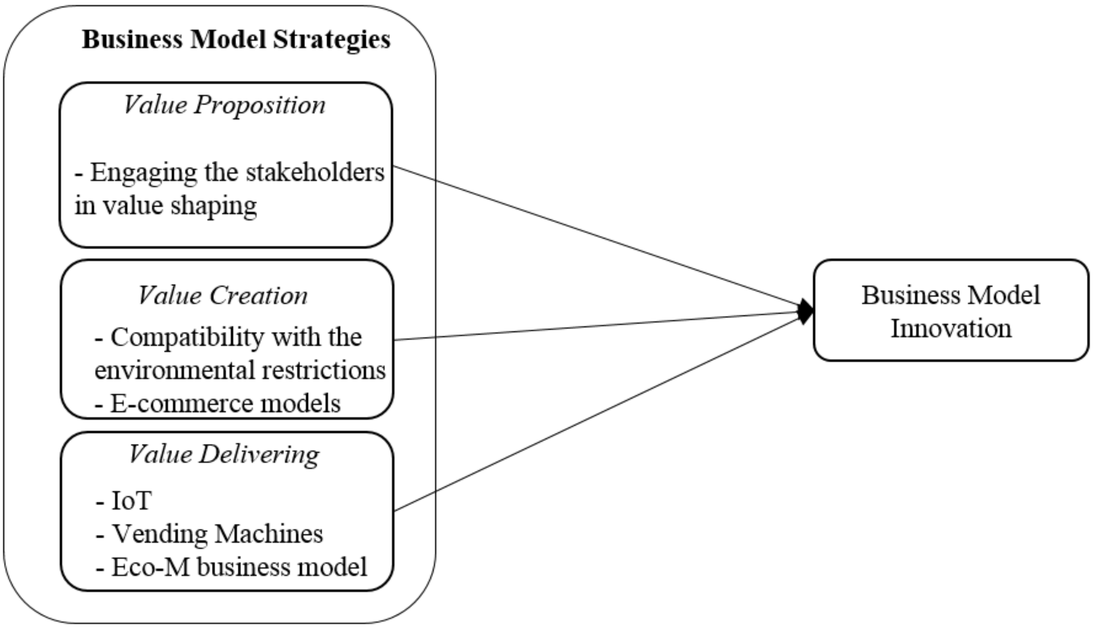


Figure 21. Business model strategies to business model innovation in the FSC based on the literature

Source: Author's framework

Along with the mentioned studies, there are studies present BMI driving forces either for a specific part of the FSC or for the whole of the FSC. For instance, VARELA-CANDAMIO et al. (2018) claim that women not only play vital roles in designing and implementing a sustainable business model in the farms, but also raise the demand for the sustainable products by increasing the awareness about the local food in the communities. PÖLLING et al. (2017) argue that the urban farm should adapt their business model according to city conditions. GIACOSA et al. (2017) see adding new innovations and technologies to traditional mechanisms as a source of innovation in business models for the processors in the FSC. Besides, LIBERTI et al. (2018), inspired by the circular economy concept and circular business models, provide recommendations to produce energy from the inevitable wastes. BERTI et al. (2017) disrupt the current FSC affected by digitalization. They introduce a digital food hub, which is an online marketplace, to connect the local food producers and consumers. Ultimately, ADEKUNLE et al. (2018) consider the customers intimacy and the product quality as driving sources to BMI for the whole FSC (see Figure 22).

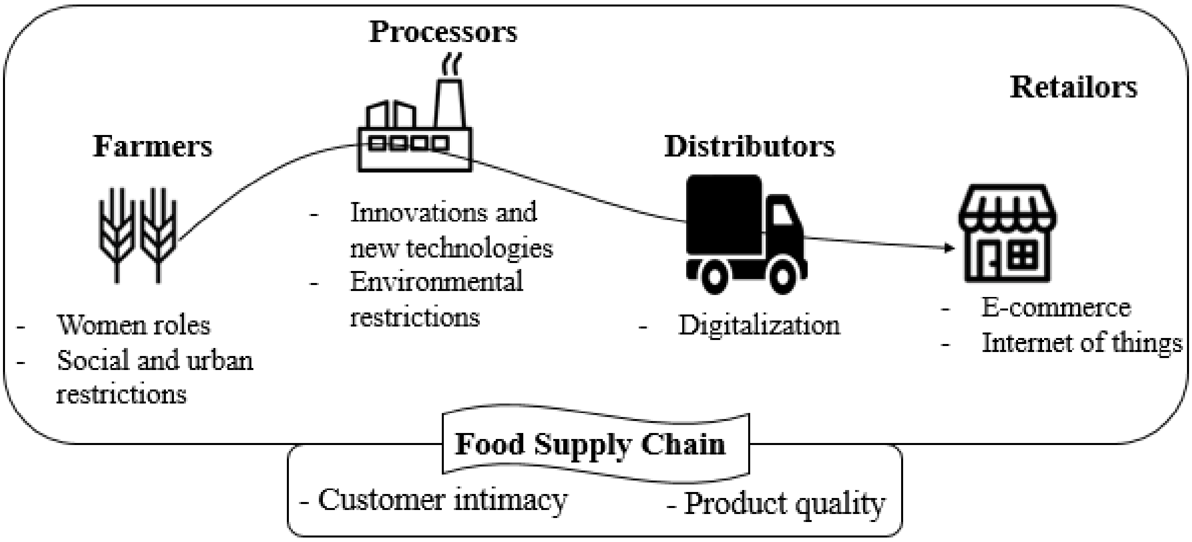


Figure 22. Business model innovation driving forces in the food supply chain

Source: Author's framework

5.4. Social Capital and Food Security

In this section the ninth research question of this study, which is presented below, is addressed:

RQ9: How does social capital improve food security?

5.4.1. Food Availability

Ample evidence has been found in the literature that social capital can improve food security by improving food availability in various ways. Food availability, indeed, refers to the availability of adequate high-quality food in a region. The findings of a case study in Zimbabwe show that social capital, along with innovative technologies and market information, is a prerequisite for food availability, and their contribution to improving food security is higher than farm research initiatives (NYIKAHADZOI et al. 2012). A study conducted by KERR (2005) disclosed that Malawian smallholder farmers are running out of food in some months of the year and have to do Ganye. In fact, KERR (2005) argues that Ganye is a kind of piecework labor working on the others' farms in which the laborers are compensated by food or cash. Although KERR (2005) believes that Ganye alone is a very weak form of social capital, this social activity increases food availability (KERR 2005). BROWNE et al. (2017) Show that rituals have a significant effect on food security and food availability in Timor-Leste. They argue that ritual support the production of some agricultural products (such as rice and maize), and these products are widely used in most ritual ceremonies. In addition, BROWNE et al. (2017) believe that the act of sacrificing animals in rituals is another influential factor in increasing the production and the population of these animals. DE JALON et al. (2018) argue that social capital can contribute to food security by increasing farmers' capacity to adapt to climate change. DE JALON et al. (2018) show that the exchange of knowledge gained through interactions among the smallholder farms' community in sub-Saharan Africa has a positive and significant impact on farm-management practices, using fertilizers and agrochemicals, management of pest and crop, soil conservation practices, applying appropriate irrigation systems, utilizing more resistant crop varieties, each of which is a strategy for adapting to climate change.

SAINT VILLE et al. (2016) investigate social capital's role in supporting innovation in smallholder farming systems. They figured out that there are strong social connections among the smallholder farmers in the Caribbean where such social connections exchange and make available the information among the farmers. In such a social network, various support resources that promote food availability are maintained (SAINT VILLE et al. 2016). SAINT VILLE et al. (2017) argue that stakeholder interactions affect national food security policy. The result of their study reveals that there is a need to provide supportive conditions, such as alignment of different forms of social capital built based on the interactions among stakeholders, and trust and knowledge exchange among stakeholders in the policy network, for aggregating multi-stakeholder interactions in the development of Saint Lucia's National Agricultural Policy. To conserve the availability of two traditional varieties of wheat in Turkey, HELICKE (2019) found that social capital is an essential factor to connect small producers, national and external actors, like lack of social networks, threats the seed exchange connections (HELICKE 2019). In other words, they imply that social capital contributes to food availability through facilitating seed exchange. Membership of food producers in related communities can have benefits for producers and improve the quality of food security. In this regard, NAUGHTON et al. (2017) argue that the women producing shea butter and belonging to the shea butter organization were more motivated and more committed to producing shea butter, and they could access more markets and have a higher ability to negotiate revenues.

MWAKIWA et al. (2018) believe that social capital plays a sustainable role in producing foods for households. They articulate that working on community gardens boosts social capital and will be resulted in the food supply while managing resources. Social networks, such as gardening activity, captivate people to maintain their food security. Not only is food security the goal of people participating in common gardening, but also it creates an opportunity for divertissement where people could gather, share information and enhance the social networks in rural areas (PORTER & MCILVAINE-NEWSAD, 2013). Assessing the different determinants of community gardening in Philadelphia, it is highlighted that community gardening boosts food security and social capital (GARRETT & LEEDS 2015). In Saint-Jose, California, it is revealed that home gardens get a beneficial link with social capital (GREY et al. 2014). Studying home gardening in Saint-Jose, California, GREY et al. (2014) found that home gardening is a linkage between food security and social capital. Because they argue that in addition to providing food, food gardening increases bonding social capital through the sharing of knowledge and products. There are other studies in the literature with similar results, but these studies have used different terminology, PASCOE & MICHAEL HOWES (2017), for example, use community gardening, GALLAHER et al. (2013) use sack gardening and urban agriculture, and VITIELLO & WOLF-POWERS (2014) use urban agriculture terms. All these studies imply that social capital improves food availability primarily through knowledge and product sharing, which in turn improves food security.

5.4.2. Food Accessibility

According to the definition, food accessibility refers to people’s ability to access physically and economically to food. FURNESS & GALLAHER (2018), LEE et al. (2018), BOUBACAR et al. (2017), SMITH & FRANKENBERGER (2018), KASCHULA (2011), and QUETULIO-NAVARRA et al. (2018), for instance, show that interaction among members of a community will result in the exchange of food products among them and increases the food accessibility in the region.

A case study in Rockford, Illinois, FURNESS & GALLAHER (2018) evaluates the relationship between community gardening and food accessibility. They explain the magnitude of benefits gained by both the community and non-community members of these gardens. Because most of the products in these gardens go into food pantries and are accessible to others (FURNESS & GALLAHER 2018). The results of a study by OLARINDE et al. (2020) reveal that Nigerian Cassava farming households who belonged to more social networks had higher opportunities to access food. Lee et al. (2018) investigated the relationship between household food security and social connectedness among peri-urban Peruvian Amazonian communities. They found out that those households have more social connectedness within and outside the community reported less food insecurity, especially as the food was regularly shared among the members. Bunch et al. (2020) illustrate that social capital increases the households' food security in Greater Bahr el Ghazal and the Equatorias in South Sudan. BOUBACAR et al. (2017) developed a tool to assess household resilience in Niger. Their research shows that social capital can improve families' resilience exposed to floods and subsequently increase access to food in the area. In a study of households in northern Bangladesh, SMITH & FRANKENBERGER (2018) found out that social capital could increase food security by increasing households' resilience to natural shocks, such as floods. They show that increasing resilience in flood-prone areas increases the number of months that households can access enough food. KAISER et al. (2020) found that using social networks provides food for US households. In other words, they claim that belonging to social communities facilitates access to food for households. In a study of households in KwaZulu-Natal, South Africa, KASCHULA (2011) found that families with adults at risk for chronic illness were more likely to have food donated by community networks. However, these families have also been exposed to food insecurity. However, KASCHULA (2018) found that families with Acquired Immunodeficiency Syndrome (AIDS)/Human Immunodeficiency Viruses (HIV) have not benefited from these donated foods because of social labels. Quetulio-Navarra et al. (2018) showed that culturally underpinned food exchange practices in Central Java, Indonesia, facilitated the food accessibility among the households that have subsequently led to children's food security five years old in this area. All these studies were implying the importance of sharing food products among community members in improving access to food.

There is evidence in the literature that social capital can contribute to food accessibility by sharing information among members of a community. For example, WHITLEY (2013) defines "food deserts," a place in which there is no grocery store or only one with limited and expensive food items. The results of his study show that people with less social connection reported more problems in having access to food, and in contrast, those with more social ties reported no problems accessing food. The results of the study of SSEGUYA et al. (2018) also disclose that social capital is linked positively with food access. Studying households' insecurity in rural Uganda, SSEGUYA et al. (2018) illustrate that social capital, through increasing access to information and sharing and shaping norms and mutual trust, improves food access among the households. By analyzing the studies that took place in African, MISSELHORN (2005) found that low social capital among the communities increased poverty and conflict among the community and reduced human health, which in turn led to less accessibility to healthy foods among members of the community. MISSELHORN (2005) believes that social capital can improve food security and by building the social resilience of the community. Studying the participatory community planning approach to agricultural extension in Kenya, KIARA (2011) shows that increasing smallholder farmers' interactions through public extension processes have increased women's, youths', poor, and vulnerable groups' engagement in generating information and providing solutions to increase access to food. In addition, such community interactions promoted smallholder farmers from subsistence to business farming that contributes to the food security of the region as well. Microfinance organizations in Uganda are trying to improve food security and reduce poverty by providing farmers with financial resources. In a study of rural women in Uganda, MEADOR & FRITZ (2017) found that financial institutions can improve food accessibility by creating social capital by increasing the women's interactions in the community.

5.4.3. Food Utilization

Among the articles reviewed, there are studies that show that the interactions of members of a community are inversely related to malnutrition. A study among 330 low-income households from Hartford, Connecticut, the USA, revealed that even when households' financial or food resources are limited, households with higher social status have lower food insecurity and are less likely to experience hunger (MARTIN et al. 2004). A study by MISSELHORN (2009) in KwaZulu-Natal illustrated that social capital was directly related to food security, and factors (such as divorce, religious conflicts, cultural differences, and leadership conflicts) that undermined social capital ultimately led to food insecurity among members. By studying neighborhood characteristics and their relationship to household food security among low-income Toronto families, KIRKPATRICK & TARASUK (2010) found that in neighborhoods with less perceived social capital, households faced the problem of lack of nutrients needed for a healthy life, in other words, these households were exposed to food insecurity. RAYAMAJHEE & BOHARA (2019) consider involvement in voluntary associations as a measure of social capital and investigate the effect of such volunteering activities on food security among households in western Nepal. They found out participating in financial associations (such as micro-finance, insurance, trade, and business associations), as a volunteer has a direct impact on hunger mitigation, and participation in informational associations (such agriculture, water, forest groups) helps Nepali women to improve the nutritional quality of diets and the food utilization. According to MTIKA (2001), the AIDS epidemic among the Malawi rural households weakens the social immunity and social capital among the members. He found that weakening relationships among community members makes them very vulnerable and ultimately leads to food insecurity among rural households, who have serious difficulty providing healthy food and adequate nutrition for a healthy life. Studying the social context of severe child malnutrition in a rural area of the Democratic Republic of Congo, KISMUL et al. (2015) found solutions, including gbisa, to tackle food insecurity and child malnutrition. Gbisa, indeed, is inter-household cooperation in providing the labor force for the farms. In this form of cooperation, close kin and neighbors go to the others' farms to help the farmers, for example, inland clearing and timely weeding. In return, they receive enough food plus a kind of capital and even cash as compensation. These studies illustrate that social capital can improve food utilization through sharing products and information among members of a community.

5.4.4. Food System Stability

Food stability outlines that all people should have access to enough food all the time, regardless of any unforeseen risk (e.g., weather change, pandemic, economic crisis, etc.), which could prevent households from accessing food. Food insecurity is a problem of food abundance and infrastructure and includes the group member's food access and their alliance. Thus, each member within a group of people should access their common resources inside their territory. CHRIEST & NILEST (2018) found that high social capital in the rural communities in the US can increase the resilience and adaptation of the community to extreme weather events, and it also increases food security to deal with problems caused by climate change shocks. Studying Ethiopian rural households, WOSSEN et al. (2016) found that shocks, such as drought, market shocks (i.e., food price), and health shocks, in both household and rural levels, increased food insecurity. Their findings also reveal that membership in informal communities and organizations reduced these shocks' effects on household food security. CHEN et al. (2014) believe that government support policies to combat drought have made a significant contribution to stabilizing the food system and have been able to help improve food security in China by increasing agricultural production CHEN et al. (2014). Social interactions that increase the resilience and eliminate the households' vulnerability will result in a more stable food system and a decline in food insecurity.

5.4.5. Lessons from studying the role of social capital in food security

Figure 23 illustrates that social capital improves food availability and food accessibility through two mechanisms: Knowledge sharing and product sharing (i.e., food sharing). Food utilization, on the other hand, is developed only through a product-sharing mechanism. Figure 23 states that social capital increases the stability of the food system. In general, the social capital and interactions of the members of a society stabilize a food system by eliminating the members' vulnerability and increasing their resilience.

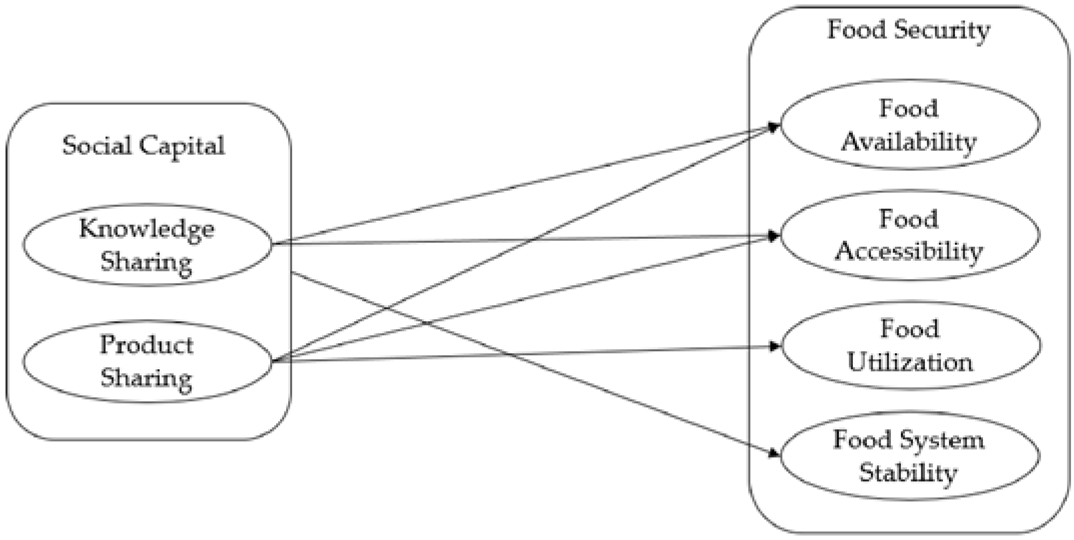


Figure 23. The contributions of social capital to food security

Source: Author's framework

5.4.6. The summary of Hypotheses testing

The results presented in this chapter showed that all the hypotheses presented in this study were confirmed and their summary is presented in Table 25.

Table 25. The summary of hypotheses testing

Hypothesis	Explanation	Result
H1	Machine learning models are able to predict the food production.	Confirmed
H2	Machine learning models have the ability to predict the future trend of domestic agricultural production in Iran.	Confirmed
H3	Machine learning models have the ability to predict the future trend of domestic livestock production in Iran.	Confirmed
H4	Machine learning models have the ability to predict the future trend of domestic agricultural production in Turkey.	Confirmed

H5	Machine learning models have the ability to predict the future trend of domestic livestock production in Turkey.	Confirmed
H6	Machine learning models have the ability to predict the future trend of domestic agricultural production in Iraq.	Confirmed
H7	Machine learning models have the ability to predict domestic the future trend of livestock production in Iraq	Confirmed

6. CONCLUSION AND RECOMMENDATIONS

6.1. Introduction

On the one hand, drought and climate change have reduced agricultural production, which in turn has reduced food supply. On the other hand, the population of different countries, especially in the Middle East, is expected to increase, which will increase the demand for food. This decrease in food production and the increase in food demand create a gap that imposes food insecurity on these countries. Limited access to adequate nutritionally healthy food leads to food insecurity. 2014 million of the world population are undernourished and 704 million of them encounter the severe food insecurity. Available healthy food in the market does not guarantee the food security because accessing to food and the ability to buy food is an essential factor to tackle food insecurity as well. Lack of knowledge and awareness of the society about food security is another factor results in food insecurity. Food insecurity is a factor contributing to many problems in the society and responding to the problem raised by food insecurity is more costly than providing healthy food to the society. Food insecurity and its global consequences is an issue that directly or indirectly affects all the countries and has the physical, mental, psychological, economic and social consequences to hundreds of millions of people. According to the World Health Organization, approximately 2% of Child deaths in developing countries are the result of chronic hunger and malnourished. Hunger resulted from poverty and food insecurity. Food insecurity weakens skills and reduces people productivity and gradually over a long period of time their abilities are deprived, and they cannot play a role in education, production and economy, therefore access to adequate and nutritious food is one of the most important priorities of the world and it is one of the major plans of government policies. Various solutions have been proposed to bridge this gap and address food insecurity. Various stakeholders from various industries, such as the food and agriculture industry, research institutes, and policymakers, have come up with solutions to address the growing demand for food. In fact, the goal is not just to provide food, but also to make available and accessible food for the growing demand. In the analysis of the roots of such problem in developing countries, poverty, war, government policies, environmental degradation, lack of progress in agriculture, and culture have been cited as causes of food insecurity. Sometime the problem is not physical access to food, but it is behaviors of people and their food choices. Therefore, in the literature, in addition to recommendations such as increasing the level of education and income of the head of the family, it is also recommended to change the food habits and increase the awareness of society about the food security. In general, macroeconomic policies, prices, wages, employment, increasing agricultural productivity, rural economic growth, and food supply are cited as effective factors on food security of a region.

Governments select different policies to address food security. One of these policies is the provision of food through programs to support farmers and ranchers. These support programs are aimed at encouraging domestic producers to increase domestic food production and be able to utilize domestic capacities to meet the demand for food. Governments consider favorable protection laws for the agriculture and livestock sector, while this sector is particularly sensitive because it is directly related to human food. For instance, Drought has also affected livestock fodder production, in Iran. The continuation of this situation is a great threat to the livestock sector in Iran, because now in this situation, productive livestock especially sheep are sent to the slaughterhouse because they are not economically viable for the farmer. That is why the Iranian government has adopted mechanisms through which, on the one hand, livestock farmers can provide food for their livestock at a low cost, and on the other hand, by providing subsidies to low-income people, to increase their purchase power in buying dairy products and meat. In general, reducing the price of livestock inputs and increasing the purchasing power of consumers are the government's solution to the challenges in supplying livestock inputs.

Before implementing any program to achieve food security, knowing the amount of food products produced in the country can be a basis for planning and designing solutions to achieve food security. Therefore, the present study is conducted to find a proper machine learning model to predict food production (i.e., agricultural production and livestock production) produced locally in Iran, Iraq, and Turkey. Due to the higher predictive performance of the ANFIS model compared to the MLP model in the dataset of this study, this model was employed to predict the food production of the three countries. The use of machine learning and deep learning models to predict data trends using past data patterns has become very common due to its high predictive power. The results of this study show that the ANFIS model, which is a hybrid deep learning model, has a remarkable ability to predict the trend of agricultural and food production based on past data.

Livestock production in Iran is expected to increase by 13% in 2030 that can result in a decrease in agricultural production. Because in practice, in order to increase livestock production, some agricultural lands are turned into pastures, and it is even possible to turn agricultural lands into places for keeping and raising livestock. On the other hand, with the increase of livestock production, a higher percentage of agricultural production goes to livestock consumption and this share is removed from the human food basket.

However, the output of the forecast model shows that agricultural production in Iran will increase by 18% in the next ten years. Since Iran is a country exposed to drought, water supply management and land use management are among the key issues that macro-management in Iran must make appropriate decisions in this regard. Technological infrastructure for optimizing agricultural production, facilitating the transportation system for the transfer of agricultural products are other infrastructures that should be considered in Iran. Among the three countries surveyed in this study, Iran has the highest livestock production, and this production is expected to increase by 13%.

According to the findings in 2030, compared to 2020, livestock production in Turkey will decrease by half a percent, and in contrast, agricultural production is expected to increase by 8% in the next ten years. In general, the climate of Turkey is more suitable for agriculture compared to the other two countries under study, namely Iran and Iraq, and it is not surprising that in both 2020 and 2030, Turkey's agricultural production was higher than the other two countries. The results shows that agricultural production in 2030 in Turkey, Iran, and Iraq is projected to be 48471123 kg, 35992727 kg, and 247.1713 kg, respectively.

The results of this study show that agricultural and livestock production in Iraq in 2030 will increase at a faster rate compared to the other two countries, namely Iran and Turkey as it is predicted that livestock production in Iraq increases in 2030 compared to 2020 with a growth rate of 21% from 781.9615 kg to 949.6233 kg. The same for agricultural production in Iraq, so that agricultural production in Iraq is expected to reach 287.1713 kg in 2030 with a growth rate of 28% from 193.1157 kg in 2020.

Despite the fact that both livestock and agricultural production in Iraq is expected to increase at a higher rate compared to Iran and Turkey in the next ten years, the amount of production is very low compared to the amount of production in other countries. Due to the population of Iraq, which is almost half of the population of Iran and Turkey, the amount of food production in this country is very low, and the most important reason could be unfavorable climate for agriculture and animal husbandry, as well as drought in this country. Of course, with proper water management and proper selection of crops, they can achieve optimal production. Therefore, in addition to water management and land use management, it is suggested to pay attention to crop management in this country.

Iran's agricultural production is also very considerable and after Turkey produces the most agricultural products and it is also predicted that these products will increase in the next ten years with a growth rate of 18%. Despite the increase in agricultural and livestock production in Iran, the effects of climate change should not be ignored. Every year, climate change has severely damaged agricultural production, and Iran and Iraq face serious drought problems. In addition, severe disasters caused by climate change have overshadowed agricultural production and reduced agricultural production.

The obvious point of the output of the predictive model of this study is to predict the increase of food products in this region, but this increase in production does not guarantee food security. First of all, despite the domestic production of these three countries, they need imported food because they do not have the ability to produce all the food needed by their entire society, especially in Iraq. Second, government poverty alleviation programs, urban life, and the globalization of many people's lifestyles have changed, and the need for different foods has emerged in society.

6.2. Recommendations

Policy makers and decision makers of countries in the macro level such as food security policy makers, policy makers in agriculture and food industry, decision makers and policy makers related to food, agriculture, and livestock import and export, use the predictive model proposed in this study. Because this model can give them a possible picture of what the food production process will look like in the future of a country. Such an image would allow policymakers to plan more precisely to achieve their goals, especially food security. On the other hand, the findings of this study, which predicts the amount of agricultural and livestock production of the three countries of Iran, Iraq, and Turkey, provide insight to both policy makers and macro level decision makers of these countries, as well as activists in the food supply chain, from farmers to food processing and distribution companies, that can be used to plan and policy.

On the other hand, this study provides a basis for future research. Future research could test the predictive model of the present study in similar data for other countries and compare the results with the results of this study. On the other hand, it is suggested that in future research, based on an empirical study and a causal study, identify independent variables affecting the volume of food production produced in a country.

A country's domestic agricultural and livestock production play a very important role in addressing the challenges posed by food insecurity in a country. Hence, in many countries, various support programs are offered to encourage farmers and ranchers to unleash the potential of domestic production and to be able to supply food from inside as much as possible. Of course, importing food products is another option for governments to ensure that food security is achieved. The development of agriculture and animal husbandry in a country is not only a way to provide food, but also leads to the development of the region (especially rural development) and increase employment. Hence, agricultural and livestock support programs are always in government programs. The results of predictive models in the present study showed that agricultural production is expected to increase in all countries and in Iran and Iraq it is predicted that livestock production will also increase. Agricultural development strategies should be planned around the three axes of conserving resources, increasing farmers' incomes, and strengthening food security. Where agricultural development leads to food security and increased farmers' incomes, while at the same time this development is sustainable and does not harm natural resources. In a country like Iran and Iraq, which are facing drought problems, agricultural development programs should be towards modernization and industrialization of agricultural implementation mechanisms so that the country's water resources are used optimally, and groundwater is not harmed. In addition to water management, land use management is another important issue for governments to consider when making agricultural development decisions. Balancing land use is very important in sustainable development planning. In general, agricultural development can be done through rural development and through long-term strategic goals such as a high level of competition in the agricultural sector, sustainable management of natural resources and support for economic power in rural areas.

The first priority should be to focus on the agricultural sector, where voluntary agricultural-environmental-climate actions are managed and planned. The second priority is to strengthen agricultural companies by investing in the agricultural sector, as well as other actors in the food supply chain, including distributors and final suppliers of food products. Next, economic development in rural areas and local rural development projects should be supported to create attractive and sustainable rural areas and villages with better future prospects. Finally, a regional development strategy must be developed in which the participation of many citizens is strengthened; In this way, a special value-added area is created to support rural development.

Encouraging the private sector to invest and participate in the agricultural development program is another measure that governments can use to advance food security goals. The addition of the private sector in this direction can not only contribute to food security, but also to develop the region by creating jobs and increasing people's income levels. Because in addition to the availability of food in the market, the ability of families to buy them is one of the main factors affecting food security. That is why some governments, such as the Iranian government, have provided subsidies to the low-income groups so that they can increase their purchasing power and provide the food they need to live a healthy life.

The market for agricultural products in emerging economies is growing rapidly, and due to rising incomes and changing consumer tastes, new opportunities are emerging every day for agricultural and food industry actors in these countries. The main challenge now is how to bring small farmers into this growing market to help strengthen the agricultural sector. Experiments shows that if a country's agricultural sector does not have a competitive environment, that country will increase its reliance on imported food products, and rural poverty reduction programs focusing on the agricultural economy will be less successful. In the meantime, small and medium-sized enterprises play a very important role in establishing links between small farmers and large markets for agricultural products at the national level; These companies not only meet consumer demand for agricultural products, but also create a significant number of jobs. In order to strengthen food value chains and increase the access of smallholder farmers to the market for these products, governments should launch a major effort to improve infrastructure and support farmers. It is required to build road networks and expand rural access to electricity, water and information and communication technology. In addition, they should support for the development of infrastructure that facilitates the delivery of agricultural products with minimal waste - such as storage facilities, dedicated agricultural terminals, and machinery needed in the processing industry.

Having the necessary infrastructure in the agricultural sector reduces transaction costs (costs paid through intermediaries) for farmers, improves the processing of agricultural products, reduces post-harvest crop waste, and finally puts low-income farmers into the cycle. By accessing markets beyond the local market, smallholder farmers will be able to improve their lives. Financing for commercial agriculture and the food industry in these countries should be supported. This support can be also accompanied by a wide range of consulting services in the areas of productivity improvement, climate change adaptation practices, food safety and participation in small supply chains.

Other findings of the present study on the impact of business model innovation on the food supply chain provide evidence of the importance of entrepreneurship and new business models on food supply. Different countries have paid attention to the issue of entrepreneurship for three reasons, which are: 1) creation and development of technology, 2) wealth creation in society, and 3) job creation.

The wider gap between rural and urban areas in developing countries and the dominance of industry over agriculture and the tendency of development strategies and policies towards industry, along with the socio-economic characteristics of rural and agricultural communities, has led to less growth in agricultural entrepreneurship. In developing countries, the farmer is the weakest producer in the country. He lacks the professional skills and support needed by the government and local and national organizations to act as a dynamic entrepreneur. Although land is a rich resource in these countries and has good potential for entrepreneurship, farmers are still poor.

Changes in the market (globalization, population growth, agricultural labor market transformation, food security, market competitiveness), agricultural policies (moving towards market-based commercial agriculture) and society itself (rising unemployment and underemployment, environment issues, biodiversity, natural resources) are among the factors that make the need for entrepreneurship in agriculture even more apparent. A structural change in the current methods of agricultural production is necessary and market-based agriculture in the context of sustainable development will be the basic strategy of agricultural development. In this type of agriculture, the farmer must produce in such a way that he can sell his products in a competitive market that is based on customer demands. For this purpose, the farmer must be opportunistic and correctly identify the needs of the customer and then design and implement the necessary strategy to meet these needs. In other words, today's farmer must be an entrepreneur. Therefore, for the present article, we offer the following suggestions for the development of entrepreneurship in the agricultural sector:

1) It is necessary to identify the current situation of human resources and capabilities and current shortcomings of the agricultural sector in terms of entrepreneurship. In this regard, a systematic view is necessary so that the balance and stability of the agricultural system and its interaction with other social and economic systems of society is not disturbed,

2) Proper infrastructure must be provided for this work. Because the first important principle in the development of entrepreneurship at the macro level is the development of infrastructure:

A) Government policies in the agricultural sector:

- Prioritize agriculture in development planning
- Moving towards a competitive market for agricultural products

- Reduction / elimination or revision of export and import laws of agricultural products and inputs
- Strengthen the manufacturing, value-added, and agricultural services sectors
- Diversification of agricultural activities and alternative agriculture

B) Socio-economic conditions:

- Applying and paying attention to successful "role models" (entrepreneurial farmers)
- Use of economic incentives and suitable and low-interest loans

C) Education

- Vocational technical training in agriculture
- Business skills training
- Develop and strengthen entrepreneurial traits and skills
- Short-term entrepreneurship training programs for different groups of farmers
- Development of technology parks

D) Financial and non-financial support

- Consulting programs
- Creating and developing efficient networks
- Entrepreneurial information system and network
- Research and Development
- Tax loans and incentives
- Physical facilities (physical infrastructure, inputs and required raw materials, roads, telecommunications, transportation, etc.)

3) Governments should actively develop the hardware and software needed to implement the desired mechanisms.

4) Strategies to produce new products to present to the market,

5) Strategies to provide new agricultural services to the community,

6) Strategies to penetrate the market or create a new market,

7) Strategies for starting a new agricultural business. This can be done in the field of in-farm activities, processing-related activities and agricultural complementary industries with the aim of producing added value to agricultural products, or activities outside the farm and in the agricultural services sector,

8) Strategies for applying technology and new production methods in agriculture.

6.3. Limitations

The findings of the present study include limitations that prevent them from being generalized. One of the main limitations of this study is that the present study considers only the domestic production of a country. In other words, the purpose of this study is to examine the domestic capacity of a country to combat food insecurity, while a country's food supply can be obtained in various ways in addition to domestic production. Importing foodstuffs is one of these ways that have not been considered in this study. On the other hand, not all domestic products of a country are consumed for domestic consumption and a percentage of production is always exported, which is not considered in the present study. Another limitation of this study is the political and economic conditions of these countries are considered stable. The political and economic conditions of a country have a great impact on agricultural and livestock production. For example, economic, social or political crises or even wars can hamper a country's domestic production. Even changes in government support policies for domestic producers can affect a country's output, which is considered a constant variable in the present study.

7. NEW SCIENTIFIC RESUALTS

Countries face many challenges in tackling the problems posed by food insecurity; However, the existing literature offers many solutions to address these challenges. Having a comprehensive picture of what is expected to happen in the future will be a good guide for designing appropriate programs and solutions to deal with phenomena in the future. Since there is no model in the literature that predicts the domestic capacity of countries to meet their food demand in the future, the present study seeks to cover this theoretical gap. Therefore, the main contribution of the present study has been to offer a model that has the ability to predict agricultural and livestock production in a country using machine learning models. Because the predictive accuracy of machine learning models is high and the application of these predictive models in various fields of research is increasing. Below the contribution of this study are provided.

1) Innovation in the proposed model to study a country's domestic potential for food supply:

The present study considers the agricultural and livestock products produced in a country to represent the domestic potential of a country for food supply in that country. Data related to agricultural and livestock production of three countries, Iran, Turkey, and Iraq, were collected from FAOSTAT, a database related to the FAO. In fact, these data show the amount of domestic production of agricultural and livestock products in each country during the last 50 years. As mentioned, the sum of these products considered as the domestic capacity of a country in providing food for that country.

2) The dissertation contributes to up-to-date analysis on business model innovation and food supply chain literature:

The present study presents the importance of business model innovation (BMI) in providing solutions to improve and enhance the food supply chain (FSC) using a systematic literature review method. This dissertation is the first study to present the up-to-date relationship between BMI and FSC. This study demonstrates how BMI strategies are implemented at each stage of the FSC and will bring innovations to improve the food security. This contribution provides an in-depth understanding of how BMI affects FSC and proposes a conceptual model accordingly.

3) The dissertation contributes to up-to-date analysis on social capital and food security literature:

This dissertation elaborately demonstrates how social capital created in communities can lead to food security by studying the state of art of contribution of social capital in food security. In this study, using a systematic literature review method, explains how social capital, using the two mechanisms of knowledge sharing and product sharing, can improve the four main pillars of food security (namely, food availability, food accessibility, food utilization, and food system stability).

4) This dissertation presents food security analyzes in the context of three countries:

The present study uses a systematic literature review method to study food security status and the proposed literature solutions for improving the four pillars of food security (namely, food availability, food accessibility, food utilization, and food system stability) for Iran, Turkey, and Iraq separately. The output of this phase of the research presents a novel innovation for the food security literature and especially for the three countries under study. The output of this phase of the research showed that strategies to increase food security of households and water management are the most important solutions to deal with food security in Iran. At the same time, food security improvement solutions in Turkey are mainly focused on yield management, land use management and water management. Finally, the results of this study show that the focus of studies on food security in Iraq is concentrated on macro-agricultural management and land management.

5) This dissertation provides information related to the future of food supply on the content of the three countries:

This dissertation, based on the time series data of agricultural and livestock products of three countries, Iran, Turkey, and Iraq, and using the predictive model of ANFIS machine learning, predict domestic potential of these three countries in food supply the next ten years (until 2030). In other words, this study separately predicts how much agricultural products and how much livestock each of these three countries will produce in the next ten years. The findings of this study reveal that agricultural production in all three countries (i.e., Iran, Turkey, and Iraq) is expected to increase in 2030 compared to 2020. The ANFIS forecasting model also shows that livestock production in Iran and Iraq is expected to increase in 2030 compared to 2020, while the results of the prediction livestock production in Turkey shows a decrease in livestock production in this country in 2030 compared to 2020 are forecast.

6) The methodology of this study and the use of deep learning models on the data of agricultural products and livestock products are of the innovations of the present study because

this study is the first study that uses these deep learning models for this purpose. Since the results have been promising, it is suggested that the ANFIS model for similar datasets be used for future research. In other words, the output of this study provides a tool for policy makers and decision makers at the macro level of food security through which they can depict a possible view of the future of food production and based on it to design policies and plans related to food security. The conceptual model of this study, which considers the agricultural and livestock production of a country as the internal potential of that country in food supply, is another innovation of this research. The findings of this study, in addition to the conceptual model and confirmation of the predictive accuracy of the ANFIS model, have added information about the forecast of agricultural and livestock products of Iran, Turkey and Iraq for the next ten years to the research literature, which is considered as another contribution of this study.

8. SUMMARY

On the one hand, drought and climate change have reduced agricultural production, which in turn has reduced food supply. On the other hand, the population of different countries, especially in the Middle East, is expected to increase, which will increase the demand for food. This decrease in food production and the increase in food demand create a gap that imposes food insecurity on these countries. Various solutions have been proposed to bridge this gap and address food insecurity. Various stakeholders from various industries, such as the food and agriculture industry, research institutes, and policymakers, have come up with solutions to address the growing demand for food. In fact, the goal is not just to provide food, but to increase supply for the growing demand for a healthy population. Before implementing any program to achieve food security, knowing the amount of food products produced in the country can be a basis for planning and designing solutions to achieve food security. In other words, predicting the future of a country's food production can provide macro-level decision makers with a picture to use to plan for tackling food insecurity and its consequences. There are many methods for predicting time series data in the literature, but due to the high predictive performance of machine learning models and deep learning models, the use of these models has become very common. Therefore, the present study is conducted to find a proper machine learning model to predict food production (i.e., agricultural production and livestock production) produced locally in Iran, Iraq, and Turkey. In this study, the predictive performance of two machine learning models, namely MLP and ANFIS, was compared on time series data of agricultural products and livestock products taken from FAOSATAT (i.e., FAO database). For this purpose, first the mentioned models were trained by 70% of the data and then their predictive performance was tested with the rest 30% of the data. Initially, the findings showed that the ANFIS model had a higher predictive performance than the MLP model in both predicting agricultural production and livestock production in all three countries studied. Therefore, this model was used to predict agricultural and livestock production for Iran, Turkey, and Iraq for the next ten years. The results of the forecasts disclosed that agricultural production in all three countries of Iran, Turkey and Iraq is expected to increase remarkably in 2030 compared to 2020. However, the results of livestock production forecasts in these three countries revealed that livestock production is expected to increase only in Iran and Iraq, and livestock production in Turkey will decrease in 2030 compared to 2020. The reason for the decline in livestock production in Turkey can be justified. Because it is predicted that agricultural production in this country will increase and with the increase of agricultural production, the lands allocated for rangeland will become agricultural lands and will reduce livestock production in this country. In addition, the present study showed that social capital, on the one hand, can improve food security in a society through product and knowledge sharing mechanisms. On the other hand, the study found that business model innovation could improve food supply chain performance by improving food security by increasing access to food in an area.

The present study confirms the appropriateness of the performance of ANFIS machine learning model in predicting agricultural and livestock production using quantitative empirical research, and that this output contributes to both machine learning literature and food security literature. The results obtained from food production forecasts in this article contribute to the food security literature and provide methodology to food security decision makers at the macro level of Iran, Turkey and Iraq, based on which they can deal with food insecurity. On the other hand, this study also contributes to the social capital literature and the literature related to business models by showing the impact of social capital on food security and the impact of business innovation model on the food supply chain. These findings provide general guidelines for food security decision makers that cannot be used as solutions to increase food security.

9. APPENDICES

Appendix (1) References

1. ABBASPOUR-GILANDEH, M. & ABBASPOUR-GILANDEH, Y. (2019): Modelling soil compaction of agricultural soils using fuzzy logic approach and adaptive neuro-fuzzy inference system (ANFIS) approaches. *Modeling Earth Systems and Environment*, 5, 13-20.

2. ABOLHASSANI, M. H., KOLAHDOOZ, F., MAJDZADEH, R., ESHRAGHIAN, M., SHANESHIN, M., JANG, S. L. & DJAZAYERY, A. (2015): Identification and Prioritization of Food Insecurity and Vulnerability Indices in Iran. *Iranian journal of public health*, 44, 244.

3. ABRAHAM, A. (2005): Adaptation of fuzzy inference system using neural learning. Fuzzy systems engineering. In *Fuzzy systems engineering* (pp. 53-83). Springer, Berlin, Heidelberg.

4. ADEKUNLE, A., LYEW, D., ORSAT, V. & RAGHAVAN, V. (2018): Helping agribusinesses—Small millets value chain—To grow in India. *Agriculture*, 8, 44.

5. AHUMADA, O.; VILLALOBOS, J.R. (2009): Application of planning models in the agri-food supply chain: A review. *European Journal of Operation Research*, *196*, 1–20.

6. AKHOUNDI, A. & NAZIF, S. (2018): Sustainability assessment of wastewater reuse alternatives using the evidential reasoning approach. *Journal of Cleaner Production*, 195, 1350-1376.

7. ALAMDARLO, H. N., RIYAHI, F. & VAKILPOOR, M. H. (2019): Wheat Self-Sufficiency, Water Restriction and Virtual Water Trade in Iran. *Networks and Spatial Economics*, 19, 503-520.

8. AL-FATLAWI, R. & AL TAIY, H. (2019): The reasons related to the stop of farmers to adopt the technique of plastic houses in Diwaniyah province of Iraq. *Plant Archives*, 19, 452-457.

9. AL-MAHASNEH, M., RABABAH, T., BANI-AMER, M., AL-OMARI, N. & MAHASNEH, M. (2013): Fuzzy and conventional modeling of open sun drying kinetics for roasted green wheat. *International Journal of Food Properties*, 16, 70-80.

10. AMIT, R.; ZOTT, C. (2012, March 20): Creating value through business model innovation. *MIT Sloan Management Review*, 41-53.

11. ASADI-LARI, M., MOOSAVI JAHROMI, L., MONTAZERI, A., REZAEE, N., HAERI MEHRIZI, A. A., SHAMS-BEYRANVAND, M., VAEZ-MAHDAVI, M.-R., KHAZAEE-POOL, M., GHANBARI, A. & GHOLAMI, A. (2019): Socio-economic risk factors of household food insecurity and their population attributable risk: A population-based study. *Medical Journal of The Islamic Republic of Iran (MJIRI)*, 33, 715-721.

12. ASIF, M., TUNC, C. E., YAZICI, M. A., TUTUS, Y., REHMAN, R., REHMAN, A. & OZTURK, L. (2019): Effect of predicted climate change on growth and yield performance of wheat under varied nitrogen and zinc supply. *Plant and soil*, 434, 231-244.

13. BAGHERI, M., AL-JABERY, K., WUNSCH, D. & BURKEN, J. G. (2020): Examining plant uptake and translocation of emerging contaminants using machine learning: implications to food security. *Science of The Total Environment*, 698, 133999.

14. BARTH, H., ULVENBLAD, P.-O. & ULVENBLAD, P. (2017): Towards a conceptual framework of sustainable business model innovation in the agri-food sector: a systematic literature review. *Sustainability,* 9, 1620.

15. BARZEGAR, A., ABBASZADEH, N., SARBAKHSH, P. & JAFARI, A. (2019): The relationship between food security, dietary patterns, and socioeconomic status in Iranian pregnant women. *Progress in Nutrition*, 21, 261-269.

16. BECCHETTI, L. & COSTANTINO, M. (2008): The effects of fair trade on affiliated producers: An impact analysis on Kenyan farmers. *World Development*, 36, 823-842.

17. BERTI, G.; MULLIGAN, C.; YAP, H. (2017): diGital food hubs as disruptive business models based on Coopetition and "shared value" for sustainability in the agri-food sector. In *Global Opportunities for Entrepreneurial Growth: Coopetition and Knowledge Dynamics within and across Firms*; Emerald Publishing Limited: Bingley, UK, 415–438.

18. BHOJANI, S. H. & BHATT, N. (2020): Wheat crop yield prediction using new activation functions in neural network. *Neural Computing and Applications*, 1-11.

19. BOUBACAR, S., PELLING, M., BARCENA, A. & MONTANDON, R. (2017): The erosive effects of small disasters on household absorptive capacity in Niamey: A nested HEA approach. *Environment and urbanization,* 29, 33-50.

20. BOWLES, S. & GINTIS, H. (2002): Social capital and community governance. *The economic journal,* 112, F419-F436.

21. BREARS, R. C. (2016): *Urban water security*, John Wiley & Sons.

22. BROWNE, M., GONCALO, L., XIMENES, A., LOPES, M. & ERSKINE, W. (2017): Do rituals serve as a brake on innovation in staple food cropping in Timor-Leste? *Food Security,* 9, 441-451.

23. BUDIATI, T., SURYANINGSIH, W., BIYANTO, T., PANGESTIKA, N., PANGESTU, M., SAPUTRA, F., HIDAYAT, A., WIDYAWATI, A., FIRDAUS, F. & SABILLA, D. (2021): Finite Impulse Response Type Multilayer Perceptron Artificial Neural Network Model for Bacteria Growth Modeling Inhibited by Lemon Basil Waste Extract. *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 012001.

24. BUNCH, M., PATHAN, S., BATTAGLIA, A., GREER-WOOTTEN, B., MASCOLL, A., RUSSELL, T. & FOLKEMA, J. (2020): Quantifying community resilience in South Sudan: The FEED project (Fortifying Equality and Economic Diversification). *Ecology and Society*, 25.

25. CAGIRGAN, M. I., MBAYE, N., SILME, R. S., OUEDRAOGO, N. & TOPUZ, H. (2013): The impact of climate variability on occurrence of sesame phyllody and symptomatology of the disease in a Mediterranean environment. *Turkish Journal of Field Crops*, 18, 101-108.

26. CARLETTO, C., KILIC, T. & KIRK, A. (2011): Nontraditional crops, traditional constraints: The long-term welfare impacts of export crop adoption among Guatemalan smallholders. *Agricultural Economics*, 42, 61-76.

27. CHEAH, S., HO, Y.-P. & LI, S. (2018): Business Model Innovation for Sustainable Performance in Retail and Hospitality Industries. *Sustainability,* 10, 3952.

28. CHEN, H., WANG, J. & HUANG, J. (2014): Policy support, social capital, and farmers' adaptation to drought in China. *Global Environmental Change,* 24, 193-202.

29. CHERAGHI, M. & KAZEMI, N. (2018): Food security and related economic factors in rural elderly women. *Koomesh,* 20.

30. CHESBROUGH, H. (2010): Business model innovation: Opportunities and barriers. *Long Range Planning, 43,* 354–363.

31. CHRIEST, A. & NILES, M. (2018): The role of community social capital for food security following an extreme weather event. *Journal of Rural Studies,* 64, 80-90.

32. CODRESCU, C. (2014): Quadratic recurrent finite impulse response MLP for indirect immunofluorescence image recognition. 1st *Workshop on Pattern Recognition Techniques for Indirect Immunofluorescence Images. IEEE*, 49-52.

33. CONCEPCION, R. S., SYBINGCO, E., LAUGUICO, S. C. & DADIOS, E. P. (2019): Implementation of multilayer perceptron neural network on quality assessment of tomato puree in aerobic storage using electronic nose. IEEE International Conference on Cybernetics and Intelligent Systems (CIS) and IEEE Conference on Robotics, *Automation and Mechatronics (RAM), 2019. IEEE,* 65-70.

34. CYBENKO, G. (1989): Approximation by superpositions of a sigmoidal function. *Mathematics of control, signals and systems,* 2, 303-314.

35. D'AMOUR, C. B., REITSMA, F., BAIOCCHI, G., BARTHEL, S., GÜNERALP, B., ERB, K.-H., HABERL, H., CREUTZIG, F. & SETO, K. C. (2017): Future urban land expansion and implications for global croplands. *Proceedings of the National Academy of Sciences*, 114, 8939-8944.

36. DASGUPTA, P. (2011): A matter of trust: Social capital and economic development. *ABCDE,* 119.

37. DAVIDSON, V. J., RYKS, J. & CHU, T. (2001): Fuzzy models to predict consumer ratings for biscuits based on digital image features. *IEEE Transactions on Fuzzy Systems*, 9, 62-67.

38. DE JALÓN, S. G., IGLESIAS, A. & NEUMANN, M. B. (2018): Responses of sub-Saharan smallholders to climate change: Strategies and drivers of adaptation. *Environmental Science & Policy*, 90, 38-45.

39. DEAN, W. R., SHARKEY, J. R. & JOHNSON, C. M. (2011): Food insecurity is associated with social capital, perceived personal disparity, and partnership status among older and senior adults in a largely rural area of central Texas. *Journal of nutrition in gerontology and geriatrics,* 30, 169-186.

40. DEMIRDÖĞEN, A., OLHAN, E. & CHAVAS, J.-P. (2016): Food vs. fiber: An analysis of agricultural support policy in Turkey. *Food policy*, 61, 1-8.

41. DI GREGORIO, D. (2017): Place-based business models for resilient local economies: Cases from Italian slow food, agritourism and the albergo diffuso. *Journal of Enterprising Communities: People and Places in the Global Economy*, 11, 113-128.

42. DIVISION, U. P. (2020): World population prospects: the 2020 revision [Online]. Available: http://www.unpopulation.org [Accessed 02.03.2020 2020].

43. EKHLASPOUR, P., FOROUMANDI, E., EBRAHIMI-MAMEGHANI, M., JAFARI-KOSHKI, T. & AREFHOSSEINI, S. R. (2019): Household food security status and its associated factors in Baft-Kerman, IRAN: a cross-sectional study. *Ecology of food and nutrition*, 58, 608-619.

44. EMAMI, M., ALMASSI, M. & BAKHODA, H. (2018): Agricultural mechanization, a key to food security in developing countries: strategy formulating for Iran. *Agriculture & Food Security*, 7, 24.

45. ESCANO, J., BORDONS, C., VILAS, C., GARCÍA, M. R. & ALONSO, A. A. (2009): Neurofuzzy model based predictive control for thermal batch processes. *Journal of Process Control*, 19, 1566-1575.

46. ESFAHANI, A. K., MIRDAMADI, S. M., HOSSEINI, S. J. F. & LASHGARARA, F. (2019): Overseas cultivation: the complimentary approach for developing food security. *Bulgarian Journal of Agricultural Science*, 25, 26-35.

47. ESFARJANI, F., HOSSEINI, H., KHAKSAR, R., ROUSTAEE, R., ALIKHANIAN, H., KHALAFI, M., KHANEGHAH, A. M. & MOHAMMADI-NASRABADI, F. (2019): Home Food Safety Practice and Household Food Insecurity: A Structural Equation Modeling Approach. *Iranian Journal of Public Health*, 48, 1870.

48. ESTURK, O. & OREN, M. N. (2014): Impact of household socio-economic factors on food security: case of Adana. *Pakistan Journal of Nutrition*, 13, 1-6.

49. FANG, C.-L., BAO, C. & HUANG, J.-C. (2007): Management implications to water resources constraint force on socio-economic system in rapid urbanization: a case study of the Hexi Corridor, NW China. *Water Resources Management*, 21, 1613-1633.

50. FAO (2009): Feeding the World, Eradicating Hunger. World Summit on Food Security. Rome.

51. FAO (2019): The state of food security and nutrition in the world 2019: safeguarding against economic slowdowns and downturns. Rome, Italy: FAO.

52. FATHI BEYRANVAND, H., EGHTESADI, S., ATAI JAFARI, A. & MOVAHEDI, A. (2019): Prevalence of Food Insecurity in Pregnant Women in Khorramabad City and its Association with General Health and other Factors. *Iranian Journal of Nutrition Sciences & Food Technology*, 14, 21-30.

53. FRANCESCHELLI, M. V., SANTORO, G. & CANDELO, E. (2018): Business model innovation for sustainability: a food start-up case study. *British Food Journal*, 120, 2483-2494.

54. FURNESS, W. W. & GALLAHER, C. M. (2018): Food access, food security and community gardens in Rockford, IL. *Local Environment*, 23, 414-430.

55. GALLAHER, C. M., KERR, J. M., NJENGA, M., KARANJA, N. K. & WINKLERPRINS, A. M. (2013): Urban agriculture, social capital, and food security in the Kibera slums of Nairobi, Kenya. *Agriculture and human values,* 30, 389-404.

56. GAMBARDELLA, A.; MCGAHAN, A.M. (2010): Business-model innovation: General purpose technologies and their implications for industry structure. *Long Range Planning*, *43*, 262–271.

57. GARRETT, A. & LEEDS, M. A. (2015): The economics of community gardening. *Eastern Economic Journal*, 41, 200-213.

58. GHOUSH, M. A., SAMHOURI, M., AL-HOLY, M. & HERALD, T. (2008): Formulation and fuzzy modeling of emulsion stability and viscosity of a gum–protein emulsifier in a model mayonnaise system. *Journal of Food Engineering*, 84, 348-357.

59. GIACOSA, E., FERRARIS, A. & MONGE, F. (2017): How to strengthen the business model of an Italian family food business. *British Food Journal*, 119, 2309-2324.

60. GOBER, P. (2010): Desert urbanization and the challenges of water sustainability. *Current Opinion in Environmental Sustainability*, 2, 144-150.

61. GÖRMÜŞ, E. (2019): Food banks and food insecurity: cases of Brazil and Turkey. *Forum for Development Studies*, Taylor & Francis, 67-81.

62. GRABOWSKA, M. (2015): Innovativeness in business models. *Procedia Computer Science*, *65*, 1023–1030.

63. GRAY, L., GUZMAN, P., GLOWA, K. M. & DREVNO, A. G. (2014): Can home gardens scale up into movements for social change? The role of home gardens in providing food security and community change in San Jose, California. *Local Environment*, 19, 187-203.

64. GREENBERG, S., GUTERMAN, H. & ROTMAN, S. R. (1995): Rotation-invariant MLP classifiers for automatic aerial image recognition. *Eighteenth Convention of Electrical and Electronics Engineers in Israel. IEEE*, 2.2. 4/1-2.2. 4/5.

65. HATAB, A. A., CAVINATO, M. E. R., LINDEMER, A. & LAGERKVIST, C.-J. (2019): Urban sprawl, food security and agricultural systems in developing countries: A systematic review of the literature. *Cities*, 94, 129-142.

66. HEIDARI, A., MIRZAII, F., RAHNAMA, M. & ALIDOOST, F. (2019): A theoretical framework for explaining the determinants of food waste reduction in residential households: a case study of Mashhad, Iran. *Environmental Science and Pollution Research*, 1-11.

67. HELICKE, N. A. (2019): Markets and collective action: a case study of traditional wheat varieties in Turkey. *Journal of Economy Culture and Society*, 59, 13-30.

68. HERRERO, M., THORNTON, P. K., GERBER, P. & REID, R. S. (2009): Livestock, livelihoods and the environment: understanding the trade-offs. *Current Opinion in Environmental Sustainability*, 1, 111-120.

69. HIGGINS, A., MILLER, C., ARCHER, A., TON, T., FLETCHER, C. & MCALLISTER, R. (2010): Challenges of operations research practice in agricultural value chains. *Journal of the Operational Research Society*, 61, 964-973.

70. HIGGINS, A., MILLER, C., ARCHER, A., TON, T., FLETCHER, C. & MCALLISTER, R. (2010): Challenges of operations research practice in agricultural value chains. *Journal of the Operational Research Society*, 61, 964-973.

71. HOPKINS, L. C. & HOLBEN, D. H. (2018): Food insecure community gardeners in rural Appalachian Ohio more strongly agree that their produce intake improved and food spending decreased as a result of community gardening compared to food secure community gardeners. *Journal of Hunger & Environmental Nutrition,* 13, 540-552.

72. HOSSEINI, S., CHARVADEH, M. P., SALAMI, H. & FLORA, C. (2017): The impact of the targeted subsidies policy on household food security in urban areas in Iran. *Cities*, 63, 110-117.

73. HUANG, T. C., LEE, T. J. & LEE, K. H. (2009): Innovative e-commerce model for food tourism products. *International Journal of Tourism Research*, 11, 595-600.

74. IBAN, M. C. & AKSU, O. (2020): A model for big spatial rural data infrastructure in Turkey: Sensor-driven and integrative approach. *Land Use Policy*, 91, 104376.

75. JANG, J.-S. (1993): ANFIS: adaptive-network-based fuzzy inference system. *IEEE transactions on systems, man, and cybernetics*, 23, 665-685.

76. JANG, J.-S. R. (1991): Fuzzy modeling using generalized neural networks and kalman filter algorithm. *AAAI*, 762-767.

77. JOLINK, A. & NIESTEN, E. (2015): Sustainable development and business models of entrepreneurs in the organic food industry. *Business Strategy and the Environment*, 24, 386-401.

78. JUMAH, R. & MUJUMDAR, A. S. (2005): Modeling intermittent drying using an adaptive neuro-fuzzy inference system. *Drying Technology*, 23, 1075-1092.

79. KÄHKÖNEN, A.-K. (2012): Value net–a new business model for the food industry? British Food Journal, 114, 681-701.

80. KAISER, M., BARNHART, S. & HUBER-KRUM, S. (2020): Measuring social cohesion and social capital within the context of community food security: a confirmatory factor analysis. *Journal of Hunger & Environmental Nutrition*, 15, 591-612.

81. KALE, S. S. & PATIL, P. S. A (2019): Machine Learning Approach to Predict Crop Yield and Success Rate. *IEEE Pune Section International Conference (PuneCon), 2019. IEEE*, 1-5.

82. KANSANGA, M., LUGINAAH, I., BEZNER KERR, R., LUPAFYA, E. & DAKISHONI, L. (2020): Beyond ecological synergies: examining the impact of participatory agroecology on social capital in smallholder farming communities. *International Journal of Sustainable Development & World Ecology,* 27, 1-14.

83. KARABOGA, D. & KAYA, E. (2019): Adaptive network based fuzzy inference system (ANFIS) training approaches: a comprehensive survey. *Artificial Intelligence Review*, 52, 2263-2293.

84. KARANDISH, F. & HOEKSTRA, A. (2017): Informing national food and water security policy through water footprint assessment: the case of Iran. *Water*, 9, 831.

85. KARANDISH, F., SALARI, S. & DARZI-NAFTCHALI, A. (2015): Application of virtual water trade to evaluate cropping pattern in arid regions. *Water resources management*, 29, 4061-4074.

86. KARIMI, P., QURESHI, A. S., BAHRAMLOO, R. & MOLDEN, D. (2012): Reducing carbon emissions through improved irrigation and groundwater management: A case study from Iran. *Agricultural water management*, 108, 52-60.

87. KASCHULA, S. (2011): Using people to cope with the hunger: social networks and food transfers amongst HIV/AIDS afflicted households in KwaZulu-Natal, South Africa. *AIDS and Behavior,* 15, 1490.

88. KAUR, J. & KAUR, P. D. (2018): CE-GMS: A cloud IoT-enabled grocery management system. *Electronic Commerce Research and Applications*, 28, 63-72.

89. KERR, R. B. (2005): Informal labor and social relations in northern Malawi: The theoretical challenges and implications of ganyu labor for food security. *Rural sociology*, 70, 167-187.

90. KHOSHNEVISAN, B., RAFIEE, S., OMID, M. & MOUSAZADEH, H. (2014): Development of an intelligent system based on ANFIS for predicting wheat grain yield on the basis of energy inputs. *Information processing in agriculture*, 1, 14-22.

91. KIARA, J. K. (2011): Focal area approach: a participatory community planning approach to agricultural extension and market development in Kenya. *International journal of agricultural sustainability,* 9, 248-257.

92. KIM, J.-B., LEE, H.-H. & YANG, H.-C. (2014): Proposal of Eco-M Business Model: Specialty Store of Eco-friendly Agricultural Products Joined with Suburban Agriculture. *The Journal of Asian Finance, Economics and Business (JAFEB)*, 1, 15-21.

93. KIRKPATRICK, S. I. & TARASUK, V. (2010): Assessing the relevance of neighbourhood characteristics to the household food security of low-income Toronto families. *Public health nutrition*, 13, 1139-1148.

94. KISMUL, H., HATLØY, A., ANDERSEN, P., MAPATANO, M., VAN DEN BROECK, J. & MOLAND, K. M. (2015): The social context of severe child malnutrition: a qualitative household case study from a rural area of the Democratic Republic of Congo. *International journal for equity in health*, 14, 1-14.

95. KONUKÇU, F., ALBUT, S. & ALTÜRK, B. (2017): Land use/land cover change modelling of Ergene River Basin in western Turkey using CORINE land use/land cover data. *Agron. Res*, 15, 435-443.

96. LAM, M. B., NGUYEN, T.-H. & CHUNG, W.-Y. (2020): Deep learning-based food quality estimation using radio frequency-powered sensor mote. *IEEE Access*, 8, 88360-88371.

97. LASHGARARA, F., MIRDAMADI, S. M. & HOSSEINI, S. J. F. (2011):. Identification of appropriate tools of information and communication technologies (ICT) in the improvement of food security of Iran's rural households. *African Journal of Biotechnology*, 10, 9082-9088.

98. LEE, G. O., SURKAN, P. J., ZELNER, J., OLÓRTEGUI, M. P., YORI, P. P., AMBIKAPATHI, R., CAULFIELD, L. E., GILMAN, R. H. & KOSEK, M. N. (2018): Social connectedness is associated with food security among peri-urban Peruvian Amazonian communities. *SSM-population health,* 4, 254-262.

99. LIBERATI, A., ALTMAN, D. G., TETZLAFF, J., MULROW, C., GØTZSCHE, P. C., IOANNIDIS, J. P., CLARKE, M., DEVEREAUX, P. J., KLEIJNEN, J. & MOHER, D. (2009): The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Annals of internal medicine,* 151, W-65-W-94.

100. LIBERTI, F., PISTOLESI, V., MASSOLI, S., BARTOCCI, P., BIDINI, G. & FANTOZZI, F. (2018): i-REXFO LIFE: an innovative business model to reduce food waste. *Energy Procedia*, 148, 439-446.

101. LU, Y., LI, X., ZHONG, J. & XIONG, Y. (2010): Research on the innovation of strategic business model in green agricultural products based on Internet of things (IOT). *2nd International Conference on E-business and Information System Security, 2010. IEEE,* 1-3.

102. MARTIKAINEN, A., NIEMI, P. & PEKKANEN, P. (2014): Developing a service offering for a logistical service provider—Case of local food supply chain. *International Journal of Production Economics*, 157, 318-326.

103. MARTIN, K. S., ROGERS, B. L., COOK, J. T. & JOSEPH, H. M. (2004): Social capital is associated with decreased risk of hunger. *Social science & medicine,* 58, 2645-2654.

104. MARTINOVSKI, S. (2016): Nutrition Business Models of Consumer Behavior When Purchasing Self-Explanatory Food Products. *Journal of Hygienic Engineering and Design, 53-58*.

105. MAXWELL, S. & SLATER, R. (2003): Food policy old and new. *Development policy review*, 21, 531-553.

106. MEADOR, J. & FRITZ, A. (2017): Food security in rural Uganda: assessing latent effects of microfinance on pre-participation. *Development in practice,* 27, 340-353.

107. MEHRABI, F. & SEPASKHAH, A. R. (2019): Partial root zone drying irrigation, planting methods and nitrogen fertilization influence on physiologic and agronomic parameters of winter wheat. *Agricultural Water Management*, 223, 105688.

108. MISSELHORN, A. (2009): Is a focus on social capital useful in considering food security interventions? Insights from KwaZulu-Natal. *Development Southern Africa,* 26, 189-208.

109. MISSELHORN, A. A. (2005): What drives food insecurity in southern Africa? A meta-analysis of household economy studies. *Global environmental change,* 15, 33-43.

110. MOHADDES, S. & FAHIMIFARD, S. (2018): Application of Adaptive Neuro-Fuzzy Inference Syste m (ANFIS) in Forecasting Agricultural Products Export Revenues (Case of Iran's Agriculture Sector). PhD. Dissertation, Jomo, Kenyatta University of Agriculture and Technology.

111. MORSHEDI, L., LASHGARARA, F., HOSSEINI, F., JAMAL, S. & OMIDI NAJAFABADI, M. (2017): The role of organic farming for improving food security from the perspective of fars farmers. *Sustainability*, 9, 2086.

112. MOTLAGH, A. R. D., AZADBAKHT, L. & KABOLI, N. E. (2019): Food Insecurity in Obese Adolescent Females in Tehran Schools: An Examination of Anthropometric and Socio-Economic Factors. *Current Research in Nutrition and Food Science Journal*, 7, 280-286.

113. MTIKA, M. M. (2001): The AIDS epidemic in Malawi and its threat to household food security. *Human organization*, 60, 178-188.

114. MURATOGLU, A. (2019): Water footprint assessment within a catchment: A case study for Upper Tigris River Basin. *Ecological Indicators*, 106, 105467.

115. MWAKIWA, E., MAPARARA, T., TATSVAREI, S. & MUZAMHINDO, N. (2018): Is community management of resources by urban households, feasible? Lessons from community gardens in Gweru, Zimbabwe. *Urban Forestry & Urban Greening*, 34, 97-104.

116. NARAYANAN, S. (2014): Profits from participation in high value agriculture: Evidence of heterogeneous benefits in contract farming schemes in Southern India. *Food Policy,* 44, 142-157.

117. NARROD, C., ROY, D., OKELLO, J., AVENDAÑO, B., RICH, K. & THORAT, A. (2009): Public–private partnerships and collective action in high value fruit and vegetable supply chains. *Food policy,* 34, 8-15.

118. NAUGHTON, C. C., DEUBEL, T. F. & MIHELCIC, J. R. (2017): Household food security, economic empowerment, and the social capital of women's shea butter production in Mali. *Food Security,* 9, 773-784.

119. NOSRATABADI, S., KAROLY, S., BESZEDES, B., FELDE, I., ARDABILI, S. & MOSAVI, A. (2020): Comparative Analysis of ANN-ICA and ANN-GWO for Crop Yield Prediction. In *2020 RIVF International Conference on Computing and Communication Technologies (RIVF)* (pp. 1-5). IEEE.

120. NOSRATABADI, S., MOSAVI, A. & LAKNER, Z. (2020): Food Supply Chain and Business Model Innovation. *Foods,* 9, 132.

121. NYIKAHADZOI, K., SIZIBA, S., MANGO, N., MAPFUMO, P., ADEKUNHLE, A. & FATUNBI, O. (2012): Creating food self reliance among the smallholder farmers of eastern Zimbabwe: exploring the role of integrated agricultural research for development. *Food Security,* 4, 647-656.

122. OLARINDE, L. O., ABASS, A. B., ABDOULAYE, T., ADEPOJU, A. A., ADIO, M. O., FANIFOSI, E. G. & WASIU, A. (2020): The influence of social networking on food security status of cassava farming households in Nigeria. *Sustainability,* 12, 5420.

123. OLIVIER, D. W. & HEINECKEN, L. (2017): The personal and social benefits of urban agriculture experienced by cultivators on the Cape Flats. *Development Southern Africa,* 34, 168-181.

124. OZCATALBAS, O. & AKCAOZ, H. (2010): Rural women and agricultural extension in Turkey. *Journal of food, agriculture & environment*, 8, 261-267.

125. ÖZKAN-GÜNAY, E. N. & FEDAI, H. (2011): Climate change and agricultural trade in the european food market: The case of turkey and her major rivals. *16th International Business Information Management Association*, 403-421.

126. PAHK, Y. & BAEK, J. (2015): Stakeholder centred approach to sustainable design: A case study of co-designing community enterprises for local food production and consumption. In Weber, C., Husung, C., Cascini, G., Cantamessa, M., Marjanovic, D., Bordegoni, M., *ICED*, Korea, Republic of (South Korea): Ulsan National Institute of Science and Technology (UNIST), 269-278.

127. PAREWAI, I., AS, M., MINE, T. & KOEPPEN, M. (2020): Identification and Classification of Sashimi Food Using Multispectral Technology. *Proceedings of the 2020 2nd Asia Pacific Information Technology Conference*, 66-72.

128. PARRY, M. L., ROSENZWEIG, C., IGLESIAS, A., LIVERMORE, M. & FISCHER, G. (2004): Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global environmental change,* 14, 53-67.

129. PASCOE, J. & HOWES, M. (2017): A growing movement: motivations for joining community gardens. *WIT Transactions on Ecology and the Environment,* 226, 381-389.

130. PAYMARD, P., YAGHOUBI, F., NOURI, M. & BANNAYAN, M. (2019): Projecting climate change impacts on rainfed wheat yield, water demand, and water use efficiency in northeast Iran. *Theoretical and Applied Climatology,* 138, 1361-1373.

131. PEKCAN, G. (2006): Food and nutrition policies: what's being done in Turkey. *Public Health Nutrition,* 9, 158-162.

132. PEŁKA, P. & DUDEK, G. (2019): Pattern-based forecasting monthly electricity demand using multilayer perceptron. *International Conference on Artificial Intelligence and Soft Computing,* Springer, 663-672.

133. PEREIRA, Á., VILLANUEVA-REY, P., VENCE, X., MOREIRA, M. T. & FEIJÓO, G. (2018): Fresh milk supply through vending machines: Consumption patterns and associated environmental impacts. *Sustainable Production and Consumption,* 15, 119-130.

134. PLÀ, L. M., SANDARS, D. L. & HIGGINS, A. J. (2014): A perspective on operational research prospects for agriculture. *Journal of the Operational Research Society,* 65, 1078-1089.

135. PÖLLING, B., PRADOS, M.-J., TORQUATI, B. M., GIACCHÈ, G., RECASENS, X., PAFFARINI, C., ALFRANCA, O. & LORLEBERG, W. (2017a): Business models in urban farming: A comparative analysis of case studies from Spain, Italy and Germany. *Moravian Geographical Reports,* 25, 166-180.

136. PÖLLING, B., SROKA, W. & MERGENTHALER, M. (2017b): Success of urban farming's city-adjustments and business models—Findings from a survey among farmers in Ruhr Metropolis, Germany. *Land use policy,* 69, 372-385.

137. PORTER, R. & MCILVAINE-NEWSAD, H. (2013): Gardening in green space for environmental justice: food security, leisure and social capital. *Leisure/Loisir,* 37, 379-395.

138. PRAKASH, O. & KUMAR, A. (2014): ANFIS modelling of a natural convection greenhouse drying system for jaggery: an experimental validation. *International Journal of Sustainable Energy*, 33, 316-335.

139. PUTNAM, R. (1993): The prosperous community: Social capital and public life. *The american prospect,* 13.

140. QASEMIPOUR, E. & ABBASI, A. (2019): Virtual water flow and water footprint assessment of an arid region: A case study of South Khorasan province, Iran. *Water,* 11, 1755.

141. QIN, L. & YANG, S. X. (2011): An adaptive neuro-fuzzy approach to risk factor analysis of Salmonella Typhimurium infection. *Applied Soft Computing*, 11, 4875-4882.

142. QUETULIO-NAVARRA, M., FRUNT, E. & NIEHOF, A. (2018): The role of social capital and institutions in food security and wellbeing of children under five for resettled households in Central Java, Indonesia. *Diversity and change in food wellbeing: Cases from Southeast Asia and Nepal.* Wageningen Academic Publishers.

143. RAEISI, L. G., MORID, S., DELAVAR, M. & SRINIVASAN, R. (2019): Effect and side-effect assessment of different agricultural water saving measures in an integrated framework. *Agricultural Water Management*, 223, 105685.

144. RAYAMAJHEE, V. & BOHARA, A. K. (2019): Do voluntary associations reduce hunger? An empirical exploration of the social capital-food security nexus among food impoverished households in western Nepal. *Food Security,* 11, 405-415.

145. RIBEIRO, I., SOBRAL, P., PEÇAS, P. & HENRIQUES, E. (2018): A sustainable business model to fight food waste. *Journal of cleaner production*, 177, 262-275.

146. RICKARDS, L. & SHORTIS, E. (2019): SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

147. ROSENBLATT, F. (1961): *Principles of neurodynamics. perceptrons and the theory of brain mechanisms*. New York: Cornell Aeronautical Lab Inc Buffalo.

148. RUANE, J. & SONNINO, A. (2011): Agricultural biotechnologies in developing countries and their possible contribution to food security. *Journal of biotechnology,* 156, 356-363.

149. RUSSO, L., ALBANESE, D., SIETTOS, C. I., DI MATTEO, M. & CRESCITELLI, S. (2012): A neuro-fuzzy computational approach for multicriteria optimisation of the quality of espresso coffee by pod based on the extraction time, temperature and blend. *International journal of food science & technology*, 47, 837-846.

150. SAGDIC, O., OZTURK, I. & KISI, O. (2012): Modeling antimicrobial effect of different grape pomace and extracts on S. aureus and E. coli in vegetable soup using artificial neural network and fuzzy logic system. *Expert Systems with Applications*, 39, 6792-6798.

151. SAINT VILLE, A. S., HICKEY, G. M. & PHILLIP, L. E. (2017): How do stakeholder interactions influence national food security policy in the Caribbean? The case of Saint Lucia. *Food Policy,* 68, 53-64.

152. SAINT VILLE, A. S., HICKEY, G. M., LOCHER, U. & PHILLIP, L. E. (2016): Exploring the role of social capital in influencing knowledge flows and innovation in smallholder farming communities in the Caribbean. *Food Security*, 8, 535-549.

153. SAMHOURI, M., ABUGHOUSH, M. & HERALD, T. (2007): Fuzzy identification and modeling of a gum-protein emulsifier in a model mayonnaise color development system. *International Journal of Food Engineering*, 3.

154. SCHMIDHUBER, J. & TUBIELLO, F. N. (2007): Global food security under climate change. *Proceedings of the National Academy of Sciences*, 104, 19703-19708.

155. SETO, K. C., GÜNERALP, B. & HUTYRA, L. R. (2012): Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences*, 109, 16083-16088.

156. SEVIK, H., CETIN, M., OZEL, H. B., OZEL, S. & CETIN, I. Z. (2020): Changes in heavy metal accumulation in some edible landscape plants depending on traffic density. *Environmental Monitoring and Assessment*, 192, 78.

157. SHAHBAZIKHAH, P., ASADOLLAHI-BABOLI, M., KHAKSAR, R., ALAMDARI, R. F. & ZARE-SHAHABADI, V. (2011): Predicting partition coefficients of migrants in food simulant/polymer systems using adaptive neuro-fuzzy inference system. *Journal of the Brazilian Chemical Society*, 22, 1446-1451.

158. SHAHRAKI, S. H., AMIRKHIZI, F., AMIRKHIZI, B. & HAMEDI, S. (2016): Household food insecurity is associated with nutritional status among Iranian children. *Ecology of food and nutrition*, 55, 473-490.

159. SHAMSHIRBAND, S., ESMAEILBEIKI, F., ZAREHAGHI, D., NEYSHABOURI, M., SAMADIANFARD, S., GHORBANI, M. A., MOSAVI, A., NABIPOUR, N. & CHAU, K.-W. (2020): Comparative analysis of hybrid models of firefly optimization algorithm with support vector machines and multilayer perceptron for predicting soil temperature at different depths. *Engineering Applications of Computational Fluid Mechanics*, 14, 939-953.

160. SHASTRY, A., SANJAY, H. & HEGDE, M. (2015): A parameter based ANFIS model for crop yield prediction. *2015 IEEE International Advance Computing Conference (IACC)*. IEEE, 253-257.

161. SHIH, C.-W. & WANG, C.-H. (2016): Integrating wireless sensor networks with statistical quality control to develop a cold chain system in food industries. *Computer Standards & Interfaces*, 45, 62-78.

162. SHIMANAKA, H., KAJIWARA, T. & KOMACHI, M. (2019): Machine translation evaluation with BERT regressor. *arXiv preprint arXiv*:1907.12679.

163. SIAHIPOUR, S., KHODABAKHSHI, A., MEHRAD-MAJD, H., NOROOZI, M. & MOGHADAM, S. A. H. Z. (2019): Study of food security and its related factors in Iranian families referred to health centers in Qazvin. *Progress in Nutrition*, 21, 321-328.

164. ȘİMȘEK, O. & CAKMAK, B. (2012): Future-proof scenarios and risk analysis for wheat by AgroMetShell model. *Tarim Bilimleri Dergisi*, 18, 187-196.

165. SINGH, R. K. & VERMA, H. K. (2020): Influence of Social Media Analytics on Online Food Delivery Systems. *International Journal of Information System Modeling and Design (IJISMD)*, 11, 1-21.

166. SMITH, L. C. & FRANKENBERGER, T. R. (2018): Does resilience capacity reduce the negative impact of shocks on household food security? Evidence from the 2014 floods in Northern Bangladesh. *World Development*, 102, 358-376.

167. SONNINO, R. (2016): The new geography of food security: exploring the potential of urban food strategies. *The Geographical Journal*, 182, 190-200.

168. SOORANI, F. & AHMADVAND, M. (2019): Determinants of consumers' food management behavior: Applying and extending the theory of planned behavior. *Waste Management*, 98, 151-159.

169. SSEGUYA, H., MAZUR, R. E. & FLORA, C. B. (2018): Social capital dimensions in household food security interventions: implications for rural Uganda. *Agriculture and Human values*, 35, 117-129.

170. TABRIZI, J. S., NIKNIAZ, L., SADEGHI-BAZARGANI, H., FARAHBAKHSH, M. & NIKNIAZ, Z. (2018): Socio-demographic Determinants of Household Food Insecurity among Iranian: A Population-based Study from Northwest of Iran. *Iranian journal of public health*, 47, 893.

171. TAGHADOMI-SABERI, S., OMID, M., EMAM-DJOMEH, Z. & AHMADI, H. (2014): Evaluating the potential of artificial neural network and neuro-fuzzy techniques for estimating antioxidant activity and anthocyanin content of sweet cherry during ripening by using image processing. *Journal of the Science of Food and Agriculture*, 94, 95-101.

172. TAGHIZADEH-HESARY, F., RASOULINEZHAD, E. & YOSHINO, N. (2019): Energy and food security: Linkages through price volatility. *Energy policy*, 128, 796-806.

173. TAHIR, Y., RAHMAN, A. U. & RAVANA, S. D. (2020): An affect-based classification of emotions associated with images of food. *Journal of Food Measurement and Characterization*, 1-12.

174. TAN, K., YE, Y., CAO, Q., DU, P. & DONG, J. (2014): Estimation of arsenic contamination in reclaimed agricultural soils using reflectance spectroscopy and ANFIS model. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 7, 2540-2546.

175. THORNTON, P. K. (2010): Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365, 2853-2867.

176. TOKER, O. S. & DOGAN, M. (2013): Effect of temperature and starch concentration on the creep/recovery behaviour of the grape molasses: modelling with ANN, ANFIS and response surface methodology. *European Food Research and Technology*, 236, 1049-1061.

177. UDAYANA, I. P. A. E. D., SUDARMA, M. & NUGRAHA, P. G. S. C (2020): Implementation of Convolutional Neural Networks to Recognize Images of Common Indonesian Food. *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, 012023.

178. ULVENBLAD, P., BARTH, H., BJÖRKLUND, J. C., HOVESKOG, M., ULVENBLAD, P.-O. & STÅHL, J. (2018): Barriers to business model innovation in the agri-food industry: A systematic literature review. *Outlook on Agriculture*, 47, 308-314.

179. ULVENBLAD, P.-O.; ULVENBLAD, P.; TELL, J. (2019): An overview of sustainable business models for innovation in Swedish agri-food production. *Journal of Integrative Environmental Sciences*, *16*, 1–22.

180. URBINATI, L. (2019): Detection of food contaminants with Microwave Sensing and Machine Learning. Doctoral dissertation, Politecnico di Torino Politecnico di Torino.

181. VAN DEN BROECK, G. & MAERTENS, M. (2016a): Horticultural exports and food security in developing countries. *Global food security*, 10, 11-20.

182. VAN DEN BROECK, G. & MAERTENS, M. (2016b): Moving Up or Moving Out? Insights on Rural Development and Poverty Reduction in Senegal. *World Development*, 99, 95-109.

183. VAN DER VORST, J.G. (2000): Effective Food Supply Chains: Generating, Modelling and Evaluating Supply Chain Scenarios. Ph.D. Thesis.

184. VANLI, Ö., USTUNDAG, B. B., AHMAD, I., HERNANDEZ-OCHOA, I. M. & HOOGENBOOM, G. (2019): Using crop modeling to evaluate the impacts of climate change on wheat in southeastern turkey. *Environmental Science and Pollution Research*, 26, 29397-29408.

185. VARELA-CANDAMIO, L., CALVO, N. & NOVO-CORTI, I. (2018): The role of public subsidies for efficiency and environmental adaptation of farming: A multi-layered business model based on functional foods and rural women. *Journal of cleaner production*, 183, 555-565.

186. VERPOORTEN, M., ARORA, A., STOOP, N. & SWINNEN, J. (2013): Self-reported food insecurity in Africa during the food price crisis. *Food Policy*, 39, 51-63.

187. VITIELLO, D. & WOLF-POWERS, L. (2014): Growing food to grow cities? The potential of agriculture foreconomic and community development in the urban United States. *Community Development Journal*, 49, 508-523.

188. VOJTOVIC, S., NAVICKAS, V. & GRUZAUSKAS, V. (2016): Sustainable business development process: the case of the food and beverage industry. *Zeszyty Naukowe Politechniki Poznańskiej. Organizacja i Zarządzanie,* 68, 225-239.

189.WHITLEY, S. (2013): Changing times in rural America: Food assistance and food insecurity in food deserts. *Journal of Family Social Work*, 16, 36-52.

190. WORLD HEALTH ORGANIZATION (2019): The state of food security and nutrition in the world 2019: safeguarding against economic slowdowns and downturns. Food and Agriculture Organization.

191. WOSSEN, T., DI FALCO, S., BERGER, T. & MCCLAIN, W. (2016): You are not alone: social capital and risk exposure in rural Ethiopia. *Food security,* 8, 799-813.

192. WU, W., AL-SHAFIE, W. M., MHAIMEED, A. S., ZIADAT, F., NANGIA, V. & PAYNE, W. B. (2014): Soil salinity mapping by multiscale remote sensing in Mesopotamia,

Iraq. IEEE *Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 7, 4442-4452.

193. WUNDERLICH, S. M. & MARTINEZ, N. M. (2018): Conserving natural resources through food loss reduction: Production and consumption stages of the food supply chain. *International Soil and Water Conservation Research,* 6, 331-339.

194. XU, S., BARBIERI, C. & SEEKAMP, E. (2020): Social Capital along Wine Trails: Spilling the Wine to Residents? *Sustainability,* 12, 1592.

195. YADEGARI, L., DOLATIAN, M., MAHMOODI, Z., SHAHSAVARI, S. & SHARIFI, N. (2017): The relationship between socioeconomic factors and food security in pregnant women. *Shiraz E-Medical Journal*, 18.

196. YOLMEH, M., NAJAFI, M. B. H. & SALEHI, F. (2014): Genetic algorithm-artificial neural network and adaptive neuro-fuzzy inference system modeling of antibacterial activity of annatto dye on Salmonella enteritidis. *Microbial pathogenesis*, 67, 36-40.

197. YÖRÜK, N. G. & GÜNER, A. (2017): Control of fermented sausage, salami, sausage, and hamburger meatballs produced in meat production facilities applying the ISO Food Security System for food pathogens. *Turkish Journal of Veterinary and Animal Sciences*, 41, 337-344.

198. YUNIARTI, D., PURWANINGSIH, Y., SOESILO, A. & SURYANTORO, A. (2019): CLIMATE CHANGE-FOOD SECURITY-FINANCIAL ASSETS NEXUS: EVIDENCE FROM INDONESIA. *Humanities & Social Sciences Reviews*, 7, 62-68

199. ZHANG, L., TRAORE, S., GE, J., LI, Y., WANG, S., ZHU, G., CUI, Y. & FIPPS, G. (2019): Using boosted tree regression and artificial neural networks to forecast upland rice yield under climate change in Sahel. *Computers and Electronics in Agriculture*, 166, 105031.

200. ZHENG, H., JIANG, B. & LU, H. (2011): An adaptive neural-fuzzy inference system (ANFIS) for detection of bruises on Chinese bayberry (Myrica rubra) based on fractal dimension and RGB intensity color. *Journal of Food Engineering*, 104, 663-667.

201. ZHU, Q., STOLCKE, A., CHEN, B. Y. & MORGAN, N. (2005): Using MLP features in SRI's conversational speech recognition system. In *INTERSPEECH*-2005, *Ninth European Conference on Speech Communication and Technology*, 2141-2144.

202. ZONDAG, M.M.; MUELLER, E.F.; FERRIN, B.G. (2017): The application of value nets in food supply chains: A multiple case study. *Scandinavian Journal of Management*, *33*, 199–212.

203. ZOTT, C.; AMIT, R.; MASSA, L. (2011): The business model: Recent developments and future research. *Journal of Management*, *37,* 1019–1042.

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