The Effects of Natural Disasters on the Health Sector in Iran

Shahpari, Ghazal

Tarbiat Modares University

21 July 2018

Approval of the Examination Committee Present at the Doctoral Thesis Defense Session:

The members of the examination committee present at the doctoral thesis defense of Ms. **Ghazal Shahpari**, a doctoral candidate in Health Economics, with the title "**The Effects of Natural Disasters on the Health Sector in Iran,"** have reviewed the content of the thesis and recommend its acceptance for the awarding of the **doctoral degree**.

Members of the Examination Committee	Name & Surname	Affiliation	Place of work
Supervisor	Dr. Hossein Sadeghi	Associate Professor	Tarbiat Modares University
Co- Supervisor	Dr. Abbas Assari	Associate Professor	Tarbiat Modares University
Co- Supervisor (second)	Dr. Mohammad Hasanzadeh	Associate Professor	University of Ardabil
Internal Reviewer	Dr. Lotfali Agheli	Associate Professor	Tarbiat Modares University
Internal Reviewer	Dr. Hasan Heydari	Assistance Professor	Tarbiat Modares University
External Reviewer	Dr. Ghahraman Abdoli	Full Professor	Tehran University
External Reviewer	Dr. Nader Mehregan	Full Professor	Bu-Ali Sina University

Regulations on Material and Intellectual Property Rights Regarding the Results of Scientific Research

Tarbiat Modares University

Introduction

In line with the university's research and technology policies aimed at achieving justice and human dignity—essential for scientific and technological advancement—and ensuring the material and intellectual rights of the university and researchers, it is necessary for faculty members, students, graduates, and other project collaborators to adhere to the following provisions regarding the results of scientific research conducted under the university’s coordination, including theses, dissertations, and research projects:

Article 1

The university holds the copyright and reproduction rights of theses/dissertations and any resulting financial income. However, the intellectual rights of the creators shall be preserved.

Article 2

Any publication of articles derived from a thesis/dissertation, whether in scientific journals or presented at academic conferences, must be under the university’s name. The main supervisor, one of the co-supervisors, an advisor, or the corresponding student must be listed as an author with the main supervisor’s approval. However, the academic responsibility for the published article lies with the supervisors and the student.

Note: If an article is published after the student’s graduation and includes a combination of new information and results from the thesis/dissertation, the university's name must still be included.

Article 3

The publication of books, software, or special works (such as artistic works, including films, photographs, paintings, and plays) resulting from theses, dissertations, or any research projects conducted within the university—covering faculties, research centers, institutes, science and technology parks, and other units—must be authorized in writing by the university's Research Vice Presidency and comply with approved regulations.

Article 4

The registration of patents, development of technical knowledge, or presentation of findings at national, regional, and international festivals—when derived from theses, dissertations, or university research projects—must be carried out in coordination with the supervisor or project director through the university's Research Vice Presidency.

Article 5

This regulation consists of five articles and one note. It was approved by the Research Council on **June 21, 2008**, endorsed by the University's Executive Board on **July 13, 2008**, and officially ratified by the University Council on **October 6, 2008**. It has been in effect since the date of its ratification.

Commitment Statement

I, **Ghazal Shahpari**, a Ph.D. student in Health Economics, Faculty of Management and Economics, enrolled in the academic year **2013**, hereby commit to fully complying with all provisions stated in the **Regulations on Material and Intellectual Property Rights Regarding the Results of Scientific Research of Tarbiat Modares University** when publishing scientific findings derived from my thesis/dissertation. In the event of any violation of the aforementioned regulations, I grant the university full authority to revoke any patent rights or other privileges registered under my name and transfer them to the university. Furthermore, I agree to promptly compensate for any damages incurred as assessed by the university and waive my right to any objections regarding these matters.

Ghazal Shahpari

21st July 2018

Regulations on the Publication of Students' Theses and Dissertations

Tarbiat Modares University

Given that the publication and dissemination of students' theses and dissertations represent a part of the university’s scientific and research activities, graduates of Tarbiat Modares University commit to adhering to the following provisions to respect the university’s rights:

Article 1

If a student intends to publish their thesis/dissertation, they must first inform the **Office for Scientific Publications** of the university in writing.

Article 2

On the third page of the book (following the title page), the following statement must be printed:

"This book is the result of the author's Ph.D. dissertation in Health Economics, defended in 2018 at the Faculty of Management and Economics, Tarbiat Modares University, under the supervision of Dr. Hossein Sadeghi and the advisory of Dr. Abbas Assari and Dr. Mohammad Hassanzadeh."

Article 3

To compensate for part of the university's publication costs, the author must donate **1% of the printed copies** (for each print run) to the **Office for Scientific Publications**. The university reserves the right to sell any excess copies for the benefit of the publication center.

Article 4

Failure to comply with Article 3 requires the author to pay **50% of the total printed copies' value** as compensation to Tarbiat Modares University.

Article 5

The student acknowledges and accepts that if they fail to pay the required compensation, the university has the right to pursue legal action to claim and recover the amount. Furthermore, the university is entitled to request a court order to seize and sell an equivalent number of the author’s published books to recover the compensation outlined in **Article 4**.

Article 6

I, **Ghazal Shahpari**, a Ph.D. student in Health Economics, hereby accept and commit to fully complying with the above obligations and their enforcement mechanisms.

Ghazal Shahpari

21st July 2018

T.M.U.

Tarbiat Modares University

Faculty of Management and Economics

The Effects of Natural Disasters on the Health Sector in Iran

Dissertation submitted in the Partial Fulfilment of the Requirement for the Degree of Doctor of Philosophy (Ph.D.) in Economics

By:

Ghazal Shahpari

Supervisor:

Dr. Hossein Sadeghi

Co- Supervisors:

Dr. Abbas Assari

Dr. Mohammad Hasanzadeh

2018

Abstract:

In the last decades, natural disasters have burdened many economic and physical losses to the countries. After disaster, the level of capital stock decreases strongly and household assets will be at risk seriously, and by decreasing the amount of income and saving, it will lead to lower the levels of welfare. According to the study of the natural disasters that had happened in Iran, earthquake and drought are the main disasters that can affect economies. After disaster happened, government's expenditure will increase to help victims. While, by an accurate programming to reduce risks before the disaster, the loss will decline dramatically.

In this dissertation, by applying computable general equilibrium models, economic effects of earthquake and drought on the macroeconomic variables, health sector and household welfare have been studied. Decreasing in the amount of capital stock and decreasing in the amount of available water are the scenarios that have been investigated in this dissertation. According to the results, both earthquake and drought lead to decline of GDP and also change the production of health sector. Since the consumption, saving and income of household decrease, it can be concluded that the household welfare also declines.

The amount of capital in the building sector in comparison with the whole investment is high in Iran. Earthquake is the major reason for buildings to be destroyed, therefore finding an appropriate solution to save the national wealth seems necessary. Then, by presenting a conceptual method, insurance has been introduced as the most effective solutions for facing with losses of disasters, and especially earthquake. By using legal requirements, appropriate and justly pricing for premium and government supports of some groups of the society, the shortage of demand for the earthquake insurance must be solved and by increasing in the liquidity, the insurance industry will be developed. And also, in the long run, earthquake insurance will lead to reinforced and standard building that will lower the losses down as much as possible.

For drought, in addition to the insurance, managing water resources accurately should be considered. Studying the consequences of dam constructions, moving or displacement of the rivers, building installations are necessary. In recent years these kinds of actions have severe negative effects on the water resources and ecosystem and lead to drought. Besides studying on the economic efficiency of importing agriculture product is that needs lots of water, is another solution of saving water.

Keywords: Natural Disasters, Health Sector, Earthquake, Drought, Computable General Equilibrium Models.

Chapter 1
Introduction and Overview of the Research Proposal

1-1. Introduction

Natural Disasters are shocks that are beyond human control and annually cause significant loss of life and financial damage to societies in various parts of the world. Natural disasters are side effects of the Earth's natural processes that have no human origin and are typically unpredictable or, at least, cannot be foreseen long before they occur. These phenomena are geophysical, atmospheric, or hydrological events that have significant potential to cause damage (Benson, 2004). Some types of natural disasters, such as air pollution or global warming, are indirectly caused by human activities, including deforestation. Natural disasters can lead to the loss of human life and the destruction of property, usually resulting in economic damage, the severity of which depends on the community's ability to recover from it.

Although most natural disasters seem to be beyond human control, the damage caused by them is manageable, which depends on preventive actions taken before the disaster, such as reinforcing buildings to prevent earthquake damage or constructing dams and levees to mitigate flood-related damages. Education is also one of the ways to cope with the damage caused by natural disasters, and it can reduce the harmful psychological effects. In developed countries such as the United States, Japan, and other European nations, strategies have been adopted to reduce the damages caused by disasters. In other words, these countries have largely managed to control the damage from disasters. However, in third-world countries, disaster prevention and mitigation management are not strong enough due to institutional, economic, and social reasons. Therefore, the occurrence of disasters in these countries typically results in irreparable damage.

1-2. Problem Statement

Natural disasters leave direct and indirect effects, large-scale or regional impacts on different areas and countries due to their inherent uncertainty. Short-term migration, destruction of housing units, job losses, a decrease in industrial production and agricultural products, damage to infrastructure, and disruptions in transportation, communication, and marketing networks are among these impacts. Private sector consumption, government expenditures, private sector investment, savings, inflation, unemployment, and balance of payments are some macroeconomic variables that are affected by natural disasters depending on the level of economic development (Imamqolipour, 2008).

Natural disasters, such as earthquakes and storms, contribute significantly to the health burden on the affected society and threaten the capacity of health services to meet healthcare needs. The health damage and economic losses caused by natural disasters disproportionately affect developing countries, especially the poor in these nations.

Natural disasters are not random. Countries located on earthquake belts or those prone to droughts and severe storms are well-known. Iran, due to its specific climatic conditions (located in a dry and semi-dry climate), its position on the earthquake belt, and steep mountain slopes in certain regions, periodically experiences catastrophic natural disasters.

It is essential to note that these events cause widespread human and financial losses. Governments are expected to take immediate action after such phenomena occur, covering all damages and carrying out the reconstruction and compensation efforts for the affected individuals. However, in developed countries, insurance companies complement government aid and, by collecting premiums according to the likelihood of natural disasters, become active after a crisis and provide most of the necessary assistance to the affected victims.

When a natural disaster occurs, the demand for health services sharply increases. In other words, people's health is affected by natural disasters, making them in need of health services such as emergency medical care, surgery, medications, vaccinations, etc. The health sector is one of the most important sectors affected by natural disasters. This research aims to study the effects and consequences of the most significant natural disasters that have occurred in Iran.

1-3. Necessity of the Research

Loss of life and extensive financial damage are common consequences of natural disasters, which typically impose significant costs on governments. In developed countries, these costs are often transferred to large insurance companies. An important aspect of this issue is the inherent uncertainty of these disasters, which complicates relief efforts and damage compensation. Given the above, it is crucial to plan for managing such crises. Proper and logical planning requires adequate knowledge of how these disasters impact the economy. This research aims to study the effects of natural disasters, specifically earthquakes and droughts, on the health sector in the country. The goal is to minimize human losses in the event of similar incidents through timely and proper planning.

1-4. Theoretical Literature

1-4-1. Theoretical Foundations

The effects of natural disasters on different sectors of the economy vary. Earthquakes disrupt productive capacities and, in some cases, lead to their destruction. Additionally, the labor force in earthquake-affected areas significantly decreases, and the shortage of skilled workers greatly reduces human capital. Personal savings also decrease, especially in countries where insurance companies do not compensate for damages. Consequently, the reduction in available investment resources weakens production. Droughts have a more significant impact on rural populations. These phenomena also have different effects on people's health. Earthquakes typically result in higher mortality and physical injuries compared to droughts. The effects of drought often manifest in the long term, whereas earthquakes, in addition to long-term effects, have immediate and short-term health consequences for the affected individuals. The classification of natural disasters worldwide and in Iran will be presented next, followed by an examination of the natural disasters with the highest likelihood of occurrence and those that cause the most damage to the health sector.

1-4-2. Classification of Natural Disasters Worldwide

In a general classification, natural disasters are divided into two categories:
A. Geologically-related natural disasters, which arise from changes related to the Earth. Earthquakes, volcanoes, and tsunamis are key natural disasters in this category.
B. Weather-related natural disasters, which result from meteorological phenomena.

Floods, storms, and droughts are the major natural disasters in this category, putting countries at serious risk (Aron et al., 2006).

The impact of natural disasters in group A is less predictable than those in group B, as disasters in the first category can lead to secondary events that are not foreseeable. Additionally, these events typically cause more severe economic damage and loss of life.

1-4-3. Natural Disasters Occurring in Iran

Not all the natural disasters mentioned above occur in Iran. In the category of weather-related natural disasters, the problem of flooding has been largely mitigated by the construction of numerous dams and embankments in the country, making floods less of a natural disaster leading to significant loss of life. Additionally, according to the history of natural disasters, storms have not been reported as a deadly natural disaster in Iran. In the category of geological natural disasters, due to Iran's geographical position away from oceans, tsunamis do not occur, and there has been no volcanic activity in the past century. Therefore, the natural disasters that occur in Iran can be classified as follows:
A. **Earthquake:** An earthquake occurs when two blocks of the Earth suddenly shift and move against each other. The surface where the displacement occurs is called a fault. The point where the earthquake originates deep in the Earth is called the epicenter, and the corresponding point on the Earth's surface is called the earthquake's center.

Types of earthquakes include:

1. **Tectonic Earthquakes:** The cause of these earthquakes is the movement of the tectonic plates that form the Earth's crust, and this is the type of earthquake referred to in this dissertation.
2. **Volcanic Earthquakes:** These earthquakes occur only in active volcanic regions.

3. **Collapse Earthquakes:** These occur due to the collapse of caves or underground channels, and they are typically small and localized.
4. **Induced Earthquakes:** These earthquakes result from activities such as the filling of reservoirs, sudden changes in lake water levels, the injection of water into the Earth, or the extraction of fluids from the ground, especially in areas with active faults.
5. **Explosion Earthquakes:** These earthquakes are caused by military or industrial explosions or construction activities (usgs.gov).

This phenomenon is the most important and severe natural disaster threatening our country. Being located in an earthquake-prone zone has led Iran to experience numerous earthquakes. The most critical factor that exacerbates the damage caused is the way buildings are constructed and their lack of structural integrity. In desert areas, mud brick is often used in construction, which results in heavy and fragile structures that cannot withstand earthquakes. Even with relatively low-intensity quakes, these buildings collapse, leading to significant human casualties and damage.

1-4-4. Examining the Effects of Earthquakes on the Health Sector

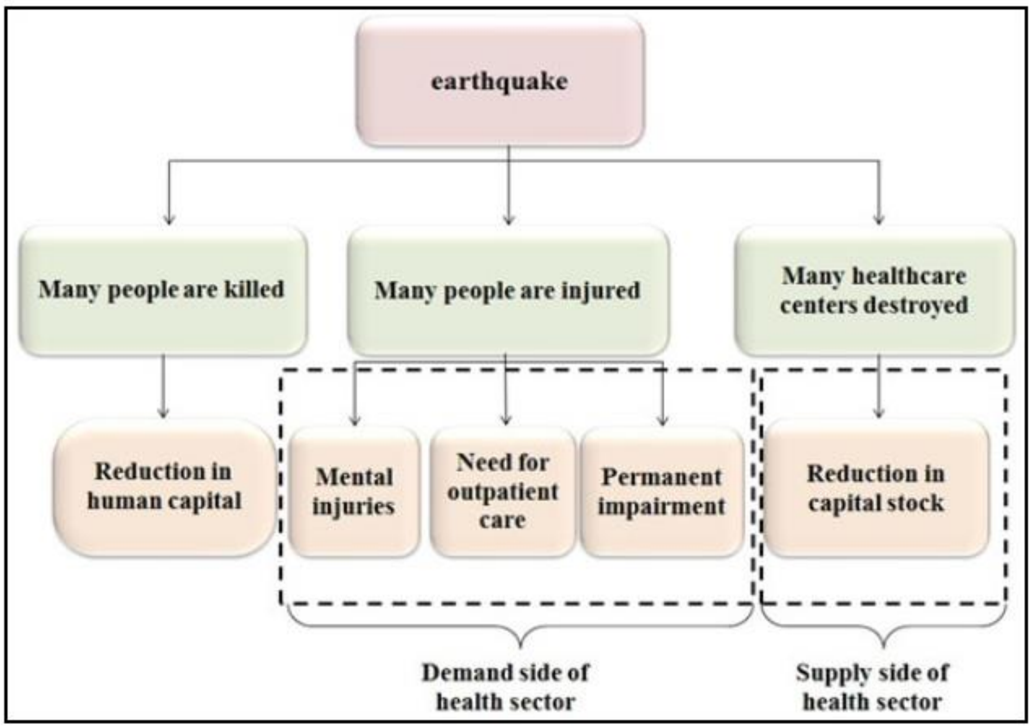
After an earthquake, some individuals in the affected areas may lose their lives, while others may suffer injuries, thus requiring healthcare services. These individuals can be categorized into three groups based on the type of healthcare services they need:

1. Individuals requiring outpatient healthcare services.
2. Individuals who suffer permanent disabilities and will require long-term healthcare.
3. Individuals who have experienced psychological and emotional trauma.

After an earthquake, the demand for healthcare services usually increases exponentially. The damage caused by the earthquake can be studied from two perspectives:

A. **Through Households:** From this perspective, the demand for healthcare services increases dramatically after an earthquake, creating significant challenges for households. The savings and living standards of households that were previously sufficient to meet their needs are severely affected by the disaster, and families may require outside assistance due to the financial burden. In summary, households face a decline in welfare when confronted with natural disasters, particularly after an earthquake.

B. **Through the Health Sector:** As mentioned, the demand for healthcare services increases sharply after an earthquake. The affected region will require doctors and various specialists, and therefore, healthcare services must be quickly scaled up. Organizations such as the Red Cross and Red Crescent are always prepared for such crises, but typically, local resources are insufficient for highly dangerous situations and severe earthquakes. The diagram below shows the effects of earthquakes on the health sector.



B. Drought: Drought refers to a period of reduced soil moisture when there is insufficient water for plants, animals, and living organisms, usually due to a lack of rainfall over one or more periods. Among natural disasters, the frequency of this phenomenon, in terms of its intensity, duration, total area affected, fatalities, economic damage, and long-term social effects, is greater than other natural disasters (Imamgholipour, 2008). Unlike other natural disasters, drought is not an instantaneous phenomenon and occurs over time, leaving long-term effects. To mitigate these impacts and ensure the effectiveness of water reserves, efficient management of groundwater resources and demand for water is required (Gil et al., 2010).

1-4-5. Analyzing Drought in Iran

The average annual rainfall in Iran is approximately 250 millimeters, less than a quarter of the global average (1133 millimeters). As a result, much of Iran falls within the arid climate zone. In addition to the lack of rainfall, severe fluctuations in precipitation on a daily, seasonal, and yearly scale contribute to the uncertainty of receiving the minimum rainfall needed for agricultural uses, surface water streams, groundwater replenishment, and human consumption (Ziaei et al., 2013). Over the past 30 years, the average annual rainfall in the country has been about 420 to 430 billion cubic meters, with approximately two-thirds of this amount evaporating. As a result, the available water for extraction is 130 billion cubic meters. According to international standards, only 20% of this available water can be used for various activities to prevent environmental degradation, equating to 26 billion cubic meters ($26 = 20\% \times 130$). However, during this period, approximately 100 billion cubic meters of water were consumed. This excessive water extraction has led to irreversible damage, such as the destruction of surface waters, wetlands, and rivers. Groundwater levels have decreased, and many underground resources have been depleted. If water management had been appropriately carried out, these stored resources and ecosystems would not have been harmed. Unfortunately, due to mismanagement, the country has turned into a vast desert, leading to the occurrence of phenomena such as storms and dust storms. Desertification, which has resulted from the poor management of water resources, increases particulate matter and leads to air pollution. Studies indicate that air pollution increases public health costs

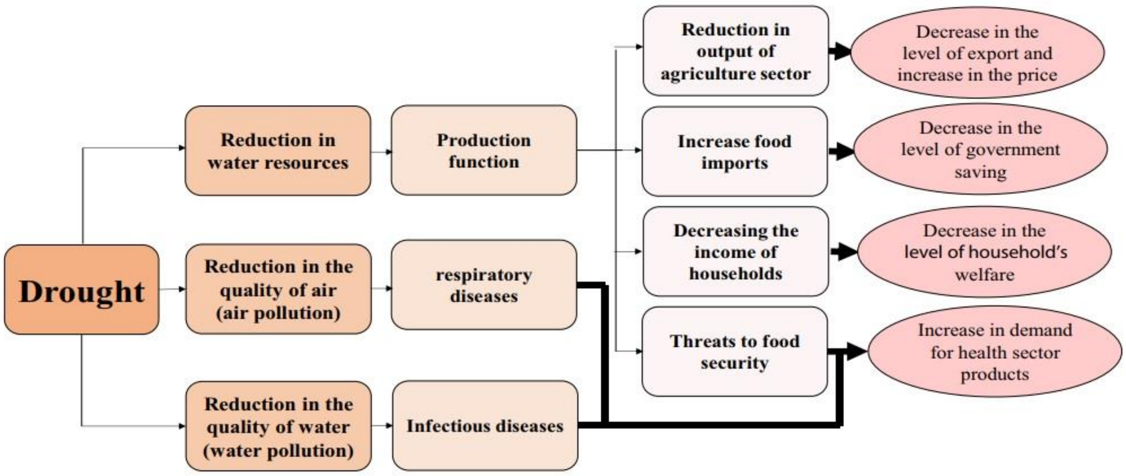
(Fattahi et al., 2013). Investigations show that after droughts, the area under cultivation for agricultural products sharply decreases. In other words, to adapt to drought conditions, farmers are forced to reduce their cultivated area (Mokhtari et al., 2007). Agricultural production decreases, but due to oil revenues, food demands have been covered through imports of agricultural goods.

1-4-5-1. Examining the Effects of Drought on the Health Sector
Drought impacts the health of individuals in various ways. Some of these effects include:

1. **Air Quality:** Drought leads to a reduction in air quality. This is due to an increase in suspended particles, pollen, smoke, and pollution, which can lead to respiratory diseases. This effect is especially significant for individuals who are more vulnerable, such as children and the elderly.
2. **Sanitation:** Access to clean and sanitary water is directly linked to hygiene, the prevention of diseases, and especially contagious diseases. In times of drought, individuals are forced to conserve and ration water. If water conservation reduces water usage for sanitary purposes such as handwashing and personal hygiene, it can create conditions conducive to the spread of diseases (Gil, 2010).
3. **Mental and Behavioral Health:** Some occupations, such as farming, horticulture, and pastoralism, are highly dependent on rainfall. Stress and financial concerns can lead to depression. Drought in rural areas, where individuals have no alternative income sources and means of survival, can lead to a loss of mental health. Studies in Australia, India, and certain U.S. states show a significant correlation between increased suicide rates among farmers in rural areas and recurring droughts (Sartor et al., 2007).
4. **Malnutrition:** Rural economies rely heavily on agriculture. During drought, farmers and rural residents who depend on self-consumption for a significant portion of their food may face food shortages, and in some cases, the quality of consumed food can severely decline. With the occurrence of drought, the cost of providing food for these families increases. Therefore, the effects of drought in rural areas are more profound than in other regions, and the consequences for rural populations are more severe (Mokhtari et al., 2007). Studies on the life of nomads show that these individuals lack access to proper

healthcare and educational facilities, and during droughts, they are at higher risk due to increased poverty and a sharp decline in income.

The following diagram shows the impact of drought on the health sector.



1-5. Research Objectives

Given the background provided, the main objective of this research is to examine the impact of natural disasters, particularly earthquakes and droughts, on the health sector in Iran. Alongside this primary goal, the following secondary objectives are considered:

1. To examine how the supply and demand in the health sector change due to the occurrence of disasters.
2. To investigate the impact of preventive measures before the occurrence of disasters on the health sector.
3. To evaluate the role of the government and insurance companies after natural disasters.
4. To assess the impact of natural disasters on well-being and household costs from a health perspective.

5. To propose solutions to mitigate the negative consequences of disasters on the health economy.

1-6. Research Questions

Based on the objectives outlined above, the main research questions can be stated as follows:

- How do natural disasters affect the health status of individuals in the society?
- How do natural disasters reduce household welfare?
- How do natural disasters impact government expenditures?
- How do natural disasters affect health sector production?
- What methods can be used to manage the damages caused by natural disasters?

1-7. Research Hypotheses

Considering that this research will use the method of computable general equilibrium models, and the nature of this approach is neither probabilistic nor statistical but rather mathematical, it solves a system of equations using mathematical techniques. Since this study has a survey nature, it is not possible to formulate hypotheses beforehand. The nature of this research means that findings will emerge throughout the process, and therefore, hypotheses cannot be set before the research begins.

1-8. Research Methodology

Since this research seeks to analyze the impact of natural disasters on the health sector in Iran's economy, analytical and descriptive methods will be the best choice for achieving this goal. Partial equilibrium methods can be used to analyze the impact of natural disasters on health sector economic variables, but these methods have limitations. In partial equilibrium approaches, the conditions in other sectors of the economy are assumed to remain fixed, so not all influencing factors can be explored. On the other hand, in general equilibrium approaches, the "ceteris paribus" assumption is discarded, and the interrelations among all economic sectors are studied. Computable general equilibrium (CGE) models are powerful tools for analyzing complex relationships (Tabi, 2006). CGE models can be defined in both static and dynamic states. Since the general equilibrium approach offers a broader perspective on the variables and interactions that affect them, it is likely to produce more accurate results. Moreover, due to the widespread consequences of natural disasters, this method will be used in the present study.

1-8-1. Explanation of Computable General Equilibrium Models

In a computable general equilibrium (CGE) model, concepts such as income distribution among different groups, demand patterns, balance of payments, multi-sectoral production structure, and a set of behavioral equations representing the behavior of firms, households, and other institutions within the economy, subject to their constraints, are considered systematically.

Variables:
In CGE models, three types of variables are considered:

1. **Endogenous Variables:** These variables bring the three markets and their macroeconomic indicators into equilibrium. These include commodity prices, production factors' prices, exchange rates, production levels, and employment levels.
2. **Exogenous Variables:** These variables are dictated by forces from outside or within the system and are not influenced by the system itself. They include factors such as the stock of production factors, global prices, structural constraints, and limitations.
3. **Policy Variables:** These variables are determined with the aim of influencing endogenous variables, such as tariffs, subsidies, taxes, and government expenditures.

Parameters:
Parameters are values that indicate the sensitivity of endogenous variables to exogenous variables and the sensitivity of endogenous variables to each other. A system of equations integrates the variables and parameters, which is then computed.

Simultaneous Equations System:

This system includes vectors of endogenous variables (non-stochastic part of the model), exogenous variables (systematic part of the model), and parameters.

1-8-2. Modeling Stages

Given the nature of this research, the process of examining how natural disasters in Iran affect the health sector can be broken down into the following stages. The general framework of the research method is presented in Figure 1-4.

Stage 1: Identifying Natural Disasters:

In this stage, through theoretical foundations and empirical studies, the nature and characteristics of natural disasters occurring in Iran are identified, and the relevant definitions are provided. Given the diverse nature of disasters and their varying effects on the health of individuals, the focus in this stage will be solely on providing relevant concepts. After defining the key concepts, the effects of each disaster on health can be determined.

Stage 2: Identifying the Main Effects of Each Disaster:

The main effects of each type of natural disaster on the health sector will be determined.

Stage 3: Scenario Creation:

Using the computable general equilibrium models, the two major natural disasters impacting the health sector in Iran will be simulated. The impact of each disaster will be analyzed, and the model will be solved using the GAMS software.

Stage 4: Damage Analysis and Reviewing Solutions for Improving Performance in Future Disasters:

The risk management approach for natural disasters should focus on reducing community vulnerability to prevent irreparable damage, as well as increasing preparedness and resilience.

1-9. Innovation & Contribution

This research has two main aspects of innovation. The first is that the examination of the impact of natural disasters on the health sector, despite the significant importance and extensive damage these disasters have caused to Iran, has not been studied until now. Among the few studies conducted on the economic impacts of disasters, there is no research specifically addressing the economic effects of these phenomena on the health sector. Therefore, investigating this topic distinguishes this research from others and is one of its innovative aspects.

The second aspect of innovation lies in the research methodology. The use of the Computable General Equilibrium (CGE) method and scenario creation to analyze the effects of natural disasters on the health sector in Iran's economy is another novel aspect of this research.

I. For earthquakes

This study contributes to the existing body of literature by providing a comprehensive analysis of the economic impacts of earthquakes in Iran, particularly focusing on the health sector and household welfare. While previous research has employed CGE models to assess the economic consequences of earthquakes in various countries, this paper distinguishes itself by investigating the effects on the health sector, an area that has been largely overlooked.

II. For drought:

The primary objective of this research is to conduct a comprehensive analysis of the macroeconomic impacts of drought, with the aim of advancing the understanding of this field. To achieve this, the study will first assess the effects of drought on health sector consumption. Next, the impact of drought on the agricultural sector will be quantified. Finally, the research will briefly analyze the changes in household welfare, focusing on income, savings, and consumption. This approach takes into account a wide range of drought effects, from macroeconomic to microeconomic perspectives, while also addressing socio-economic factors and health-related issues, which have been rarely explored in previous studies.

Chapter 2
Theory

2-1. Introduction

After presenting the problem and defining the aspects of the topic in the previous chapter, this chapter will discuss the theoretical foundations and empirical basis of the subject. Since this dissertation examines the effects of natural disasters on macroeconomic variables, it falls under the domain of macroeconomics. In fact, the shock caused by natural disasters will be examined at the macroeconomic level. Gross Domestic Product (GDP), government expenditures, employment status in different economic sectors after the shock, and the price levels, are all macroeconomic variables studied in this dissertation. On the other hand, for a more comprehensive and accurate study, the effects of natural disasters on household income, savings, and consumption are also examined.

Natural disasters are phenomena that cause destruction of national resources and threaten the functioning and security of human societies. In general, disasters assess societies' ability to respond to emergency situations. If there is a well-organized strategy in place, unforeseen conditions and consequences can be quickly addressed. However, predicting and planning for natural disasters is extremely difficult because natural disasters are inherently different from normal emergency events. While emergency events can also cause significant damage, the difference between these events and natural disasters is not just in their intensity. Natural disasters with high intensity can affect a society from several economic, social, physical, and psychological perspectives. Therefore, to save society from a catastrophic situation, planning that considers multiple possible scenarios is necessary (March, 2002).

Natural disasters, depending on their type, lead to both direct and indirect effects on the economy. Natural disasters directly affect the stock of physical and human capital, influencing production, consumption, investment, and the current account (Imamgholipour, 2014).

The most significant natural disasters are those that threaten human life and result in severe casualties. Next in line are those disasters that cause damage to the environment. The third category involves those disasters that damage human assets (Moqimi, 2014). The characteristics of natural disasters are defined by their occurrence type, location, magnitude, size, frequency, and the population affected.

The characteristics of natural disasters refer to how they impact the lives and health of individuals, society, and the environment, and how they affect personal assets. Natural disasters may have an actual or potential status, with the potential status being a threat to the future, such as the seismic activity of a region that poses a threat to life, the environment, and residents' assets (Moqimi, 2014; Imamgholipour, 2014).

The occurrence of natural disasters like floods and earthquakes has been considered by some economists, such as Thomas Malthus (1766), as a positive phenomenon. According to Malthus's population theory, the root cause of all calamities is the imbalance between population growth and the growth of food supplies. He believed that population growth follows a geometric progression, while the growth of food supplies follows an arithmetic progression. Therefore, events such as earthquakes, floods, and wars, which result in the death of a large number of people, act as factors to create balance between population growth and food supply (Tavakkoli, 1993).

If a region has the potential to experience a natural disaster, planning, conducting necessary studies, and investing in making the region resilient is crucial to reduce damages and ensure the community is prepared for the phenomenon.

All types of natural disasters impact health, with the extent and severity of the effects depending on the type of disaster. Saving the lives of the victims, supporting public health in emergency conditions, the need for rapid evacuation from the disaster area, and changes in treatment methods, as well as changes in medium- and long-term health programs, are key impacts of natural disasters on the health sector. These impacts suggest that not only the immediate needs but also the long-term effects of disasters on communities must be considered in studies. Evaluating these impacts requires access to data to determine the extent of destruction of various elements in the health sector. In the absence of such data, case studies or forecasts must be used to estimate the effects and the time required for reconstruction. Collecting and analyzing data, as well as implementing health information systems, is essential for disaster preparedness.

Displacement and migration due to natural disasters, whether planned or spontaneous, result in many challenges for the destination, including imbalances in meeting the health needs of the new population, increasing mortality rates, and increasing disease incidence. This can also lead to the spread of contagious diseases due to migrants residing in unsanitary conditions and lack of access to clean water.

Damages to health infrastructure, such as medical equipment, are examples of this impact, including:

- Hospitals, treatment centers, clinics, pharmacies, and other urban and rural public healthcare facilities
- Health department offices
- Laboratories and blood banks
- Urban and rural private sector clinics and treatment centers
- Medical and emergency equipment, and surgical tools
- Non-medical equipment used in the healthcare sector
- Inventory of medicines and vaccines

The severity of damage to infrastructure and medical equipment depends not only on the type of construction but also on the location and type of disaster (ECLAC, 2003).

This chapter first studies the theoretical foundations regarding the impact of earthquakes and then droughts on the economy and health sector. Subsequently, the most important domestic and foreign studies related to the topic of this dissertation will be reviewed.

2-2. Earthquake

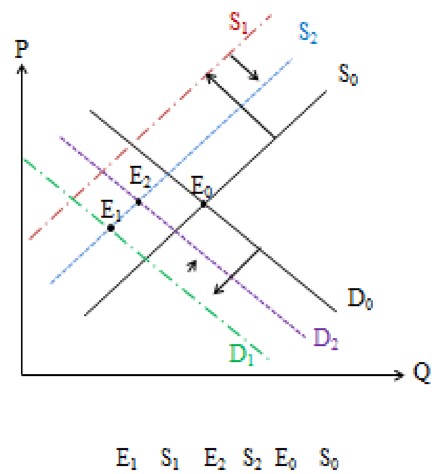
Iran’s location on the Alpine-Himalayan seismic belt has led to numerous earthquakes, with a high probability of future earthquakes. The most significant issue exacerbating the damage is the type of construction and the lack of building sturdiness. In desert areas, materials such as mud and clay are used for construction, resulting in heavy and fragile structures that cannot withstand even relatively low-intensity earthquakes. These buildings collapse easily, causing significant casualties and financial damage due to their weight.

Natural disasters affect the economy in complex ways. After disasters, damages to factories lead to a reduction in production, which is considered a direct effect of natural disasters. A shortage of raw materials, human resources, and disruptions in the production chain are other effects of natural disasters on the economy. Unemployment leads to decreased income, and a reduction in production causes a drop in tax revenues, which are other consequences of disasters from the demand side of the economy. To evaluate the effects of natural disasters and the resulting damages, it is essential to avoid double-counting and underestimating the impacts. It should also be noted that while natural disasters have negative effects on the economy during their occurrence, the policies adopted during the reconstruction phase—such as fiscal policies, taxes, social assistance, and mutual support—lead to positive outcomes. Therefore, policymakers should take the positive impacts of the reconstruction phase into account when designing policies (IPCC, 2012).

The most important method for reducing the economic losses caused by natural disasters is economic resilience. Economic resilience is divided into two categories: static resilience and dynamic resilience. Static resilience refers to the economy's ability to continue functioning and maintaining production after a shock. Dynamic resilience refers to the speed at which the economy returns to its optimal state (Rose, 2011). Most studies on natural disasters focus on static resilience.

To further explain economic resilience, supply and demand functions in the economy are illustrated in Figure 2-1, with P and Q representing price and quantity of goods and services in the economy. It is assumed that the economy initially faces equilibrium E0 with initial supply and demand curves S0 and D0. After an earthquake and the shock to the economy, due to casualties and injuries, labor capacity is severely reduced. Additionally, the capital stock decreases due to the destruction of infrastructure, equipment, and factories. As a result, the supply curve shifts rightward and upward to S1. On the demand side, due to reduced income, the demand curve shifts leftward and downward, creating a new equilibrium E1, where production decreases and prices increase.

During the reconstruction phase, investments increase on the supply side, and the government provides loans and support for reconstruction on the demand side. The affected population also needs to replace essential life goods, so both supply and demand curves shift rightward, creating a new equilibrium E2. The stronger and more resilient the economy, the closer the new equilibrium E2 is to the initial equilibrium E0, and the gap between these two points will be smaller, with the speed of recovery being faster. In other words, natural disasters have negative effects on the economy, and the degree of economic resilience determines the intensity and positive effects during the reconstruction phase and the recovery of the affected society. Proper crisis management, the availability of surplus capacity, the spirit of cooperation among people and the government, and the government's budget for allocating reconstruction aid are the main factors determining the economy's resilience.



How Supply and Demand Curves Respond to the Occurrence of an Earthquake

2-2-1. Effects of Earthquakes on the Health Sector

An earthquake causes widespread destruction, leading to a high mortality rate in the affected area. The severity of the earthquake, the location of the event, and the proximity to the epicenter play a significant role in determining the number of casualties. The highest risk of injury is for people inside or near buildings and structures, while the risk of harm in open spaces or suburbs is minimal. The intensity of the earthquake increases ground movement and displacement, which leads to structural damage (WHO, 1989). Typically, in earthquakes occurring at night, more fractures of the pelvis, chest, and spine are observed because people are asleep. As a result, internal bleeding and severe damage to internal organs can occur. In earthquakes that happen during the day, the number of serious external bleeding injuries and fractures of the skull and clavicle increases. Another major risk that threatens residents for up to 24 hours after an earthquake is fire. Depending on its severity and extent, a fire can lead to burns and suffocation due to inhaling large amounts of dust and smoke (WHO, 1989).

Secondary Health Threats: In addition to immediate consequences, earthquakes lead to secondary events that occur in the days following the disaster. The most important consequence is stress. Depending on the earthquake's severity and the vulnerability of the victims, the level of stress can vary. In cases where shelters are overcrowded, infectious diseases spread quickly, and stress resulting from the disaster weakens the immune system, making individuals more susceptible to illnesses. Depression, fear, insomnia, and loss of appetite are common after an earthquake (WHO, 1989).

Rescue Phase: In the first 24 hours after an earthquake, rescuers should focus on saving all patients whose lives are at risk and ensuring access to necessary medical care. In many cases, damage to critical infrastructure hinders an appropriate medical response. In the worst-case scenario, hospitals may also be destroyed, which often occurs in developing countries, worsening the situation, or the loss of water and electricity can prevent hospitals from providing necessary services. Earthquakes can also damage ambulances, complicating patient transportation to healthcare centers. In many studies, after an earthquake, patients and casualties have been transported to hospitals by taxis and personal vehicles. Damage to bridges and roads, particularly in severe earthquakes, delays the transportation of victims, which is especially threatening for those requiring emergency care (Arnold, 1999).

The destruction of pharmacies and medical equipment storage warehouses is another issue that exacerbates the medical crisis. After an earthquake, even if hospitals and healthcare centers are not directly damaged, there is a huge need for medications and medical supplies to treat the large influx of patients. If these needs are not met, the lives of many survivors are at serious risk. This issue is often referred to as a "secondary disaster" in previous studies.

After an earthquake, a large number of healthcare personnel are needed. Therefore, crisis management planning must include having a significant number of trained and knowledgeable healthcare workers ready to provide assistance in emergency situations. Earthquakes also increase medical costs, which affects the healthcare sector. If the victims cannot afford medical expenses, the healthcare sector generates less revenue due to the increased costs. Infectious diseases spread as a result of population displacement and sheltering in crowded conditions. The spread of diseases is linked to the size, health status, and living conditions of the affected population. Poor sanitation and limited access to healthcare services in shelters create conditions conducive to various diseases for survivors (WHO, 2005). For example, after the 2005 Pakistan earthquake, hepatitis E spread in areas with limited access to clean water, and more than 1,200 cases of jaundice were reported. Additionally, measles cases increased, reaching over 400 clinical visits (WHO, 2006).

The need for widespread interventions, such as vaccination and counseling, also raises costs in the healthcare sector. Increased healthcare costs can also affect the payment balance, especially for countries that rely on importing medical supplies.

Another impact of earthquakes on the healthcare sector is the loss of personnel. It typically takes many years to train a healthcare workforce, and this sector requires a substantial investment in human capital. After an earthquake, some people in the affected areas may lose their lives, while others may be injured, increasing the demand for healthcare services. These individuals can be categorized into three types of demand for medical care:

1. People who need outpatient medical care.
2. People who suffer permanent disabilities and will require ongoing medical care.
3. People who experience mental and emotional trauma.

As a result, following an earthquake, there is usually a dramatic increase in demand for healthcare services. In summary, the damage caused by an earthquake can be studied from two perspectives:

- From the household perspective: The occurrence of an earthquake significantly increases the demand for healthcare services and creates many challenges for households. Savings and living standards that previously sufficed may no longer be enough, and households may need external help due to the financial burden. In short, households face a decline in well-being after natural disasters, particularly earthquakes.

- From the healthcare sector perspective: As mentioned, the demand for healthcare services sharply rises after an earthquake. The affected area requires an influx of doctors and specialists. Therefore, healthcare services must rapidly scale up. Organizations like the Red Cross and Red Crescent prepare for such situations, but local resources are often insufficient for extreme and very severe earthquakes.

3-2. Drought

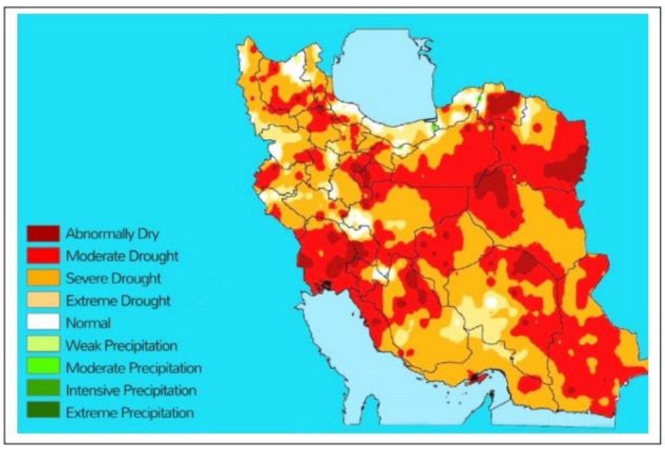
Drought is a climatic event that results from a deviation and reduction in the amount of precipitation in a geographical area compared to its long-term or normal average rainfall. As a result, drought is not a permanent characteristic of a region and can occur in any type of climate, even in humid areas where the amount of rainfall is significantly higher than in dry regions (Darijani, 2008).

According to the World Bank's definition in 1998, from an economic perspective, drought is a reduction in rainfall to a degree that reduces agricultural production compared to the annual average. This event affects different parts of the world annually to varying degrees (Hisdal & Kalaksen, 2003).

Globally, Iran is classified as a water-scarce region because the country's rainfall is less than a quarter of the global average, and its evaporation rate is about three times higher than the global average. As a result, the available water is practically one-twelfth of the global average. 75% of rainfall occurs in 25% of the country, and 75% of the rainfall also occurs during times when plants do not require water (Summary Report of the Agricultural and Natural Resources Sector in the 6th Development Plan, Institute for Research on Agricultural Planning, Economics, and Rural Development, 2015). The average annual rainfall in Iran is about 250 millimeters, which is about a quarter of the global average rainfall (1133 millimeters) (Iran Meteorological Organization Website). The available renewable water in Iran is approximately 130 billion cubic meters, of which 72% is extracted and consumed (Shakari, 2016).

Moreover, the significant fluctuations in rainfall in different regions of the country and throughout the year lead to uncertainty in receiving the required precipitation for farmers' consumption and the water needs of daily life. Therefore, the occurrence of mild to severe droughts in the country is inevitable (PirMardian & colleagues, 2008).

Figure below presents the drought map of Iran based on the SPEI index for the 7-year period leading up to 2017. As shown in this map, only very small areas experience moderate wet conditions, and drought covers almost the entire country.



Small changes in rainfall and temperature can cause severe damage to agriculture, which consumes over 90% of the available water. Therefore, the agricultural sector is the most affected by drought (Alizadeh, 2015).

When a drought begins, agriculture is the first sector to be impacted due to its heavy reliance on soil moisture. If the lack of rainfall continues, the soil moisture depletes quickly, and the adverse effects of drought persist until rainfall returns to normal and surface and groundwater resources are replenished (Javadiania & Mobashari, 2007).

During a drought, the first loss is soil moisture, followed by a decrease in surface water in reservoirs, lakes, and groundwater. Groundwater users are the last to suffer, but they recover more slowly than others when the water levels and rainfall return to normal (Iran Meteorological Organization).

Drought accelerates the degradation of natural resources. Unlike other natural disasters, drought occurs gradually over a longer period and its effects appear over time, often after several years. For this reason, it is considered a "creeping" phenomenon (Javadiania & Mobashari, 2007).

Drought leads to decreased agricultural production and, ultimately, lower income. Reduced food supply in the country increases food prices, which particularly affects lower-income groups the most. A lack of rainfall reduces the area under cultivation, and in response to decreased domestic production, food imports increase to meet demand, resulting in greater financial pressure on the national budget and worsening the current account balance and trade deficit (Khiz, 2013). The outflow of foreign currency and dependency on imports, especially for strategic items like wheat, are other consequences of food imports for society.

In summary, the effects of drought are divided into direct and indirect categories: Direct effects include: reduced crop cultivation area and agricultural output, lower fertility of pastures and forests, increased wildfires, livestock deaths, depletion of water reserves, and increased damage to wildlife and aquatic habitats. Indirect effects include: reduced income for farmers and agricultural workers, increased food prices, rising unemployment, and reduced tax revenues due to lower consumption. Additionally, reduced income for farmers can have a chain effect, leading to a decrease in trade volume for retailers and service providers, which can result in unemployment, investment risks, reduced capital, and lower government tax revenues (Mokhtari, 2007; Derijani, 2008).

Due to drought, private consumption decreases as a result of lower real income. Real income drops due to higher prices and lower nominal income. The demand for imports, particularly processed agricultural food products as substitutes for domestic products, rises. Processed foods are not a perfect substitute for locally produced foods, leading to higher prices for domestic products. This causes inflation, making domestic goods more expensive compared to foreign products, thus increasing export prices. Drought leads to a movement of labor from the agricultural sector to other sectors, and while this shift increases production in those sectors, it cannot compensate for the decline in agricultural output, leading to lower overall demand.

During drought periods, the agricultural sector suffers the most, while industry and services are less affected. In the first year of a drought, the service sector is impacted by reduced demand, but with the migration of labor from agriculture to services, wages, especially for unskilled labor, decrease. As a result, industries and services that rely heavily on this type of labor benefit from the situation and become more competitive.

At the macro level, food security is the primary concern during drought periods. The production of necessary food products significantly decreases, and food security at the micro-level, particularly among low-income households, also declines (Al-Rifi, 2012).

Drought also causes serious social consequences, such as reduced quality of life, conflict over water consumption, and migration. Migration, typically from affected areas to urban areas or other regions, can create challenges for the destination regions.

Drought affects certain crops more severely and quickly. For example, a study by Al-Rifi et al. (2012) examined the production of three strategic agricultural products (wheat, barley, and cotton) and four types of livestock (sheep, goat, cow, and camel) before and after droughts. The study found that livestock, especially camels, are more resilient to drought compared to crops. Camels can store water and survive without water for long periods. Cattle, dependent on prepared feed rather than pastures, are less affected by drought. However, sheep and goats are more vulnerable to drought. Among the crops studied, rain-fed wheat saw the highest decrease in yield, while cotton was more drought-resistant than wheat and barley. Barley is also drought-resistant and is one of the most suitable crops for drought conditions. Generally, rain-fed crops are more heavily affected by drought, while irrigated crops are less affected depending on the impact of the drought on surface water and river flow.

2-3-1. The Effects of Drought on Health:

Among natural disasters, those related to weather, like drought, have severe consequences on human and animal health as well as food and water security. This is particularly true in societies that are heavily dependent on agricultural production (Imamgholipour, 2014).

Water scarcity leads to the drying up of qanats, barren lands, and loss of wildlife and ecosystems. Additionally, drought can lead to various diseases that impose significant costs on the economy (Alizadeh, 2015).

Agricultural development is crucial for food security in many countries, but natural disasters can reduce food availability by causing production shocks. According to Eskez (2000), natural disasters pose a production risk, and to mitigate this risk, active participation from financial markets, credit reserves, and insurance contracts are needed.

Drought affects several aspects of public health, including:

1. **Air Quality:** Drought decreases air quality, which worsens due to higher concentrations of dust, pollen, smoke, and pollution, leading to respiratory diseases. This is especially dangerous for vulnerable groups such as children and the elderly.
2. **Water Quality and Water Resources:** Excessive extraction of groundwater reduces both the quantity and quality of water. High evaporation rates and irregular rainfall in dry climates, such as Iran's, affect the quantity and quality of both groundwater and surface water. Efficient water use requires appropriate monitoring and maintenance of water quality. The WQI (Water Quality Index) is one of the most appropriate indicators for evaluating and monitoring water quality, and it has been used in numerous studies. Artificial lakes behind dams are major sources of drinking water after groundwater resources (Koushafar, 1999). Due to irregular rainfall and inappropriate land use in water basins, these sources are becoming increasingly vulnerable to quality deterioration. Population growth and pollution from urban, agricultural, and industrial waste exacerbate the problem (Samadi, 2009). Generally, surface water sources like lakes and rivers are more susceptible to

contamination than groundwater resources, and the degradation of water quality threatens human health, economic development, and social well-being. Contaminated water immediately affects the human body, leading to diseases like typhoid, cholera, dysentery, and malaria, especially in children. Studies have also shown that the presence of substances like nitrates and sulfates in water can increase the risk of cancer.

Based on the definition of food security, the main concepts of food security can be categorized as follows:

1. **Availability of food** in terms of both quantity and quality, which is supplied by domestic producers or through imports.
2. **Availability of suitable food** for maintaining a diet that contains essential nutrients.
3. **Consumption of appropriate food**, availability of safe and clean water, and access to healthcare facilities to achieve nutritional well-being: This concept emphasizes factors beyond food in the definition of food security.
4. **Sustainability**: For food security to exist, communities, households, or individuals must have continuous and adequate access to proper food at all times, without disruptions caused by factors like economic crises, climate change, or seasonal shifts (FAO, 2006).

4-2. Empirical Studies

Tuya and Skidmore (2007) examined the reduction of economic and human losses caused by natural disasters in relation to development. According to this analysis, as development increases, the ratio of damage from natural disasters to GDP decreases. Additionally, by keeping the income variable constant, countries with higher literacy rates, more open economies, more complete financial systems, and smaller governments experience lower economic and human losses due to natural disasters.

In 2010, Halgat studied the economics of natural disasters. In this article, a framework for defining the costs of disasters, focusing on the most significant mechanisms that can explain these costs, was presented. From this perspective, the direct cost of a natural hazard, which is equal to the value of destruction and damage caused by that hazard, is not a good indicator of the hazard's severity. Therefore, the indirect costs resulting from the occurrence of the hazard must also be estimated. The direct costs of natural hazards are the immediate consequences of the physical occurrence of that event, which are divided into market and non-market direct costs:

- **Market costs** relate to goods and services that are traded in the market and for which prices can be easily identified. For example, drought causes direct damage to crops, especially in the agricultural sector, and other natural disasters like floods and earthquakes damage assets. These losses fall under direct market costs.
- **Non-market direct losses** include damages that cannot be replaced through market purchases. For these cases, there is no specific price, making the estimation of these losses challenging. These include health effects, loss of human life, damage to ecosystems, and destruction of historical and cultural assets. In some cases, non-market effects can be estimated using methods like determining the value of human life; however, these estimates rarely match reality, and calculating an exact value is difficult.

Indirect losses are those that are not caused directly by the event, but often result from the consequences and aftermath of disasters.

Datar (2013) examined the effects of natural disasters on child mortality, physical growth, and changes in the immune system of over 80,000 children in India using econometric methods. The results of his research showed that children exposed to one of the types of natural disasters in recent months were 9 to 18 percent more likely to suffer from acute diseases such as diarrhea, fever, and respiratory diseases compared to other children. Additionally, children living in areas where natural disasters occurred in the past year had significantly reduced height and were 18 percent less likely to have been vaccinated. In this study, the adverse effects of natural disasters were also considered as a function of the variables of gender and socio-economic status of the children. The relationship between gender and the effects of natural disasters was not significant. However, families with higher socio-economic resources were more protected from the negative effects of natural disasters.

Haddad et al. (2015) studied the economic effects of natural disasters in large cities, focusing on the floods that occurred in São Paulo, Brazil. In various parts of this city, with a population of 11 million, floods occur every summer and disrupt the residents' way of life, affecting their income as well. Using the extensive CGE model, the results of this study show that the welfare of residents decreases as a result of flooding, and the competitiveness of products from this city in both domestic and international markets decreases.

Carrera et al. (2015) evaluated the direct and indirect economic effects of flooding that occurred in October 2000 in northern Italy using extensive CGE models. With various scenarios, the most important result of this study was that the flood caused severe direct and indirect economic losses to the physical assets of the residents, and the indirect effects made up a significant portion of the damage to the residents' physical assets.

To further investigate the variables influencing each natural disaster and the results and consequences that each type of disaster brings to the economy, studies related to earthquakes and droughts are separated.

A: Studies Related to Earthquakes

Anbarji et al. (2004) considered earthquake fatalities as a function of per capita income, internal inequality, and the magnitude, depth, and proximity of earthquakes to population centers. According to the results of this study, with population, land area, distance from the earthquake's epicenter, and regional factors held constant, earthquake fatalities are a decreasing function of per capita income and equality.

In 2011, Ashour et al. studied the impacts of earthquakes on healthcare facilities for 9 earthquakes that occurred in 7 countries (including the 2003 Bam earthquake in Iran) between 1994 and 2004. The results of this study indicated that the structure and architecture of the healthcare facilities examined showed significant differences, while the destruction of equipment and installations was similar across facilities, as most healthcare equipment worldwide is similar in type and installation.

Shibusawa et al. (2011) examined the economic effects of earthquakes in Japan using a dynamic general equilibrium model. The results show that earthquakes immediately reduce capital stock, but during the rebuilding phase, investment increases to compensate for the damage. They stressed the necessity of using an insurance system to mitigate damages.

In 2014, Zhi et al. modeled the economic costs of disasters and reconstruction using dynamic computable general equilibrium models. To simulate the shock effects of natural disasters, they considered the reduction of capital stock on the supply side as a direct loss due to the occurrence of disasters. The 2008 Wenchuan earthquake in China was selected as a case study, and three scenarios were simulated:

1. No earthquake occurrence (S0)
2. Earthquake occurrence with investment for reconstruction (S1)
3. Earthquake occurrence without investment for reconstruction (S2) The difference between S1 and S0 represents the economic loss, including reconstruction costs, while the difference between S2 and S0 represents the net economic loss from the lack of reconstruction. The results indicate that the output from S1 is closer to reality compared to S2. The economic loss from S2 is nearly 1.5 times that of S1. If no reconstruction occurs under scenario S2, it would take 4 years for the gap between S2 and S0 to reduce to 3%. This study concludes that actions taken by the government post-crisis are crucial in mitigating losses, and proper management of post-crisis reconstruction can reduce damages.

Huang et al. (2014) examined the economic effects of disasters on key sectors of northern Taiwan using computable general equilibrium models. The results indicate that disasters have negative and destructive effects on labor and capital, and since household consumption decreases, welfare also declines, which they identified as one of the negative effects of earthquakes on the economy.

Riestra et al. (2015) studied the short-term effects of the 2010 Chile earthquake on welfare. They concluded that, in addition to reducing welfare, the earthquake caused cyclical unemployment due to its negative effects on employment and job search.

Giggnoux et al. (2016) studied the short- and long-term effects of earthquakes on the welfare of rural areas in Indonesia. By combining data from earthquakes since 1985, their results varied across different time periods. The study showed that in the short term, victims of the earthquake suffer economic losses that last between 2 to 5 years.

Thus, poverty traps can be eliminated with a well-designed intervention after an earthquake in the long term.

Next, the history of earthquake insurance in developed earthquake-prone countries, such as the United States and Japan, will be reviewed.

History of Earthquake Insurance in Developed Countries

History of Earthquake Insurance in the United States After the devastating San Francisco earthquake in 1906, the idea of earthquake insurance was introduced in the United States, and in 1916, earthquake insurance was made available as an independent insurance product to consumers (Steinberg, 1982). However, since about 80% of the damages from the San Francisco earthquake were due to fires following the earthquake, consumers assumed that fires would be the primary cause of damage in future earthquakes, leading to a lack of demand for earthquake insurance despite its low rates (Kenroter, 1978). In the aftermath of the 1925 Santa Barbara earthquake, which caused significant damage to residents, earthquake insurance gained popularity, as fire damage was not a significant factor in this case. It was also anticipated that earthquakes of moderate intensity might occur in other parts of the United States in the future, leading to a significant increase in earthquake insurance sales. In the 1940s and 1950s, despite no earthquakes occurring, demand for earthquake insurance grew, largely due to the increase in assets as a result of business sales. However, by 1982, only 5% of households were covered by earthquake insurance (Flores, 1985). In 1985, Flores and others examined the impact of earthquake insurance from the perspective of both consumers and providers of this insurance as a solution to the earthquake problem in Southern California. They classified buyers into three groups: households, businesses, and the government, concluding that households had the lowest demand for earthquake insurance. Further studies revealed that households viewed insurance more as an investment (rather than coverage for services) and expected government assistance and loans to cover losses after an earthquake, which was the primary reason for their lack of interest in earthquake insurance.

History of Earthquake Insurance in Japan

In Japan, earthquakes have been a major issue for centuries. In 1880, a major earthquake occurred in Yokohama, causing significant destruction to residential buildings. This earthquake motivated earthquake researchers to begin scientific investigations, alongside the idea of establishing an earthquake insurance system to facilitate reconstruction. In 1878, a German economist, Paul Mait, was invited to provide ideas for the earthquake insurance system in Japan. He proposed a compulsory national insurance system similar to the one implemented in Germany, covering five hazards: earthquakes, fires, storms, floods, and war. However, this proposal was not approved due to the government's reluctance to intervene in such matters (Shimbun, 1980). Following the 1923 Great Kanto earthquake, a significant shift in government policies occurred, which led to the introduction of the first major earthquake insurance system in Japan.

B: Studies Related to Droughts

In 2000, Benson and Clay examined the impacts of drought in countries south of the Sahara Desert. These countries have diverse infrastructures, but all have experienced significant vulnerability to drought. As a result of the drought between 1991 and 1992 in Zimbabwe, 9.5% of the industrial sector's GDP and 6% of export revenue from industry were reduced. Water rationing in industrialized countries, the reduction of hydroelectric power production, a decrease in agricultural production (especially crops used as inputs for the industrial sector), a decline in demand for agricultural inputs and other consumer goods, and an increase in government debt as a result of financing measures to compensate for the effects of drought were observed.

Chen (2007) examined the long-term health and economic impacts of the famine that occurred between 1959 and 1961 in China. The results of this study indicate that the famine had serious and severe effects on the lives of individuals, especially children, during this period. The estimates suggest that had the famine not occurred, individuals born in 1959 would, on average, have been more than 3 cm taller. This suggests that the famine led to malnutrition among the affected population, resulting in a reduction in average height. Furthermore, the famine had a profound impact on the labor force. Individuals who experienced their childhood during the years under study faced significant reductions in income in the years following the famine.

In 2012, Al-Rifi and others utilized dynamic general equilibrium models to examine the impact of drought on economic growth in Syria. Over the past 50 years, Syria has experienced intermittent droughts, with a significant decline in rainfall being the primary cause of drought during this period. In addition to reducing agricultural output, drought also affects the lives of animals, particularly those dependent on grazing, and indirectly impacts the lives of other groups. The study of the droughts between 2007 and 2009 revealed that the impacts of drought extended beyond agriculture and rural households into other sectors. The results of this study, which used the Palmer Drought Severity Index (PDSI) to evaluate the drought history, indicated that during drought years, GDP is approximately one percent lower, and food security and poverty are significantly affected by drought. The losses to capital, reduced income, and increased food prices led to an increase in poverty levels by 3% to 1.2% during moderate droughts. Additionally, drought caused a reduction in the production of strategic crops, such as wheat, and as a result, Syria has been an importer of wheat in recent years.

Among all Syrian household groups, poverty increased due to drought, which was caused by a decline in income and increased consumption costs. Although poverty increased more significantly among lower-income and rural households (with a 0.69% increase in rural households and a 0.56% increase in urban households), small farmers and herders with fewer than 200 livestock were forced to abandon herding and migrate to larger cities due to the loss of livestock. However, herders with larger herds or those engaged in camel breeding were less affected.

5-2. Summary

Based on the studies conducted, the most significant immediate effect of an earthquake on the economy can be considered as a reduction in the capital stock. Additionally, earthquakes lead to a decrease in the welfare of residents in earthquake-affected areas. These factors will be studied in Chapter Four for the Iranian economy, utilizing scenario analysis within general equilibrium models. The consequences of an earthquake on the demand and supply of healthcare services will also be analyzed. This latter issue, which is one of the main objectives of this study, has not been economically examined in previous research.

Droughts also result in a reduction in the availability of water. A change in water stocks, as one of the production inputs, leads to economic effects and influences the level of agricultural output. Moreover, droughts can trigger various diseases (such as through an increase in dust storms, reduced food security, and an increased likelihood of malnutrition, etc.) and affect the healthcare services provided. Additionally, changes in consumption, income, and savings can impact household welfare. According to previous studies, Gross Domestic Product (GDP) will also decrease as a result of natural disasters. These factors will be scenario-modeled and quantitatively analyzed in Chapter Four.

Chapter 3

Methodology

3-1. Introduction

Since this study aims to examine the effects of natural disasters on the health sector within the Iranian economy, analytical and descriptive methods are the best choice for achieving this purpose. While partial equilibrium methods can be employed to analyze the impact of natural disasters on health sector economic variables, these methods have certain limitations. In the partial equilibrium approach to the health sector, the conditions concerning other sectors of the economy are assumed to be fixed. As a result, it is not possible to analyze all factors affecting the health sector. In contrast, in the general equilibrium approach, the assumption of "other conditions remaining constant" is abandoned, and the interrelationships between all economic sectors are considered. Computable general equilibrium (CGE) models are powerful tools for analyzing complex relationships (Ahmadi, 2003).

Computable general equilibrium (CGE) models have become an essential tool for determining and evaluating the consequences of economic shocks. Since this research investigates the effects of natural disasters as a shock to the economy, the computable general equilibrium model is used to determine the extent of these effects (Imamqolipour, 2014 also referred to CGE as one of the best methods for analyzing the economic impacts of natural disasters). In this chapter, computable general equilibrium models will be briefly examined.

In recent years, computable general equilibrium models have become a powerful and standardized tool for economic analyses. Due to advancements in model identification, data availability, and the use of computers for conducting complex calculations, the cost of using CGE models in policy analysis has significantly decreased, making it easier for policymakers around the world to utilize CGE models (Lafgren, 2002).

An important point regarding the use of computable general equilibrium models is that these models assume perfect competition in the markets. However, in developing countries, some markets do not have perfect competition, which makes this assumption invalid. Nevertheless, this does not invalidate the application of these models for developing countries because prices still serve as market-clearing mechanisms and create equilibrium. However, when using these models for developing countries, it is important to note that monopolistic power on the supply side is not considered (Druys, 1982).

3-2. Structure of Computable General Equilibrium Models

These models simulate the circular flow of income and expenditure within an economy, where producers, factors of production, and consumers are present. Transactions in these models are based on the optimization of economic agents.

The demand side of the model is determined by maximizing the utility function of consumers subject to a budget constraint, while the supply side is formed by maximizing the profits of producers. For all goods, supply equals demand, and if returns to scale are constant, profits are zero for all activities.

Factors of production are supplied by their owners, namely households, to the market, with production firms being the demanders. All economic agents use either domestic or imported goods, which are substitutes for each other. The relative prices of goods determine the quantity of purchases of domestic versus imported goods, with exchange rates playing a crucial role. Exchange rates are determined in the foreign exchange market, which includes the supply and demand for currency (as a result of exports, foreign investments, imports, and capital outflows).

The functional forms of utility and production in computable general equilibrium models include Cobb-Douglas, Constant Elasticity of Substitution (CES), Leontief, Linear Expenditure System (LES), and others. It is essential that the functional form is consistent with the theoretical framework and satisfies the limitations of general equilibrium models, such as Walras' law, which ensures that supply equals demand.

3-3. Process of Using the General Equilibrium Model

To apply the model, a consistent set of data is required, and these data serve as benchmark values. Then, in the calibration process, the model's parameters are recalibrated to match the initial data. Solving the model, assuming correct parameter selection and calculation, will reproduce the initial data. To analyze the effects of shocks on the economy, the calibrated parameters are used in solving the new model. After applying the shock and changing the relevant parameters, the new equilibrium is obtained, and the effects of the shocks are analyzed by comparing the initial equilibrium with the post-shock equilibrium (Peterson, 1997).

In this section, computable general equilibrium models are briefly explained. In a computable general equilibrium model, the following components are examined as a system:

a. Income distribution among different groups
b. Demand patterns
c. Balance of payments equilibrium
d. Multi-sectoral production structure
e. A set of behavioral equations that reflect the behavior of firms, households, and other institutions within the economy, along with their constraints.

The solution to this model provides a set of prices and quantities where the excess demand (both nominal and real) across all markets for goods and services equals zero, which is why this model is called a general equilibrium model. In other words, the general equilibrium model is a Walrasian competitive equilibrium model where the following conditions hold:
a. P.Z(p)=0, meaning that excess demand equals zero.
b. Firms are price takers and seek to maximize their profits.
c. On the demand side, households aim to maximize their utility.

In these models, the effects of a policy on various markets for goods and services, labor, and the external world are considered in both linear and non-linear forms. Therefore, it is said that CGE models have a high capability in predicting the effects of implementing policies and shocks. Additionally, since the optimal behavior of economic agents is described in these models, they are based on microeconomic foundations (Berfischer, 2012).

Variables

In computable general equilibrium models, there are three types of variables:

1. **Endogenous variables**: These variables bring the three markets and their macroeconomic indicators into equilibrium. These variables include the prices

of goods, prices of factors of production, exchange rates, production levels, and employment levels.

2. **Exogenous variables**: These variables are dictated by factors outside the system, and the system does not influence them. Examples include the stocks of factors of production, world prices, constraints, and structural limitations.
3. **Policy variables**: These variables are set with the aim of affecting the endogenous variables. Examples include tariffs, subsidies, taxes, and government spending.

Parameters

Parameters are values that indicate the sensitivity of endogenous variables to exogenous variables and the sensitivity of endogenous variables to each other. The set of variables and parameters is entered into a system of simultaneous equations for calculation.

Simultaneous Equation System

This system includes the following vectors:

- Endogenous variables yyy (non-stochastic part of the model)
- Exogenous variables zzz (systematic part of the model)
- Parameters θ\thetaθ

To estimate parameters in a system of simultaneous equations, two methods can be used: econometrics and calibration.

3-4. Calibration

Calibration refers to the process of selecting parameters and exogenous variables for the equations in such a way that the observed values in the Social Accounting Matrix (SAM) can be exactly reproduced by solving the model. In other words, it is the process of determining the parameter values for the equations of the model so that the endogenous values of the related SAM can be re-generated using the calibrated model (specified in the ordinary form).

The advantage of calibration over econometrics is that, first, due to the lack of information in developing countries, the use of this method is preferable. Secondly, it easily computes unknown parameters.

3-5. Model Specification

Due to the difficulty in estimating equations of the system of simultaneous equations, the model is usually divided into several sub-models, known as blocks.

The five pillars of the model are as follows:

1. Social Accounting Matrix (SAM): The SAM focuses on the role of households in the economy and how their income is generated and distributed. It is a useful tool for examining economic shocks. The SAM is a square matrix where each account represents a specific economic process. Each account is depicted by a row and a column, with each cell representing payments from the column account to the row account. Thus, the sum of all rows (income) must equal the sum of all columns (expenditures) (Lafgren, 2002). For running any general equilibrium model, such information is required for a single year. In general, the SAM serves as an informational and statistical system that records the social and economic data relevant to a country's economy using input-output tables, national income statistics, and household income-expenditure data.

To ensure that the model reflects real-world economic conditions, data for various factors and goods are necessary. Acquiring prices for goods and factors, factor usage, output values, payments to factors, and household income and expenditure is challenging. To address this issue, the Social Accounting Matrix is used to represent financial flows between producers, factor owners, and others (Berfischer, 2012).

2. Prices
3. Production Activities
4. Institutions
5. Equilibrium Conditions, Constraints, and Behavioral Equations

Appendix A contains the system of equations based on Lafgren's 2002 model framework, including market clearing conditions and macroeconomic equilibrium, along with the strengths and weaknesses of computable general equilibrium models.

3-6. Database: Standardized Social Accounting Matrix for 2011

To utilize Lafgren's equations as the framework for computable general equilibrium models, a standardized Social Accounting Matrix (SAM) based on activities and goods classification is required. Since the latest available SAM is from 2011 (compiled by the Research Center of the Iranian Parliament), this matrix is used as the database. To focus on the relevant sectors for this research, activities, goods, production factors, and households are classified in the standardized SAM, which includes 32 goods and 32 activities.

The sets of used	
Activities (a)	*Commodities (c)*
Agriculture	Agriculture
Industry	Industry
Services	Services
Health	Health
Households	*Factors of production*
Urban	Labour
Rural	Capital

The employment statistics for the year 1390 were obtained from the Statistical Center of Iran. In addition, the most significant exogenous elements in computable general equilibrium (CGE) models are the substitution elasticities. These substitution elasticities are considered exogenously in the general equilibrium model. The values of these elasticities were selected based on previous studies (Maznani, 1394; Ashna, 1395).

3-7. Model Closure Approach

Regarding the model closure, it is assumed that in the primary market, the amount of capital used for each sector is fixed and specified, and there is mobility of capital between sectors. Additionally, in the labor market, assuming the supply of the primary factor remains constant and wages stay the same, labor is assumed to be mobile between sectors (Khajehzadeh et al., 1389 also assumed full mobility of labor and capital factors). Concerning the assumption of labor mobility between sectors, it is important to note that for specialized labor and labor employed in the public sector, mobility is not as easy. However, according to the conducted studies, the share of public sector employees compared to total employment is less than 20%. Furthermore, over the past decade, the proportion of workers with higher education (beyond an associate degree) has been approximately 16%. Therefore, given that only a small percentage of the workforce is not easily transferable, it can be concluded that the assumption of inter-sectoral mobility for the workforce is not unrealistic.

3-8. Modeling

For modeling, the standard aggregated Social Accounting Matrix (SAM) data for 1390, condensed into four goods and four activities, along with the Leontief model equations, were entered into the GAMS 24.1.3 software. The Leontief model incorporates the specific features of developing countries, making it suitable for modeling such countries (Druce, 1982; Shown, 1992). Subsequently, scenarios related to the occurrence of earthquakes and droughts and their impacts on the economy and health sector were developed, as will be discussed in detail in the next chapter. The model was then executed, and the results of the simulations are presented in the following chapter.

Chapter 4
Results & Findings

4- 1. Introduction

Following the discussion of the research methodology in the previous chapter, this chapter quantifies the effects of natural disasters on Iran's economy and health sector using the framework of computable general equilibrium (CGE) models. Using the data from the Social Accounting Matrix (SAM), the equations presented in the previous chapter are calculated and calibrated, and ultimately, the impact of the designed scenarios on the economy and health sector is evaluated. Since the aim of this research is to investigate two types of natural disasters, namely earthquakes and droughts, the effects of earthquakes will first be modeled in section A, and the effects of droughts will be modeled in the subsequent section (section B) of this chapter. Finally, appropriate strategies to mitigate the negative effects of each natural disaster (earthquake and drought) will be presented.

A: Earthquake Impact Modeling

It is important to note that in order to conduct a detailed study on earthquakes and their impacts on the economy, the economy must be examined on a local scale. This is because earthquakes typically affect the specific area that is hit, with less impact on the overall economy. However, due to the lack of required data and information, it is not feasible to carry out such a local-level examination. This limitation can be considered as one of the constraints of this study.

As mentioned in Chapter 2, the most significant consequence of an earthquake is the sudden reduction in the capital stock (Shibosawa, 2011; Huang, 2014). Major earthquakes that occurred in Iran from 1961 to 2017 have caused damages amounting to approximately 32 billion dollars to the country's economy. Assuming that most of these damages are related to the capital stock (albeit somewhat imprecisely, as the damages affect the entire economy, including humans, livestock, crops, etc.), the majority of these losses pertain to reductions in the capital stock, such as the destruction of buildings, bridges, facilities, and infrastructure. For the purposes of this study, it is assumed that the entire loss is attributed to the capital stock. Given that the average capital stock in Iran over the last 30 years (in constant 1390 prices) is approximately 13,900,000 billion Rials, and assuming an exchange rate of 40,000 Rials, an earthquake would result in a reduction of about 9% in the capital stock over these years (based on data from the Statistical Center of Iran, the Central Bank, usgs.gov, and em-dat.be). Therefore, three scenarios have been developed as follows for the reduction in capital stock. It is understood that the third scenario implies a stronger earthquake with more profound damage.

SC1, SC2 and SC3 refer to 7.5%, 10% and 12.5% decrease of the capital stock, respectively. The capital stock is considered as an exogenous variable, and then simulated three scenarios. Simulation results are reported as percentage change in economic variables from their base levels.

Macroeconomic results of simulations			
Variables	*SC1*	*SC2*	*SC3*
GDP	–3.76	–5.04	–6.35
Domestic output			
Agriculture	–1.33	–1.78	–2.23
Industry	–5.78	–7.75	–9.73
Services	–3.7	–4.96	–6.23
Health	–2.58	–3.47	–4.36
Quantity of export			
Agriculture	–0.77	–1.01	–1.24
Industry	–5.81	–7.78	–9.77
Services	–3.58	–4.8	–6.04
Health	–2.57	–3.44	–4.34

According to the results presented in the table above, the occurrence of an earthquake leads to a decrease in Gross Domestic Product (GDP), and the more intense the earthquake, the greater the reduction in GDP. These results align with the findings of Sadeghi et al. (2008) (using econometric techniques) and Bazzazan et al. (2016). An analysis of the distribution of GDP across different economic sectors reveals that, in 2011, the agricultural sector accounted for 14%, the industrial sector for 50%, the services sector for 33%, and the health sector for 3% of the total GDP.

Domestic output will decline after the earthquake and the percentage of reduction in industry is more than other sectors, which is due to capital intensive nature of industry sector. For health sector, it can be concluded that the negative effects on the supply side is more in comparison with the positive effects for demand supply. A study in Bangladesh, which is also a developing country, shows that medical care and emergency response do not efficiently respond to a disaster (Sohel and Hiroshi, 2018).

Saikia (2014) in investigating the status and problem of health service delivery in developing countries stated two main shortcomings in government spending for health services. First, institutional capacity in service delivery is a vital ingredient in providing effective services. Second, the net effect of government health services depends on the severity of market failures. From various theoretical and empirical experience, it is found that the more severe the market failures are, the greater the potential for government services to have an impact to grow positively.

In other words, although after quake there are many injured people that will increase demand for the health sector products, supply side effect is dramatically high. Supply side effects include destroy of healthcare buildings, storehouses of drugs and infrastructure of health sector. Therefore, the output of health sector will be negative after quake. It can be concluded that healthcare structures are not resilience enough.

The reduction of export is the same as output. As it was expected, since the amount of domestic output is lowered in all sectors, the amount of export will be lowered, too. To study the effects of earthquake on the welfare, income, consumption and saving of household, the result is quantified in Tables below.

Results of simulations on household income from production factors (% change)

Simulations on household income from production factors			
Household income	*SC1*	*SC2*	*SC3*
Labour	–3.81	–5.11	–6.42
Capital	–3.83	–5.15	–6.48

Results of simulations on household saving (% change)

Simulations on household saving			
	SC1	*SC2*	*SC3*
Household saving	–3.47	–4.65	–5.86

Results of simulations on household consumption (% change)

Simulations on household consumption				
Household consumption		*SC1*	*SC2*	*SC3*
Agriculture	Urban	–2.37	–3.17	–3.98
	Rural	–2.18	–2.91	–3.65
Industry	Urban	–5.08	–6.8	–8.53
	Rural	–4.89	–6.54	–8.21
Services	Urban	–3.32	–4.46	–5.61
	Rural	–3.13	–4.2	–5.29
Health	Urban	–3.04	–4.08	–5.14
	Rural	–2.85	–3.82	–4.81

Household income, results of simulations (% change)

Simulation on household income			
Household income	*SC1*	*SC2*	*SC3*
Urban	–3.5	–4.7	–5.9
Rural	–3.31	–4.44	–5.59

According to the results, after the earthquake households' income from production factors, saving, consumption and household income in both rural and urban areas will be lowered. For more intense earthquake, the reduction of these variables for both urban and rural households gets higher. But the point is that urban households are more likely to suffer in all scenarios. It may be concluded that after a disaster, since the income of urban households is more dependent on the capital, they are more vulnerable.

Income, saving and consumption can reflect the impacts of earthquake on household's welfare. As it was expected, the welfare of household become in lower levels after quake. To avoid or make the natural disaster's loss least, countries which are at risk (especially those who are located on the earthquake band such as Iran) should arrange serious actions to face with the critical situations before it happens.

Sensitivity analysis

The theoretical analysis of this studying identifies a number of key parameters which are likely to govern the extent of rebound including elasticity of substitution between domestic supply and export, σc, and elasticity of transformation between domestic supply and export, σt. An effective sensitivity analysis on these elasticities should be conducted given that the elasticities can change directly with the duration of time interval of the analysis. In other words, elasticities of substitution can have a strong impact on the results (Hanely et al., 2009). Therefore, in Table below the value of σc and σt are varied and for conciseness, the focus is on the second scenario only. In central case these parameters take the values of 2.5 and 2, respectively. For sensitivity, each of these parameters are varies (independently) to 2.4, 2.6 and 1.9, 2.1, respectively.

Sensitivity analysis						
	$\sigma_c = 2.4$	$\sigma_c = 2.5$	$\sigma_c = 2.6$	$\sigma_t = 1.9$	$\sigma_t = 2$	$\sigma_t = 2.1$
GDP	–5.05	–5.04	–5.048	–5.05	–5.04	–5.049
Domestic output						
Agriculture	–1.865	–1.78	–1.688	–1.791	–1.78	–1.761
Industry	–7.731	–7.75	–7.763	–7.737	–7.75	–7.756
Services	–4.968	–4.96	–4.949	–4.958	–4.96	–4.958
Health	–3.473	–3.47	–3.462	–3.469	–3.47	–3.466
Quantity of export						
Agriculture	–1.094	–1.01	–0.923	–1.061	–1.01	–0.955
Industry	–7.753	–7.78	–7.804	–7.761	–7.78	–7.796
Services	–4.809	–4.8	–4.793	–4.808	–4.8	–4.794
Health	–3.45	–3.44	–3.439	–3.447	–3.44	–3.442

Household income							
Labour		–5.125	–5.11	–5.095	–5.125	–5.11	–5.095
Capital		–5.133	–5.15	–5.158	–5.133	–5.15	–5.158
Household saving		–4.708	–4.65	–4.69	–4.708	–4.65	–4.69
Household consumption							
Agriculture	Urban	–3.18	–3.17	–3.165	–3.177	–3.17	–3.167
	Rural	–2.919	–2.91	–2.903	–2.917	–2.91	–2.906
Industry	Urban	–6.808	–6.8	–6.785	–6.804	–6.8	–6.789
	Rural	–6.558	–6.54	–6.533	–6.553	–6.54	–6.537
Services	Urban	–4.468	–4.46	–4.452	–4.465	–4.46	–4.454
	Rural	–4.211	–4.2	–4.194	–4.208	–4.2	–4.197
Health	Urban	–4.089	–4.08	–4.075	–4.087	–4.08	–4.077
	Rural	–3.831	–3.82	–3.816	–3.828	–3.82	–3.818

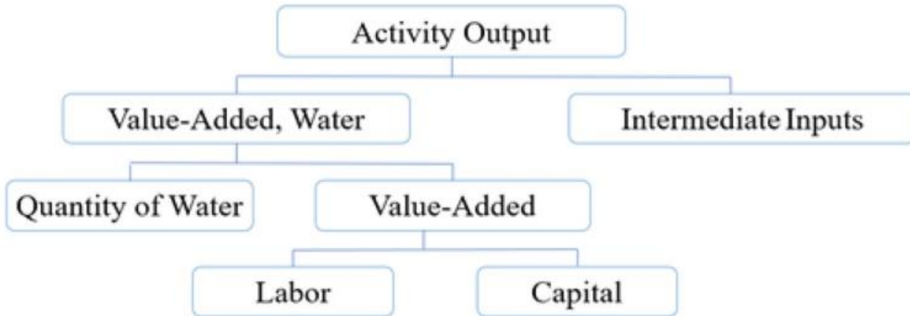
Household income						
Urban	–4.708	–4.7	–4.69	–4.705	–4.7	–4.693
Rural	–4.52	–4.44	–4.433	–4.448	–4.44	–4.436

From the above sensitivity analysis, it can be concluded that there is not any significant change among the results. Therefore, results are consistent and robust to generate the conclusion.

B: Modeling the Effects of Drought

Regarding the macro-level analysis of drought, considering that, as shown in Figure 2-1, the entire country has been affected by drought, a macroeconomic examination is justified, and there is no necessity for a localized analysis.

To simulate the effects of drought as an economic shock, water is incorporated as one of the production inputs into the production function, as follows:



As is illustrated in Fig. above, the combination of labor and capital produces value-added.

The quantity of water and value-added make value-added composited. To generate the total output of each sector, intermediate inputs and composited value-added should be combined. Then, the total production will be obtained at the top level. Therefore, production functions are as follows.

$$\mathrm{QVAW} = \mathrm{iva.QA} \tag{1}$$

$$\mathrm{QVAW} = a_a^{\mathrm{vaw}} \left[\delta_a^{\mathrm{vaw}} . QVA_a^{-\rho_{\mathrm{vaw}}} + \left(1 - \delta_a^{\mathrm{vaw}}\right) . WT^{-\rho_{\mathrm{vaw}}} \right]^{-1/\rho_{\mathrm{vaw}}} \tag{2}$$

$$\mathrm{PVAW.QVAW} = \mathrm{QVA.PVA} + \mathrm{WT.PW} \tag{3}$$

$$\frac{\mathrm{QVA}}{\mathrm{WT}} = \left(\frac{\mathrm{PW}}{\mathrm{PVA}} \cdot \frac{\delta^{\mathrm{vaw}}}{1 - \delta^{\mathrm{vaw}}} \right)^{\frac{1}{1+\rho_{\mathrm{vaw}}}} \tag{4}$$

where variables and parameters are as follows: QVAW the value-added and water composition and PVAW its price(Rials); WT the quantity of water (million cubic meter) and PW its price (Rials); QA level of activity; iva aggregate value-added coefficient; a_a Armington function shift parameter; δ^{vaw} Armington function share parameter; QVA value-added quantity; PVA value-added price (Rials), and ρ_{vaw} the elasticity of substitution between water and value-added.

Based on the conducted analyses, the amount of precipitation in the 2010-2011 hydrological year decreased by 21% compared to the previous year. According to the national rainfall status report, total precipitation was recorded at 203 mm in 2010 and 160 mm in 2011. Additionally, precipitation in the 2017-2018 hydrological year (from the beginning of October to April 14) was 107 mm, reflecting a 48% decrease compared to the previous year and a 46% decrease relative to the 49-year average (Water Resources Basic Studies Office, Ministry of Energy).

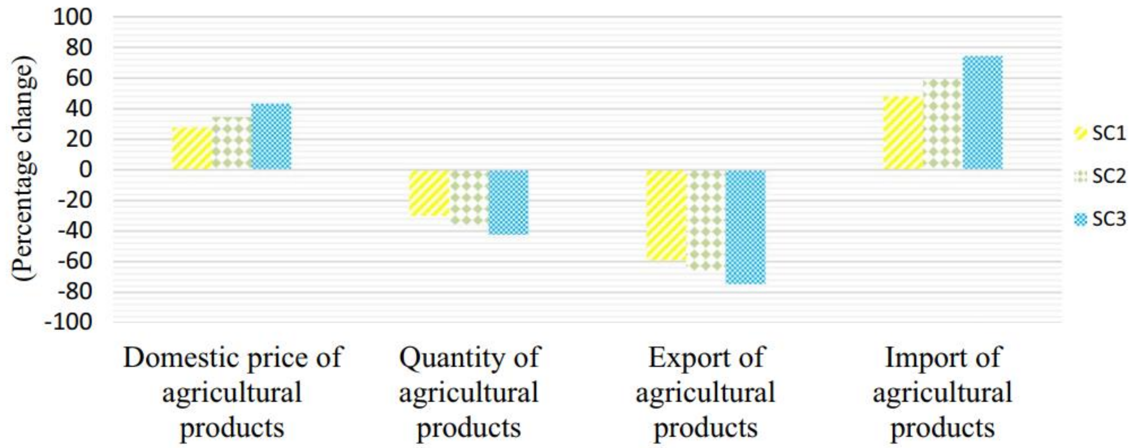
Accordingly, the following scenarios have been developed to account for the reduction in available water, the assumed scenarios SC1, SC2 and SC3 refer to a 30, 40 and 50% decrease in the amount of available water, respectively.

Result of simulations on economic growth (% change)

Variable	SC1	SC2	SC3
GDP	−3.93	−5.26	−6.89
Government saving	−624.3	−751.63	−903.33

The impacts of droughts on the agriculture sector (% change)

Variable	SC1	SC2	SC3
Domestic price of agricultural products	27.62	34.53	43.28
Quantity of agricultural products	−29.9	−35.84	−42.43
Export of agricultural products	−59.18	−66.96	−74.45
Import of agricultural products	48.17	59.66	74.19



The impacts of droughts on the agriculture sector

The impacts of droughts on the income of household from factors of production (% change)

Income of household from factors	SC1	SC2	SC3
Labor	− 10.82	− 12.74	− 15.02
Capital	− 4.2	− 5.34	− 6.74

The impacts of droughts on the household income (% change)

Household income	SC1	SC2	SC3
Urban	− 8.69	− 10.31	− 12.24
Rural	− 8.44	− 10.01	− 11.86

The impacts of droughts on the household saving (% change)

Household saving	SC1	SC2	SC3
	−37.04	−40.14	−43.4

The impacts of droughts on the household consumption in different economic sectors (% change)

Household consumption	SC1	SC2	SC3
Agriculture	−24.43	−28.53	−33.05
Industry	−3.12	−3.45	−3.84
Services	−2.22	−2.43	−2.68
Health	41.13	44.04	46.97

According to the results presented in the table above, drought leads to a decline in Gross Domestic Product (GDP), with more severe droughts resulting in greater reductions in GDP. Additionally, as indicated by the simulation results, government savings experience a significant decrease in the event of a drought. The primary reason for this decline is the subsidies allocated for each cubic meter of water. In other words, the substantial gap between the actual cost of water production and the price paid by consumers deepens during droughts due to reduced water availability, increased scarcity, and higher extraction costs. This widening gap imposes a financial burden on the government, forcing it to increasingly rely on its savings to cover water subsidies. Benson and Clay (2000) similarly identified rising government debt as a consequence of drought in their study.

The effects of drought on the agricultural sector—the first and most critical sector impacted by water shortages—are detailed in the tables above. In all scenarios, domestic prices of agricultural products rise following a drought, with greater drought severity leading to higher price increases. Agricultural production is directly linked to water resources and precipitation, meaning that as drought intensifies, agricultural output declines significantly. Consequently, agricultural exports decrease due to reduced production levels, while imports of agricultural products increase to compensate for the shortfall in domestic supply and meet demand. Al-Riffai (2012) also found that drought leads to a decline in agricultural output, while

Salami et al. (2008) concluded that drought results in increased food imports and rising price levels.

The Impact of Drought on Household Welfare

To assess the effects of drought on household welfare, the results presented in the tables above indicate that household income from production factors, household savings, consumption, and the income of both urban and rural households decrease. Given that consumption and income levels are key indicators of household welfare, a decline in these variables following a drought leads to reduced welfare. Moreover, the severity of welfare loss is directly proportional to the intensity of the drought—more severe droughts result in greater reductions in household welfare.

The decline in household consumption is most pronounced in the agricultural sector. This is because drought-induced reductions in agricultural output drive up the prices of agricultural products, leading to decreased demand and lower consumption within this sector. Additionally, drought causes widespread unemployment, particularly among farmers, which results in a sharper decline in household income from labor as a production factor compared to capital as a production factor.

Interestingly, the reduction in income is nearly equal among urban and rural households, despite expectations that rural households—being more dependent on agricultural production—would experience a greater income decline. This phenomenon can be attributed to the self-sufficiency of rural households: while urban households must purchase agricultural products, rural households that produce these goods do not need to make cash payments for their own consumption. Al-Riffai (2012) also observed increased poverty and reduced welfare as a consequence of drought.

According to the results in the table above, household demand for health sector goods and services rises during drought periods. Drought leads to an increase in respiratory diseases due to the heightened presence of airborne dust particles. Additionally, it raises the likelihood of infectious disease outbreaks, prompting more individuals to seek medical care. As the severity of drought intensifies, the demand for healthcare services correspondingly increases.

Climate change phenomena—including floods, storms, and droughts—have had adverse effects on food security. Among these, drought is the most significant factor influencing food security, as it simultaneously reduces agricultural output and household income, particularly among poor households. This dual impact leads to diminished food security, increased malnutrition, and adverse effects on public health, particularly among lower-income households. Chen (2007) also found that drought-induced malnutrition led to increased healthcare demand, while Emmett (2016) and Bauer (2017) identified the negative effects of drought on public health, particularly on children's health.

6-4. Proposed Solutions

This section presents the most effective strategies for mitigating the impact of natural disasters, specifically earthquakes and droughts.

4-6-1. Examination of Iran's Insurance Industry (2011–2015)

One key indicator of the insurance sector's development relative to the overall economy is the insurance penetration rate, which is calculated as the ratio of total insurance premiums to GDP. There is a substantial gap between Iran's insurance industry and global benchmarks in this regard.

4-6-2. Earthquake Insurance Studies in Iran

Amakchi (1993) analyzed the role of the insurance industry in the construction sector and the potential for its involvement in this field. For the insurance industry to effectively enter this sector, it must first understand the characteristics of buildings. Consequently, the industry monitors construction activities, which helps enhance the quality and quantity of buildings by strengthening their advantages and addressing weaknesses. Buildings that meet specific standards will be insured, thereby safeguarding assets against disasters. Additionally, since insured properties must meet quality requirements to ensure continued coverage, insurers adopt a policy of maintenance and preservation to minimize their liabilities in compensation payments. This emphasis on "repair and maintenance" plays a minor role in Iran's construction industry, leading to significant losses in national assets.

Sadeghi and Emamgholipour (2008) employed econometric methods to assess the impact of natural disasters on economic activities in Iran. Using an autoregressive distributed lag (ARDL) model for the period 1959–2004, they examined the effect of disaster-related damages on non-oil GDP. Their findings indicate a U-shaped relationship between natural disaster damages and overall economic activity. Specifically, non-oil GDP initially declines following a disaster but subsequently increases during the reconstruction phase. Since a disaster creates a gap between actual and optimal production levels, and it takes a considerable time to close this gap, building and asset insurance emerge as essential tools for crisis management.

Ghaffouri Ashtiani (2010) provided a comprehensive definition of risk management and studied the status of disaster insurance in Iran. He identified key challenges in the insurance industry and proposed strategic measures, including the development of a comprehensive earthquake, flood, and disaster insurance system, expansion of disaster insurance coverage through supportive, mandatory, and incentivized schemes, and integration of insurance with financial and regulatory frameworks in construction and urban development. He also emphasized the need for mechanisms that provide secure financial resources for property owners affected by disasters, without complete reliance on government assistance, through the operationalization of a disaster insurance fund. Additionally, he called for the establishment of legal, regulatory, and organizational structures for disaster insurance management, the creation of specialized risk management institutions to assess risks and vulnerabilities, and the development of scientific models to determine fair insurance premiums.

Kazemi et al. (2011) studied the factors influencing the adoption of earthquake insurance for residential properties in Zanjan. Using a descriptive-analytical method, they surveyed 350 households and identified 15 key factors affecting earthquake insurance adoption. Their findings indicated that income was the most significant factor in purchasing insurance, while housing size was the least important. Insufficient savings, high living costs, and high insurance premiums had minimal effects on insurance demand.

4-6-3. Insurance as an Effective Strategy for Natural Disaster Management

Preventive measures taken before disasters occur are more cost-effective than post-disaster recovery efforts. Developed countries adopt this approach to mitigate the impact of hazards. Strengthening building structures to enhance resilience is crucial in disaster risk reduction. This means that measures taken to minimize the adverse effects of hazards must be sustainable to effectively reduce costs. Sustainability involves constructing buildings in accordance with international civil engineering standards, ensuring proper structural design that prevents damage from destructive forces and protects inhabitants. The higher the probability of a disaster, the more critical it is to comply with construction regulations and build resilient structures.

However, adhering to these regulations increases costs for developers and reduces their profit margins. As a result, short-term profit-seeking by builders may lead to greater long-term losses. Therefore, mandating earthquake insurance would require insurance experts to hold construction engineers accountable for structural integrity. In developed countries, given the high cost of disaster damages, insurance companies and governments impose severe penalties on developers who fail to comply with resilience and sustainability standards (Moghimi, 2014).

1. Households: Preventing Overwhelming Financial Burdens

If households do not receive support during crises, they risk falling into poverty due to loss of assets, income, employment, and, in many cases, the health of the household head. Families that were previously classified as middle-income may be forced to rely on their savings to survive after an earthquake, leading to their reclassification into lower income brackets. However, with strong insurance coverage, households would not have to worry about lost wealth or a decline in their standard of living.

2. Government

Currently, due to the weak role of earthquake insurance, the government intervenes after an earthquake in a traditional and reactive manner, providing assistance to victims only post-disaster. If insurance were more prevalent, government expenditures would not skyrocket following an earthquake. The government's role in this scenario could include:

a. Reinsurance Support: Until insurance companies are sufficiently developed, the government can provide reinsurance support to help stabilize the market.

b. Support for Vulnerable Groups: To ensure widespread insurance coverage, the government could subsidize insurance premiums for low-income groups, particularly those living in high-risk areas, either partially or fully covering their costs.

3. Standardization of Building Construction

A key long-term impact of earthquake insurance is the standardization of construction practices.

Higher Insurance Premiums for Weak Structures:

In earthquake-prone countries, earthquakes occur more frequently and with greater intensity, necessitating thorough risk assessments by experts and engineers. After identifying risks, insurance premiums should be set accordingly. In developed countries, annual insurance premiums are estimated to be around 10% of total damage recovery costs. As a result, residents of unsafe buildings would have to pay higher premiums, incentivizing earthquake engineering research to assess risks and vulnerabilities more effectively. Insurance pricing would also take into account building age and the likelihood of damage. Structures lacking adequate reinforcement are more likely to collapse, even in minor earthquakes, increasing their insurance costs. This encourages property owners to invest in structural reinforcement.

4. Technological Advancements in Construction

Several factors, such as a building's location, construction supervision quality, build quality, and age, influence its vulnerability to earthquakes. Consequently, builders would be encouraged to construct buildings in safer areas, away from fault lines, fostering a cultural shift towards safer construction practices. Over time, this would lead to higher construction standards and advancements in building technology.

5. Crisis Management

A crisis arises when needs exceed available resources. To effectively manage disaster-related crises, all emergency response plans must be designed and rehearsed before disasters occur. Earthquake insurance should serve two main purposes:

1. **Compensation for Losses:** The direct goal of insurance, providing financial relief after an earthquake.
2. **Encouraging Safer Construction and Purchases:** The indirect but primary goal of insurance, which promotes better construction practices before an earthquake occurs. If insurance premiums are proportionate to building quality, proper construction practices can significantly reduce financial and human losses in the long run.

Pre-Disaster Crisis Management Through Insurance:

If earthquake insurance were mandatory for property transactions, developers would be required to obtain insurance policies. Insurers, in turn, would issue policies only for buildings that meet safety standards, leading to the reinforcement of both new and existing structures. Common retrofitting techniques include using FRP (Fiber Reinforced Polymer) for concrete buildings and adding steel bracing or reinforcement plates for steel structures. This proactive approach can mitigate disaster impacts before they occur (Babaei, 2011).

Post-Disaster Crisis Management Through Insurance:
After an earthquake, insurance provides financial support to policyholders by covering damages, helping communities recover and rebuild.

Due to the nature of natural disasters and the widespread damage they cause, it is not feasible to place the burden of compensation on a single entity or to fully recover all losses. Therefore, victims, insurance providers, domestic and international aid organizations, and the government must collectively contribute to compensating the damages.

To better analyze the behavior of economic actors, it is useful to separate **insurance demanders** (households, businesses, and the government) from **insurance suppliers** (insurers).

Insurance Demanders

Key strategies for increasing demand for earthquake insurance are outlined below for different economic actors:

a. Households

To encourage households to purchase earthquake insurance, the following measures are proposed:

- Raising awareness through media and other informational tools about earthquakes as a threat to their assets.
- Reducing earthquake insurance premiums.
- Requiring home loan and credit applicants to present earthquake insurance policies as a prerequisite for financial institutions.
- Offering discounts for group purchases of insurance policies.
- Government subsidies for low-income groups.
- Making earthquake insurance mandatory (similar to compulsory third-party auto insurance, which dominates issued insurance policies).

b. Businesses

Businesses vary in size, asset levels, risk management approaches, and awareness of earthquake hazards. Small enterprises, like households, are often reluctant to purchase earthquake insurance. However, large multinational firms, with expert risk management teams, are more likely to purchase comprehensive insurance packages (Flores, 1985).

To encourage small businesses to buy insurance, the same strategies as households—awareness campaigns, government incentives, and industry support—should be employed. For larger companies that have not yet obtained earthquake insurance, the concept of a **soft insurance market** can be leveraged. (A soft market, as opposed to a hard market, is characterized by low premiums, broad coverage, relaxed conditions, and increased competition among insurers.) (Burn, 2006; Craig, 2013).

Additionally, insurance companies often underprice premiums for large businesses, as they do for other types of insurance such as accident and fire insurance, making earthquake insurance more appealing.

c. Government

Risk management is crucial for the public sector. Insurance companies are willing to offer lower premiums for government entities, which often have skilled risk managers who recognize earthquakes as a threat to national infrastructure. Consequently, public-sector demand for earthquake insurance is expected to be sufficient, eliminating the need for additional legislation mandating insurance coverage for government buildings, assets, and facilities.

Insurance Suppliers (Insurers)

Cash flow is one of the most critical factors in sustaining businesses. A steady cash flow allows companies to fulfill their commitments and continue operating even if they are not profitable. For insurers, this is even more vital, as they must meet their obligations to policyholders.

Despite a potential increase in demand for earthquake insurance, inefficiencies in the insurance industry prevent it from functioning optimally. Currently, the insurance sector faces several challenges:

- **Statistical and pricing issues**
- **Limited capacity to compensate large-scale losses**
- **Adverse selection** (where high-risk individuals are more likely to purchase insurance)
- **Risk distribution difficulties**
- **Accurate estimation of earthquake-related damages and insured assets**

Key factors influencing earthquake damage include: earthquake intensity, location, soil type (soft or hard), ground stability, proximity to fault lines, building type, building age, urban density (higher density increases secondary risks like fire spread), and the season and time of occurrence (Bastami, 2010).

To ensure **fair pricing**, insurance companies must consider these factors. Through extensive research, public awareness efforts, infrastructure improvements, and the empowerment of insurers, disaster-related losses can be effectively mitigated.

Before issuing insurance, earthquake engineers must assess buildings for compliance with safety standards. If a structure fails to meet the required standards, it will not be insured. This process helps address **information asymmetry** between buyers and sellers, ensuring that only resilient buildings receive insurance coverage.

If regulations were enacted requiring properties to have earthquake insurance before being sold, developers would be incentivized to construct buildings according to modern safety standards.

Improper land use has led to a decrease in biodiversity density and variety, depriving ecosystems of the necessary time for natural recovery. The excessive increase in the ecological footprint indicates a shift in consumption patterns and a rise in consumerism in the country from 1961 to 2011. This necessitates proper management and precise planning to control it and efforts to reduce the ecological footprint compared to biological capacities.

Regarding the Happy Planet Index, Iran ranked 67th in 2006 but fell to 77th in 2012, indicating a worsening situation. Most dams have been constructed with the aim of energy and electricity production rather than agricultural use. In some cases, no measures have been taken for water transfer channels and networks of the dams. The evaporation rate of lakes behind dams is also significant (Institute for Planning, Agricultural Economics, and Rural Development Research, 2015). Additionally, water loss during transmission to farmlands is high. Water efficiency in agriculture is low, necessitating the adoption of modern techniques and advanced irrigation methods. Suitable strategies should be proposed to align cropping patterns with different climates. Thus, water management in the country is complex and cannot be resolved merely through dam construction and short-term or fragmented programs. The drying up of Lake Urmia, Lake Bakhtegan, the Karun and Zayandeh Rud river basins, and the severe decline in groundwater levels are unfortunate consequences of such management and planning. The lack of sufficient investment in modern irrigation techniques remains a significant challenge in the agricultural sector. Therefore, the development of secondary irrigation and drainage networks, appropriate water transfer methods, irrigation expansion projects, and fundamental measures to prevent water loss and ensure proper resource management are essential for improving the country's water efficiency (Shakeri, 2016).

4-7-1. Solutions

1. Collaboration between relevant organizations, universities, and scientific centers to utilize their expertise and experiences in predicting adverse effects of each project and estimating potential impacts before implementation, as well as leveraging the knowledge of foreign consultants.
2. Prioritization and proper allocation of investments to develop the agricultural sector, increase water efficiency, and promote modern irrigation techniques.
3. Given the water shortage in Iran and the high water consumption compared to rainfall, it is rational to invest more in water-saving technology projects. Additionally, serious efforts should be made to adapt the agricultural sector to existing drought conditions.
    - For example, drought-resistant crops should be cultivated based on the country's ecological capacity. This could change the planting calendar and mitigate climate-induced damages. In dry provinces like Isfahan, cultivating water-intensive crops like rice is unsuitable. Instead, drought-resistant plants such as figs, mulberries, sesame, and barley should be grown in arid regions.
    - Similarly, drought-resistant plants should be used for landscaping highways, boulevards, and roadsides. These plants require minimal irrigation and maintenance since they do not need fertilizers or pesticides. Suitable species for this purpose include Artemisia and Karata, which thrive in various soil types, including saline soils and low water retention soils, and withstand extreme climatic conditions such as high temperatures, evaporation, and severe winds.

Various measures can be taken to conserve plant water and prevent drought damage, including:

1. Timely pruning of trees to remove excess branches and leaves.
2. Weeding around plants and avoiding the accumulation of plant debris near tree roots to minimize moisture evaporation, using organic or plastic mulch for crops like vegetables.
3. Conducting winter irrigation of fields to retain soil moisture.
4. Avoiding the cultivation of multiple crops with varying water needs in the same farm or orchard.
5. Expanding greenhouse farming as much as possible (with attention to organic farming conditions, as genetic modification and chemical fertilizers are more prevalent in greenhouse cultivation, potentially leading to health issues for consumers).
6. Utilizing low-quality water and treating wastewater for irrigation.
7. Covering irrigation canals and using pipelines for water transfer.
8. Selecting appropriate locations for dryland farming, considering proper slope, soil type, planting direction, and avoiding plowing steep slopes to prevent soil erosion and water loss.
9. Using porous containers for irrigation.
10. Extracting water from qanats instead of relying on deep wells for irrigation.
11. Conducting meteorological studies to anticipate rainfall patterns before droughts occur. Based on expert assessments, providing farmers with accurate information on suitable crops for each season and region would be highly beneficial.
12. Planting date palm trees along the Karun River to reduce dust storms, prevent riverbed shrinkage, and increase the production of high-quality dates, boosting exports and income.
13. Establishing water research councils in universities to scientifically study water-related issues, with expert teams determining appropriate solutions.

4-8. Summary

To analyze the impact of natural disasters such as earthquakes and droughts on the economy, public health, and household welfare, separate scenarios were developed.

Earthquakes lead to a decline in capital stock, reducing GDP and production across all sectors. Since earthquakes cause injuries and increase demand for healthcare, production in the health sector declines less than in other sectors despite damage to medical facilities. The results indicate that household income from labor declines due to unemployment and reduced workforce (caused by fatalities and permanent disabilities). Household income from capital also drops due to reduced capital stock. Household savings decrease as people lose jobs and assets, necessitating spending their resources on essential needs. Consequently, household welfare diminishes compared to pre-earthquake conditions.

Regarding droughts, scenario analysis of reduced water availability due to lower rainfall reveals GDP reduction, a severe decline in government savings, increased agricultural product prices, and a drop in agricultural production volume. Household income from production factors, household savings, and urban and rural incomes also decline. As a result, household welfare and food security deteriorate. Household consumption of goods from various economic sectors decreases, while consumption of health sector products rises due to increased diseases caused by air pollution, rising particulate matter, declining water quality, and the spread of infectious diseases like cholera and typhoid due to contaminated drinking water. The likelihood of contracting communicable diseases and zoonotic infections also increases.

Given that Iran faces both the risks of severe earthquakes and ongoing drought (which has already led to a national water crisis), the need for effective management and serious planning to invest in proper disaster mitigation strategies is evident.

In addition to investing in proper education, crisis management, and the fair distribution of aid to earthquake victims, earthquake insurance is proposed as an effective solution. It can not only compensate losses and provide financial security but also encourage structural reinforcement before earthquakes, reducing damage and fatalities. Special attention should be paid to constructing healthcare facilities, particularly in earthquake-prone and underdeveloped areas, to minimize damage and ensure efficient post-disaster services.

For drought management, proper water resource management, preventing water loss in all sectors (especially agriculture, which consumes the most water), avoiding excessive and illegal water extraction, and conducting environmental impact assessments before undertaking any water-related project are essential. Preventing the excessive drilling of deep wells and implementing drought insurance for agricultural products can help mitigate drought-related damages. Additionally, carefully studying seasonal and regional crop suitability and evaluating the economic feasibility of local cultivation versus imports are crucial strategies for reducing the negative impacts of drought.

Chapter 5
Summary, Conclusion & policy implications

5-1. Introduction

Based on the results obtained in the modeling of the previous chapter, this chapter will provide a summary, conclusions, answers to the research questions, and suggestions aligned with the results and investigations carried out. This study uses a computable general equilibrium model to simulate the effects of natural disasters on the economy. Since both earthquakes and droughts, as examined in this research, have negative effects on health, production, employment, government costs, and household welfare, and given that the country has experienced both types of disasters in recent years, it is necessary to plan systematically and accurately for crisis management in this area.

5-2. Summary and Conclusion

Earthquakes impose a high death toll on the affected area due to widespread destruction. The intensity of the earthquake, its location, and the proximity to the epicenter significantly affect the number of fatalities. In most cases, damage to vital infrastructure prevents an adequate and comprehensive medical response to the patients. In the worst-case scenario, hospitals themselves are destroyed, which is a common occurrence in developing countries, increasing the severity of the damage. In some cases, power and water outages at hospitals prevent proper services for the earthquake victims. Additionally, earthquakes can damage ambulances, making it more difficult to transfer patients to treatment centers. In most studies, after an earthquake, patients and injured individuals are transported to hospitals using public transport or private vehicles. The destruction of bridges and roads in high-intensity earthquakes causes delays in transporting casualties, which is especially threatening to the health of individuals requiring emergency care (Arnold, 1999).

The destruction of pharmacies and medical equipment storage warehouses also exacerbates the treatment and relief crisis for the affected. After an earthquake, even if hospitals and treatment centers are unharmed, a large quantity of drugs and medical supplies is needed to treat the individuals and the influx of people to medical centers. If this need is not met, the lives of many survivors are at risk. This issue has been referred to as "secondary disasters" in previous studies.

After an earthquake, a large number of medical personnel is needed. Therefore, crisis management planning must ensure that a significant number of knowledgeable and trained individuals in health and medical fields are ready to be deployed during emergencies. Earthquakes also increase healthcare costs. If the injured individuals cannot afford medical expenses, the healthcare sector will earn less income relative to the costs incurred. Infectious diseases increase due to population displacement and their sheltering in camps, and the spread rate is related to the number, health, and living conditions of the affected individuals.

Another health sector impact caused by an earthquake is the loss of personnel. Typically, training a workforce for the healthcare sector takes many years, and this sector has a large human capital base, with training costs higher than other sectors.

Shibusawa (2011) used computable general equilibrium models to analyze the effects of earthquakes. In that study, a reduction in capital stock (the primary consequence after an earthquake) was modeled as a shock to the system. This research also considers a reduction in capital stock as a shock in simulating the effects of an earthquake. The main difference between this study and Shibusawa's research is the consideration of earthquake impacts on the healthcare sector. Additionally, the effects on household welfare were not considered in Shibusawa's study. In 2015, Ristira studied household welfare after an earthquake in Chile. Therefore, this thesis aims to expand on previous studies and address their gaps through more complete and precise modeling.

An earthquake reduces capital stock, and the results of the modeling in this study show a decrease in GDP and a reduction in production across all sectors. Since earthquakes lead to the onset of diseases and an increased demand for healthcare products, the reduction in the healthcare sector's production is less than in other sectors despite the destruction of treatment centers, pharmacies, and other healthcare service buildings. According to the results, household income from labor production factors decreases due to unemployment and the loss of human resources (due to the death or permanent disability of a significant number of residents, etc.), and household income from capital production factors decreases due to a reduction in capital stock. Household savings also decrease due to job loss, a reduction in assets, and the need to use savings to repurchase essential goods for daily life. As household income decreases, so does household welfare compared to a scenario without an earthquake.

Among natural disasters, climate-related ones, such as drought, have more severe consequences for human and animal health, as well as food and water security. This is especially true in societies where people are more dependent on agricultural production (Imamgholipour, 2014). Water shortages cause wells to dry up and land to become barren, leading to the destruction of wildlife and plant species, as well as the onset of various diseases that can impose high costs on the economy (Alizadeh, 2015).

Drought impacts human health in various ways, as mentioned in Chapter 2. Some of these impacts are:

1. **Air Quality:** Drought reduces air quality. This is manifested in an increase in particulate matter, pollen, smoke, and pollution, which can lead to respiratory diseases. This effect is especially severe for vulnerable groups, including children and the elderly.
2. **Water Quality:** Drought and reduced water resources lead to increased water pollution, deteriorating water quality, and an increased likelihood of infectious diseases such as cholera, typhoid, etc., due to drinking contaminated water.
3. **Sanitation:** Access to clean and safe water is directly linked to sanitation, which controls and prevents diseases, particularly infectious diseases. In a drought, individuals are forced to conserve water, and if water conservation leads to less water being used for sanitation, it may create conditions conducive to various diseases (Gill, 2010). During a drought, the risk of animals contracting diseases increases, and water reservoirs become contaminated with animals and microbes. Long cycles of disease transmission occur, and ecosystems, agriculture, and livestock are affected. Additionally, due to severe climate changes, various fevers spread among livestock, many of which are zoonotic and can easily be transmitted to humans (Imamgholipour, 2014).
4. **Mental and Behavioral Health:** Natural disasters generally have psychological effects, leading to distress, sadness, and depression

(Imamgholipour, 2014). Some jobs, such as farming, horticulture, and herding, heavily depend on rainfall. Stress and financial worries can lead to depression. For rural residents who have no other means of livelihood, drought can severely affect their mental health. Studies in Australia, India, and some U.S. states have shown a significant relationship between increased suicide rates among rural farmers and repeated droughts (Sartor et al., 2007).

5. **Food Security:** Rural economies depend heavily on agriculture. In the event of a drought, farmers and rural inhabitants, who consume a large portion of their own produce, face food shortages. In some cases, the quality of food consumed deteriorates significantly, and essential nutrients may not be provided. With drought, the cost of obtaining food increases for low-income families, thus the impact of drought in rural and low-income areas is more severe than in other areas (Mokhtari et al., 2007). Studies on the lives of nomads indicate that these groups lack access to adequate healthcare and education, and due to poverty and severe income reduction caused by drought, they are more vulnerable than others.

Al-Rifi (2012) used computable general equilibrium models to study the effects of drought in Syria. This article is one of the most comprehensive studies on drought, analyzing the effects of water shortages on livestock and agriculture, as well as the negative impacts on poverty and food security. However, it did not consider the health impacts of drought. This study analyzes the effects of drought on health, agriculture, and household welfare using a computable general equilibrium model.

In the case of drought, the results of scenario modeling for reduced water availability due to lower rainfall show a decrease in GDP, a sharp reduction in government savings, an increase in agricultural product prices, and a reduction in agricultural production. Household income from production factors, household savings, and the income of urban and rural households also decrease. As a result, household welfare and food security decrease. Household consumption of various economic sectors decreases, while consumption of healthcare services rises due to diseases caused by air pollution, increased particulate matter, and dust, along with the higher likelihood of infectious diseases and zoonoses.

The research questions will now be addressed:

- **How do natural disasters affect the health of individuals in society?** The natural disasters examined in this study, earthquakes and droughts, can both lead to a reduction in the health level of individuals. Earthquakes increase the demand for healthcare services due to the high number of fatalities and injuries, while droughts decrease health levels through air quality impacts, increased likelihood of zoonotic diseases, food insecurity, and malnutrition.
- **How do natural disasters reduce household welfare?** According to the results of the modeling, earthquakes and droughts lead to a decrease in consumption, savings, and income levels of both urban and rural households, thereby reducing household welfare.
- **How do natural disasters impact government expenditures?** The results show that earthquakes and droughts increase government costs through reduced savings, provision of loans and credit, and investment to compensate for the damages caused by the disasters.
- **How do natural disasters affect healthcare services?** Earthquakes impact both the demand and supply of healthcare services. Due to the extensive damage to healthcare centers and other service providers, the supply of healthcare services decreases, while the demand increases. In the case of drought, the demand for healthcare services increases, leading to an increase in healthcare service production.
- **How can the impacts of natural disasters be managed?** To manage natural disasters, attention should be given to the type of disaster. In this study, for the proper management of earthquake impacts, crisis management planning and education for residents in emergency response are necessary. Earthquake insurance is also examined as a suitable measure for disaster management. For drought management, the main issue is the mismanagement of water resources and the country's water reserves. Effective water resource management, water-saving techniques, modern agricultural methods, and avoiding unstudied water projects (such as dams) are critical measures.

5-3. Recommendations

In addition to the need for investment in proper education, effective crisis management, and the appropriate distribution of aid to earthquake victims, earthquake insurance has been introduced as an effective solution to reduce damages and increase the reassurance of residents regarding compensation for their losses. This insurance also serves as a strategy that can lead to the strengthening of buildings before an earthquake, reducing damage and losses after the event, especially in areas built on fault lines where the likelihood of earthquakes is higher. Special attention to the construction of healthcare facilities, especially in earthquake-prone and deprived areas, is also a key strategy for reducing damages and improving service delivery after an earthquake.

Regarding drought, proper management of water resources, preventing water wastage in all sectors, especially in agriculture (which is the highest consumer of water), preventing excessive water extraction beyond the permissible limits, conducting studies on any action that could affect the local ecosystem before implementation, preventing the drilling of deep wells, and the insurance of agricultural products against drought are suitable strategies to reduce the negative impacts of drought. Additionally, a thorough study of the crops planted each season and in each region, along with an economic evaluation of the feasibility of planting versus importing these crops, is another critical strategy to reduce the adverse consequences of drought.

The study of agricultural products in the form of product-region tables and matrices, and accurately determining the suitable time and place for planting each crop, is another important action required for managing water resources (Sadeghi, 2001). Another key strategy for drought management is to avoid any actions such as dam construction, river water diversion, and the creation of infrastructure without proper and accurate studies and assessments of the resulting consequences. These actions have often caused severe damage to water resources and ecosystems, leading to drought. Furthermore, studying the economic feasibility of importing water-intensive agricultural products instead of growing them locally is a fundamental measure that can lead to savings in the country's water resources.

For further research in this field, the following topics are recommended:

1. Utilizing dynamic computable general equilibrium models to study the effects of an earthquake and its subsequent rebuilding and investment phase (Ex-ante analysis using the DSGE method).

2. Investigating drought regionally based on rainfall levels in each area and the types of crops grown in those regions.

References

List of References:

A) Persian References

1. Imamgholipour Sefid Dashti, Sara (2008). The Impact of Natural Disasters on Selected Macroeconomic Variables in Iran. Doctoral Dissertation, Tarbiat Modares University.
2. Imamgholipour Sefid Dashti, Sara (2014). Economics of Natural Disasters, Noor Elm Publications.
3. Emkachi, Hamideh (1993). The Determining Role of Insurance in the Construction Industry. Insurance Industry Quarterly, pages 43 to 50.
4. Ali, Ahmad, Masiha Madani, and Hamid Ahmadi Balo (2009). Drought and Ways to Counteract It. Agricultural Jihad Organization of West Azerbaijan Province, Publisher: Agricultural Education and Research Promotion Organization, Agricultural Jihad Organization Extension Management, First Edition.
5. Babaei, Mohammad; Laki Rohani, Ali (2011). Comparison of Modern Concrete Beam Reinforcement Methods (FRP Reinforcements) with Older Methods, Sixth National Civil Engineering Congress, Semnan University, Iran.
6. Badri, Seyed Ali; Mousavi, Sirous (2010). An Analysis of Trends in the Changes of Certain Rural Housing Characteristics in Iran. Proceedings of the Fourth International Congress of Geographers of the Islamic World.
7. Barkhordari, Sajad; Mehrgan, Nader (2010). General Equilibrium Models and Their Application in Economics. Noor Elm Publications, First Edition.
8. Barfishe, Mari (2012). An Introduction to Computable General Equilibrium Models. Translated by Fatemeh Bazazan and Maryam Soleimani Moayyad, Tehran, Nashr Ney.
9. Bazazan, Fatemeh; Mohammadi, Parisa (2016). Modeling Regional Economic Losses Due to Natural Disasters: A Case Study of the Tehran Earthquake. Iranian Economic Research Quarterly, 21st Year, Issue 68, Fall, pages 99-127.
10. Bastami, Morteza (2010). A Review of Earthquake Insurance Development in Japan for the Building and Housing Sector. Journal of Seismology and Earthquake Engineering, 13th Year, Issues 3 and 4, pages 53 to 62.
11. Iran Meteorological Organization Website: www.irimo.ir
12. Pourriyahi, Parvaneh (1989). The Use of Insurance in Compensating for Earthquake Damage. Central Insurance Quarterly, 4th Year, Issue 2, pages 38 to 54.

13. Pirmardian, Nader (2008). Estimating the Return Period of Drought Using the Standardized Precipitation Index (SPI) in Fars Province. New Agricultural Science, 4th Year, Issue 17, pages 7 to 21.
14. Tafazzoli, Fereydoun (1993). History of Economic Thoughts. Tehran, Nashr Ney, First Edition, pages 118-120.
15. Javadnia, Islam; Mebashari, Mohammadreza (2007). Review of Agricultural Drought Assessment Methods Using Remote Sensing Techniques. Khajeh Nasir University of Technology.
16. Khalaji, Mahtab; Ebrahimi, Eisa; Hashemizadeh, Hasti, et al. (2016). Water Quality Assessment of Zayanderud Dam Lake Using the WQI Index. Iranian Fisheries Science Journal, 25th Year, Issue 5, pages 51-64.
17. Khiz, Zahra (2013). The Effects of Drought on Iran's Economy: A Computable General Equilibrium Analysis. Master's Thesis, Faculty of Agriculture, Shiraz University.
18. Darijani, Ali; Hosseini, Seyed Safdar; Ghorbani, Mohammad (2008). Estimating the Damage Value of Drought to Wheat Production in Golestan Province. Journal of Agricultural Economics and Development, Issue 64, Winter, pages 83 to 96.
19. Macro Water and Wastewater Planning Office (2015). Statistical Yearbook of Water in the Country 91-1390. Ministry of Energy, Tehran.
20. Planning and Development Office, Statistical Analysis Department, Central Insurance of the Islamic Republic of Iran (2016). Statistical Yearbook of the Insurance Industry for 1394. Central Insurance of the Islamic Republic of Iran, First Edition.
21. Razavi Neshat, Najmeh and Mehdi Masoudi Far (2016). The Effects of Drought and Ways to Counteract It, Agricultural Jihad Organization of Kerman.
22. Geological Survey and Mineral Exploration Organization of Iran Website: www.gsi.ir
23. Shakari, Abbas (2016). An Introduction to the Economy of Iran, Rafe Publishing, First Edition.
24. Shahpari, Ghazal, Hossein Sadeghi, Abbas Asari, and Mohammad Hassanzadeh (2016). Insurance: An Effective Solution for Managing Natural Hazards. Environmental Hazard Management Journal, Vol. 3, Issue 4, pages 345-364.

25. Sadeghi, Hossein (2001). The Cost of Power Outages in the Agricultural Sector, Ministry of Energy, Economic Research Institute, Tarbiat Modares University.
26. Sadeghi, Hossein and Imamgholipour Sefid Dashti, Sara (2008). Study of the Impact of Natural Disasters on Non-Oil GDP in Iran, Journal of Economic Research, Issue 83, pages 115 to 136.
27. Sahat, Saeed; Akrami, Hamid (2014). Reasons for the Lack of Earthquake Insurance Development in Iran and the Need for Its Expansion. Monthly Insurance World News, Issues 190 to 200, pages 53 to 61.
28. Ziaei Saman, et al. (2013). Simulation of the Effects of Drought on the Agriculture Subsector Nationwide. Agricultural Economics and Development, 21st Year, Issue 81, pages 203 to 229.
29. Tabiei, Omid (2006). Ecological Footprint: The Impact of Humans on Nature, First Specialized Conference on Environmental Engineering, Tehran, University of Tehran, Faculty of Environment, https://www.civilica.com/Paper-CEE01-CEE01_229.html
30. Tayebi, Seyed Kamal and Shirin Masri Nejad (2006). Methodology of Computable General Equilibrium (CGE) Model: Theory and Application. Economic Studies Quarterly, Vol. 3, Issue 1.
31. Alizadeh, Maliheh (2013). Calculating the Fuzzy Drought Index and Examining Its Impact on GDP. Master's Thesis, Faculty of Management and Economics, Tarbiat Modares University.
32. Ghafouri Ashtiani (2010). Risk Management of Natural Disasters and Insurance in Iran. 17th National Conference and 3rd International Conference on Insurance and Development.
33. Fattahi, Maryam; Abbas Asari; Hossein Sadeghi, and Hossein Asgharpoor (2013). The Impact of Air Pollution on Public Health Costs: A Comparative Study of Developing and Developed Countries. Quarterly Journal of Economic Development Research, Issue 11, pages 111 to 132.
34. Ghanbari, Yusef (2001). Economic and Social Impacts of Drought on the Qashqai Nomads. Proceedings of the First National Conference on Examining Strategies to Combat Water Crisis, pages 273 to 281.
35. Ghahramani, Fereshta (2012). Measuring the Economic and Social Impacts of Drought Using the Modified Social Accounting Matrix (SAM) Supply-Side Model.

Master's Thesis, Faculty of Management and Economics, Tarbiat Modares University.

36. Kazemi, Leila; Kalantari, Mohsen (2011). Analysis of Factors Affecting Earthquake Insurance for Residential Buildings in Zanjan City. Quarterly Journal of Geography and Urban Planning, Zagros Perspective, 3rd Year, Issue 7, pages 99 to 117.

37. Karimi, Seyed Mohammad (2013). Evaluation of the Performance of the Country's Insurance Industry and the Definition of Future Prospects. Quarterly Journal of Fiscal and Economic Policies, Special Issue on Economic Report of the Government, 1st Year, Issue 2, pages 183 to 202.

38. Keshavarz Haddad, Gholamreza; Mortezazadeh, Hamed (2010). Analyzing the Allocation Effects of Gasoline Price Stabilization within a Computable General Equilibrium Model. Iranian Economic Research, 14th Year, Issue 42, pages 25-54.

39. Koshafar, A. (1999). Study of Changes and Concentration of Physicochemical Factors in Dez Dam Lake and Determining Its Water Balance. Master's Thesis, University of Science and Research, Ahvaz Unit.

40. Mokhtari, Darius and Iraj Saleh (2007). Economic and Social Effects of Drought on Rural Households in the Sistan Region. Iran Journal of Agricultural Extension and Education Sciences, Vol. 3, Issue 1, pages 99 to 114.

41. Road, Housing, and Urban Development Research Center (2014). Earthquake Design Code for Buildings, Standard 2800, Fourth Edition, Permanent Committee for Reviewing the Earthquake Design Code for Buildings.

42. Road, Housing, and Urban Development Research Center (2017). Urgent Report on the November 21, 2017 Earthquake in Kermanshah-Sarpole Zahab.

43. National Climate Research Center, Climate Research Institute, Website: www.cri.ac.ir

44. National Drought and Crisis Management Center (2017). Meteorological Drought Status Report of the Country, Agricultural Year 96-1395. Iran Meteorological Organization.

45. Mazinani, Atefeh (2015). Targeting Subsidies for the Health Sector in Iran. Doctoral Dissertation, Tarbiat Modares University.

46. Mostafavi, Seyed Mohammad Hassan; Mehrgan, Nader; Rezaei, Rohollah (2013). Earthquake and Its Effects on the Employment Structure of Bam. Scientific and Research Journal of Economic Policy, 5th Year, Issue 9, Spring and Summer.

47. Mostafizadeh, Reza; Mohsen Zibahi (2016). Analysis and Comparison of SPI and SPEI Indices in Meteorological Drought Assessment Using R Software (Case Study: Kurdistan Province). Earth and Space Physics, Vol. 42, Issue 3, pages 633-643.
48. Moghimi, Ebrahim (2015). Risk Knowledge for a Better Life and a More Sustainable Environment. Tehran University Press, Second Edition.
49. Agricultural Planning, Economic Research, and Rural Development Institute (2015). Summary Report of the Agricultural and Natural Resources Sector Program in the Sixth Development Plan.
50. National Seismological Center Website, University of Tehran, Geophysics Institute.
51. Ministry of Energy (2018). Daily Precipitation Report by First and Second-Order Watersheds, Iran Water Resources Management Company, Water Resources Basic Studies Office.

b. References in English

52. Aaron, Popp (2006). The Effects of Natural Disasters on Long Run Growth. Major Themes in Economics. 61-82.
53. Achour, N. et al. (2011), “Earthquake induced structural and non-structural damage in hospitals”, Earthquake Spectra, Vol. 27 No. 3 pp. 617-634.
54. Al-Riffai, P. and Clemens Breisinger (2012). Droughts in Syria: an Assessment of Impacts and Options for Improving the Resilience of the Poor. Quarterly Journal of International Agriculture 51 (2012), No. 1: 21-49.
55. Amdt, C. Hussain, A. et al. (2016). “Effects of food price shocks on child malnutrition: the Mozambican expierence 2008/2009”. Economics and human biology, vol. 22, pp. 1-13.
56. Anbarci, Nejat et al (2004). Earthquake Fatalities: the Interaction of Nature and Political Economy. Journal of Public Economics, 89, pp. 1907-1933.
57. Bauer J. M., Mburu S. (2017). “Effects of drought on child health in Marsabit District, Northern Kenya”. Economics & Human Biology, vol. 24, issue C, pp. 74-79.

58. Bayer, L. J. and Reinhard Mechler (2008). Insurance against losses from natural disasters in developing countries, Reviewed for DESA publication.

59. Benson, Ch., and E. J. Clay (2004). Understanding the Economic and Financial Impacts of Natural Disasters, Disaster Risk Management Series, No. 4, World Bank.

60. Born, Patricia (2006). The catastrophic effects of natural disasters on insurance markets. J. uncertainty, vol. 33, pp. 55-72.

61. Carrera, L. (2015). Assessing direct and indirect economic impacts of a flood event through the integration of spatial and computable general equilibrium modelling. Environmental modelling and Software, 63, 109-122.

62. CCME. (2001). "Canadian water quality guidelines for the protection of aquatic life: Canadian Water Quality Index 1.0 Technical Report." In Canadian environmental quality guidelines. 1999. Winnipeg.

63. Chen, J. (2011). Dads, disease, and death: determinants of daughter discrimination. Journal of Population Economics, 24.

64. Craig E. (2013). Hard market vs. soft market: the insurance industry's cycle and why we're currently in a hard market. PSA perspective.

65. Datar, A. et al (2013). The Impact of Natural disasters on child health and investment in rural India. Social Science and Medicine. Volume 76, 83-91.

66. Dervis, K., de Melo J., & Robinson S. (1982). General equilibrium models for development policy. New York: Cambridge University Press, 1982.

67. ECLAC. 1991. Handbook for Estimating the Socio-Economic and Environmental Effects of Natural Disasters: Economic Comission for Latin America and Caribbean.

68. ECLAC. 2003. Manual for Estimating the Socio-Economic and Environmental EFfects of Disasters: Economic Comission for Latin America and Caribbean.

69. Flores P.J., Goltz J.D., Najera G.V. (1985). Earthquake Insurance a public policy dilemma. Southern California Earthquake Preparedness Project. Federal emergency management agency. Earthquake hazard reduction series 7.

70. General Insurance Rating Organization of Japan (2014). Earthquake Insurance in Japan. 3rd edition.

71. Gerdin M, Clarke M, Allen C, Kayabu B, Summerskill W, et al., (2014). Optimal Evidence in Difficult Settings: Improving Health Interventions and Decision Making in Disasters. PLoS Med 11(4): e1001632. doi: 10.1371/journal.pmed.1001632.

72. Gignoux J., (2016). "Benefit in the Wake of Disaster: Long-run Effects of Earthquakes on Welfare in Rural Indonesia", Journal of Development Economics, vol. 118, issue C, 26-44.

73. Gil, Marina et al (2010). Economic Analysis of drought risk: an application for irrigated agriculture in Spain. Agriculture Water Management, 98, 823-833.

74. Gonzalez, J.F. (2017). The economic impacts pf droughts: a framework for analysis. Ecological economics, Vol. 132, pages 196-204.

75. Gunes, H. (2001). "Gender Differences in Distress Levels, Coping Strategies and Stress Related Growth and Factors Associated with Psychological Distress and Perceived Growth Following the 1999 Marmara Earthquake", Master Thesies.

76. Haddad E., et al (2015). Economic impacts of natural disasters in megacities: The case of floods in Sao Paulo, Brazil. Habit International, 45, 106-113.

77. Hallegatte, Stephane (2010). The Economics of Natural Disasters: Concepts and Methods. The World Bank. Policy Research Working Paper, 5507.

78. Hisdal, H. and L.M. Kallaksen (2003), Estimation of regional meteorological and hydrological drought characteristics: a case study for Denmark, Journal of Hydrology, 281: 230-247.

79. Huang Michael C. et al. (2014). A General Equilibrium Assessment on a Compound Disaster in Northern Taiwan. GRIPS Discussion Paper 14-06.

80. Kiyoshi, O. (1966). Background of establishment of an earthquake insurance system and outline of the system insurance. Study magazine, 434.

81. Kunreuther H. (1978). Issues on Earthquake Insurance: A Position Paper. Prepared for the J.H. Wiggins Company, Redondo Beach, CA.

82. Lofgren, H. et al. (2002). A Standard Computable Equilibrium (CGE) Model in GAMS. International Food Policy Research Institute TMD Discussion Paper No. 75.

83. March, G. (2002) Natural Disasters and the Impacts on Health, The University of Western Ontario, Faculty of Medicine and Dentistry, Summer Student with ICLR.

84. Nasrabadi T, Maedeh PA. (2014). "Groundwater quality degradation of urban areas (case study: Tehran city, Iran)". International Journal of Environmental Science and Technology, No. 11, Vol. 2, pp. 293-302.

85. Norris, F. H., (1990). "Screening for the Traumatic Stress: A Scale for Use in the General Population", Journal of Applied Social Psychology, Vol. 6, No. 1, pp. 115-121.

86. Riestra, M., (2015). "The Impact of Natural Disasters on Welfare: Evidence from Chilian Earthquake", university of SanAndres: Buenous Aires, Victoria.

87. Rose, A., Liao, S. (2011). Modeling Regional Economic Resiliency to Earthquakes: A Computable General Equilibrium Analysis of Lifeline Disruptions, Journal of Regional Science, 45 (1): 75 – 112

88. Sadeghi, H. et al., 2008. "Studying Effects of Natural Disasters on Non-Oil GDP in Iran", Journal of economic researches, Vol. 83, pp. 115-136 (in Persian).

89. Sadeghi-Bazargani, H. et al., (2015). "Crisis Management Aspects of Bam Catastrophic Earthquake: Review Article", Health Promotion Perspectives, Vol. 5 No. 1, pp. 3-13.

90. Salami, Habibollah, et al (2008). The economic impacts of drought on the economy of Iran. Ecologocal Economics, No. 68, pp. 1032-1039.

91. Samadi, M.T., Saghi, M.H., Rahmani, A.R. and Torabzadeh, H. (2009). "Zoning of water quality of HamadanDarreh-MoradBeyg River Based on NSFWQI. Index Using Geographic Information System". Journal of Hamadan University of Medical Sciences, No.16 Vol. 3, pp. 38- 43.

92. Saylor, C. F. et al., 1993. "Children and Disasters: Clinical and Research Issues", In C. F. Saylor (ED) Children and Disasters, New York: Plenum Press.

93. Shibusawa, H., (2011). "Evaluating the Economic Impacts of a Disaster: A CGE Application to the Tokai Region of Japan", Regional Science Inquiry, vol. 3, issue 2, pp. 13-25.

94. Shimbon (1980). All about earthquake insurance. General insurance association of Japan.

95. Shoven, J. B., & Whalley, J. (1992). Applying general equilibrium. New York: Cambridge University Press.

96. Skees, J.R. (2000). A role for capital markets in natural disasters: a piece of the food security puzzle. Food Policy. 25, pp. 365-378.

97. Soberon, G. et al., (1986). “The Health Reform in Mexico: Before and After 1985 Earthquakes”, American Journal of public health, Vol. 76. No. 6, pp. 273-280.

98. Steinbrugge, K. (1982). earthquakes, Volcanoes, Tsunamis: An Anatomy of Hazards. New York, Scandi, America Group.

99. The International Disaster Data Base: www.emdat.be (EM-DAT).

100. Toya, H., Skidmore, M. (2005). Economic Development and the Impacts of Natural Disasters. Economic Letters, 94, 20-25.

101. Vicente-Serrano, S. M., Begueria, S. & Lopezmoreno, J. I., (2010). “A multi-scalar drought index sensitive to global warming: the standardized precipitation evapotranspiration index-SPEI”, Journal of Climate, 23(7), 1696-1718.

102. Vogel, J. et al., 1993. “Task force report: Children’s psychological responses to disasters”, Journal of Clinical Child Psychology, Vol. 22 No.4 pp. 464-484.

103. WHO (2007), “Risk Reduction in the Health Sector and Status of Progress in Proceedings, Disaster, Risk Reduction in the Health Sector”, Thematic Workshop, World Health Organization (WHO), Geneva.

104. Winsemius, H. C. (2018). Disaster risk, climate change, and poverty: assessing the global exposure of poor people to floods and droughts. Environment and Development Economics, vol. 23, special issue 3 (Poverty and Climate Change) pages 328-348.

105. World Bank Organization (2007). Natural Disasters: Coping with the Health Impact.

106. Xie, N., Xin, J. and Liu, S. (2014) China’s regional meteorological disaster loss analysis and evaluation based on grey cluster model. Nat Hazards, 71: 1067–1089.

107. Zweifel, P. et al. (2009), “Health Economics”, Springer, second edition, Berlin, Germany.

Appendix: GAMS code

```
$title CGEmodel1
*qfs variable. there s one fx in labor market
* ================================= Sets ========================
sets
    ac  / agricult     agriculture
industry     industrial & mining
services      services
health         health activities
agricultc      agriculture
industryc     industrial & mining
servicesc       services
healthc         health commodities
labor
capital
urbanh
ruralh
govern
ent
itax
ytax
stock
tariff
row
total/
    acnt(ac) all except total
```

a(ac) activities /

agricult agriculture

industry industrial & mining

services services

health/

c(ac) commodities/

agricultc agriculture

industryc industrial & mining

servicesc services

healthc

ce(c) traded commodities /

agricultc

industryc

servicesc

healthc/

cm(c) /

agricultc

industryc

servicesc

healthc/

f factors of production /labor, capital/

ins institutions /urbanh, ruralh, govern, ent, row/

insd(ins) /urbanh, ruralh, govern, ent/

insdng(ins) /urbanh, ruralh, ent/

h(ins) household/urbanh, ruralh/ ;

```
alias (ac,acp); alias (c,cp); alias (ins,insp);alias(insd,insdp);alias(insdng,insdngp);
alias(f,fp);alias(h,hp);

acnt(ac)=yes;acnt("total")=no; alias(acnt,acntp);

*==================Declaration of scalars and parameters=====================

parameters

ad(a)      production function shift parameter

alpha(f,a)

aq(c)      armington function shift parameter

at(c)      cet function shift parameter

beta(c,h)

cpi

cwts(c)

deltaq(c)  armington function share parameter

deltat(c)  cet function share parameter

ica(c,a)

pwm(c)     world market price of imports

pwe(c)     world market price of exports

gles(c)

eles(c)

qent(c)

qinvbar(c)

rhoq(c)    armington function exponent

rhot(c)    cet function exponent

shryh(h,f)

shry(ins,f)

te(c)      export duty rates
```

theta(a,c)

tm(c)   tariff rates on imports

ta(a)   activity tax rate

tq(c)   sale tax rate

ty(h)   income tax rate

tyent

tr(ins,insp)

trr(f)

trf(f)

sh(h)

sigc(c)

sigt(c)

iva(a)

trcent

trcgovern

trentytax

tritaxgovern

trytaxgovern

*scalars

eg0

er0   real exchange rate /1/

yg0   government revenue

yent0

eent0

gdtot0   total volume of government consumption

entdtot0

hsav0   total household savings

gsav0   government savings

entsav0 ent saving

fsav0   foreign savings

iadj0   /1/

ocap0

gdp0

ggdp0

*initial variables as parameter

mps0(h)

pa0(a)   price of activity a

pd0(c)   domestic prices

pm0(c)   domestic price of imports

pe0(c)   domestic price of exports

pq0(c)   price of composite goods

pva0(a)   value added price by sector

px0(c)   average output price by sector

qa0(a)   level of activity a

qva0(a)

qd0(c)   domestic sales

qe0(c)   exports by sector

qm0(c)   imports

qq0(c)   composite goods supply

qx0(c)   domestic output by sector

qf0(f,a)   quantity demanded of factor f from activity a

qfs0(f)   labor supply by labor category (1000 persons)

```
        qh0(c,h)    final demand for private consumption
        qint0(c,a)  intermediates uses
        qinv0(c)     final demand for productive investment
        wf0(f)      average wage rate by labor category
        wdist0(f,a)
        yf0(h,f)   transfer of income to household from factor f
        yh0(h)
        yfe0(f)   transfer of income to ins from fator parameters
       ;
*================*Data, initial values, and calibration=========================
*sam 90
table sam(*,*)


parameter
tdiff(ac) column minus row total for accout ac;
sam("total",acntp)=sum(acnt,sam(acnt,acntp));
sam(acnt,"total")=sum(acntp,sam(acnt,acntp));
tdiff(acnt)=sam("total", acnt)-sam(acnt,"total");
trcent=sam("ent","capital");
trcgovern=sam("govern","capital");
trentytax= sam("ytax","ent");
trytaxgovern=sam("govern","ytax");
tritaxgovern=sam("govern","itax");
display sam, tdiff, trcgovern;
*labor related parameters
table zz(*,a)
```

	agricult	industry	services	health
labor	4310219	6905575	10067779	54589

;

==================== Declaration of model variables =======================

Variables

er

yg government revenue

yent

gdtot total volume of government consumption

entdtot

hsav total household savings

gsav government savings

entsav

fsav foreign savings

iadj

ocap

mps(h)

pa(a)

pd(c)

pm(c)

pe(c)

pq(c)

pva(a)

px(c)

qa(a)

qd(c)

```
        qe(c)
        qm(c)
        qq(c)
        qx(c)
        qf(f,a)
        qfs(f)
        qh(c,h)
        qint(c,a)
        qinv(c)
        walras
        omega
        wf(f)
        wdist(f,a)
        yf(h,f)
        yh(h)
        ;

*=======================Declaration of model equations==========================
        equations
        pmdef(c)        definition of domestic import prices
        pedef(c)        definition of domestic export prices
        absorption(c)   value of domestic sales
        sales(c)        value of domestic output
        padef(a)
        pvadef(a)       definition of activity prices
        prodef(a)       production function
```

```
profitmax(f,a)   first order condition for profit maximum

intdem(c,a)

activitydef(c)   production and supply relation

armington(c)     composite good aggregation function

costmin(c)       f.o.c. for cost minimization of composite good

cet(c)           cet function

esupply(c)       export supply


qinveq(c)        inventory investment

yfheq(h,f)

yheq(h)          private gdp

cdeq(c,h)        private consumption behavior

grev             government revenue

entrev

hsaveq

gsaveq

entsaveq

lmequil(f)       factor market equilibrium

iseq

equil(c)         goods market equilibrium

caeq             current account balance (bill dollars)

pnorm            price normalization

obj

;
*===================Specification of model equations =====================

pmdef(c)$cm(c)..      pm(c) =e= pwm(c)*er*(1 + tm(c)) ;
```

```
pedef(c)$ce(c)..      pe(c) =e= pwe(c)*(1 + te(c))*er ;

absorption(c)..   pq(c)*qq(c) =e= (pd(c)*qd(c) + (pm(c)*qm(c))$cm(c))*(1+tq(c)) ;

sales(c)..        px(c)*qx(c) =e= pd(c)*qd(c) + (pe(c)*qe(c))$ce(c) ;

padef(a)..        pa(a) =e= sum(c, px(c)*theta(a,c));

pvadef(a)..       pva(a) =e= pa(a)*(1-ta(a))- sum(c, ica(c,a)*pq(c)) ;

prodef(a)..       qa(a) =e= ad(a)*prod(f, abs(qf(f,a))**alpha(f,a)) ;

profitmax(f,a)..  wf(f)*wdist(f,a)*qf(f,a) =e= qa(a)*pva(a)*alpha(f,a) ;

intdem(c,a)..     qint(c,a)=e=ica(c,a)*qa(a);

activitydef(c)..   qx(c) =e=sum(a, theta(a,c)*qa(a)) ;

armington(c)$cm(c)..   qq(c) =e= aq(c)*(deltaq(c)*(abs(qm(c)$cm(c)))**(-rhoq(c)) +

        (1-deltaq(c))*abs(qd(c))**(-rhoq(c)))**(-1/rhoq(c)) ;

costmin(c)$cm(c)..     abs(qm(c)$cm(c))/qd(c) =e= abs((pd(c)/pm(c))*(deltaq(c)/(1-
deltaq(c))))**(1/(1 + rhoq(c)));

cet(c)$ce(c)..        qx(c) =e= at(c)*( deltat(c)*abs(qe(c)$ce(c))**rhot(c) +

        ( 1-deltat(c))*abs(qd(c))**rhot(c) )**(1/rhot(c)) ;

esupply(c)$ce(c)..     (qe(c)$ce(c))/qd(c) =e= abs(pe(c)/pd(c)*(1 - deltat(c))/deltat(c) )

                       **(1/(rhot(c)-1) ) ;

qinveq(c)..       qinv(c) =e= qinvbar(c)*iadj ;

yfheq(h,f)..      yf(h,f) =e= shryh(h,f)*(sum(a,wf(f)*wdist(f,a)*qf(f,a))+trr(f)*er);

yheq(h)..         yh(h)=e= sum(f, yf(h,f))+sum(insd,tr(h,insd))+tr(h,"row")*er ;

cdeq(c,h)..       qh(c,h) =e= (beta(c,h)*(1-mps(h))*yh(h)*(1-ty(h))*(1-sh(h)))/ pq(c) ;

grev..          yg =e=
sum(h,ty(h)*yh(h))+tyent*yent0+sum(c,tq(c)*(pd(c)*qd(c)+(pm(c)*qm(c))$cm(c)))+sum(a,pa(a)
*qa(a)*ta(a))+sum(c$cm(c),tm(c)*pwm(c)*er*qm(c))+
sum(c$ce(c),te(c)*pwe(c)*er*qe(c))+tr("govern","row")*er+tr("govern","govern")+trcgovern ;

entrev..          yent =e=
sum(f,shry("ent",f)*(sum(a,wf(f)*wdist(f,a)*qf(f,a))+trr(f)*er))+sum(insd, tr("ent",insd)) ;

hsaveq..          hsav=e=sum(h,mps(h)*(1-ty(h))*(1-sh(h))*yh(h));
```

```
    gsaveq..       gsav=e= yg-(sum(c,pq(c)*gles(c)*gdtot)+
sum(insd,tr(insd,"govern"))+tr("row","govern")*er);

    entsaveq..      entsav =e= yent- (sum(c, pq(c)*eles(c)*entdtot)+sum(ins,tr(ins,"ent"))+
trentytax) ;

   lmequil(f)..    sum(a,qf(f,a))=e=qfs(f);

    equil(c)..      qq(c) =e= sum(a,qint(c,a))+ sum(h,qh(c,h))+ pq(c)*gles(c)*gdtot+
pq(c)*eles(c)*entdtot+ qinv(c);

    caeq..          sum(c$cm(c), pwm(c)*qm(c))+sum(f,trf(f))+sum(ins,tr("row",ins))+ocap =e=
sum(c$ce(c), pwe(c)*qe(c))+sum(f,trr(f))+sum(ins,tr(ins,"row"))+fsav;

    iseq..          sum(c,qinv(c)*pq(c))+ocap+walras =e= hsav+gsav+entsav+fsav*er ;

    pnorm..         sum(c,pq(c)*cwts(c))=e=cpi ;

    obj..           omega=e=1;

*     obj..         omega =e= prod(c,sum(h,abs(qh(c,h))**beta(c,h))) ;

*===================Model definition==================================

** The above set of equations augmented with closure equations and

* the numeraire constitute the model in GAMS-code and this model is

* called CGE_Model1 in NLP (CNS)format and CGE_Model1_MCP in MCP format

*Model CGE_Model1 /all/;

model cgemodel1 /all/;

* End of GAMS code
```