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Desertification and Its Economic Impact on Food Security in the Arabian Peninsula

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ABSTRACT

Desertification is the process of degradation of agricultural lands and turning them into dry, uncultivable deserts due to factors such as climate change, incorrect settlement, removal of vegetation, and others. Desertification negatively affects food security in several ways: deterioration agricultural area, lack of water resources, and increased hunger and social instability. In order to combat desertification and protect food security, measures must be taken to reduce the increase in desertification and improve the management of water resources. This includes implementing sustainable irrigation techniques, conserving biodiversity and encouraging sustainable agricultural practices. It also requires international cooperation to combat climate change and implement policies aimed at reducing greenhouse gas emissions and enhancing the sustainability of agriculture in areas vulnerable to desertification. Solving the problem of desertification requires joint efforts from governments, the international community, farmers, and non-governmental organizations so as to ensure food security for affected communities.

1. Introduction

Desertification is a geographical area characterized by scarcity of water and lack of green plants. It occurs as a result of low rainfall and high-speed evaporation of water, which leads to soil deterioration and low moisture. Furthermore, it appears in different areas around the world, including the Arabian Peninsula, North Africa, and parts of Asia and North America.

Above all, desertification occurs as a result of several environmental and human factors. Concerning the environmental factors, they include lack of rainfall, strong winds that contribute to faster water evaporation, and climate change. As for the human factors, human interactions can play a role in exacerbating desertification, such as cultivating land in inappropriate ways, sustainable, deforestation, natural vegetation, and excessive groundwater extraction.

However, desertification has many negative impacts on the environment and human life. That is, it may lead to the loss of biodiversity and the degradation of natural resources, and thus the

ability of lands to support agriculture and provide food for the population decreases. It also affects the social and economic life of local communities, as it forces people to leave their areas and search for other resources for living.

In fact, desertification is an important environmental challenge that requires joint efforts to address it. Strategies used to combat desertification include agricultural improvement and effective water management, encouraging the cultivation of drought-resistant plants, and applying afforestation and environmental education techniques. Governments and communities can also cooperate in implementing programs to resettle affected populations and provide alternative job opportunities for those affected by desertification.

Food security in the Arabian Peninsula depends on several factors, including rain and water resources, as well as agricultural technology and the economy. Many countries in the region depend on food imports, but there are ongoing efforts to enhance local production and diversity of food sources. Food security is an important issue in the region, and achieving it requires international cooperation, as well as continuous efforts to improve agricultural infrastructure and enhance environmental sustainability.

Desertification is the process of soil and ecosystem degradation in arid and semi-arid areas due to climate change and unsustainable human activities. It can lead to loss of biodiversity, degradation of agricultural land, decline in water resources, increased food shortages and threats for food security.

Desertification poses a major threat to food security for the following reasons:

- **Loss of fertile soil:** Desertification leads to soil degradation and loss of the fertile upper layer. The composition of the soil and its ability to contain the water and nutrients necessary for plant growth decrease. This reduces the productivity of farmland and leads to crop and food shortages.
- **Water shortage:** Desertification results in a shortage of water available for agriculture. Climate change and soil degradation are causing a decline in ground and surface water resources. Thus, that reduces the possibility of agricultural irrigation and increases the cultivated areas, and accordingly affects crop productivity and causes food shortages.
- **Decline in biodiversity:** Desertification leads to the loss of biodiversity in affected areas. It reduces the availability of native plants and animals important for human nutrition. Consequently, it reduces crop diversity and available food resources, putting food security at risk.
- **Population migration and deterioration of rural life:** Desertification leads to the migration of populations from affected areas due to lack of job opportunities and lack of physical resources. People resort to migrating to urban areas in search of better opportunities, affecting rural life and the ability to develop agriculture and secure food.
- **Import dependence:** In areas affected by desertification, local crop shortages can lead to increased dependence on imports to meet food needs. Countries depend on food imports from abroad, which exposes them to food dependency and economic dependency.

In general, desertification leads to a decrease in available food resources and a deterioration in the ability to produce food in the affected areas. This puts food security at risk, as it becomes difficult to meet the population's needs adequately and sustainably.

2. The Study Area

The Arabian Peninsula is located in the southwestern part of the continent of Asia. It includes several countries: Saudi Arabia, Yemen, Oman, the Emirates, Qatar, Bahrain, and Kuwait. It is bordered to the north by Iraq and Jordan, to the west by the Gulf of Aqaba and the Red Sea, to the east by the Arabian Gulf, and to the south by the Arabian Sea (Figure 1). The study area occupies a large area of southwest Asia, reaching about 3 million km^2, which constitutes about 6.7% of the total area of the continent. Thus, the study area comes in third place after China and India in terms of area (https://ar.wikipedia.org/wiki).

According to World Bank estimates, the population of the Arabian Peninsula was about 71.2 million people in 2010, and it rose to 91.2 million people in 2022. The Kingdom of Saudi Arabia is the largest country in the Arabian Peninsula with a population of 36.2 million people, and the Kingdom of Bahrain comes in last place with a population of 1.4 million people.

Source: https://www.soyoul.com/%D8%B4%D8%A8%D9

Figure 1. Administrative Borders of the Arabian Peninsula

3. Objective of the Study

The study, first and foremost, aims to identify the phenomenon of desertification and the sectors that are most affected by it, namely the agricultural sector. Besides, it identifies the development of the size of areas cultivated with important grain crops (wheat, corn, barley, and others), degraded lands, and the size of the food gap. It also aims to educate people about the seriousness of this environmental problem resulting from human disturbance of the environmental balance, as well as highlighting the importance of preserving resources while exploiting them.

4. Research Methodology

The appropriate approach for this study is the descriptive and analytical approach, which relies on collecting data and information that helps to accurately describe the problem and analyze it to reach accurate results. The historical approach is also to be followed to study the various stages of development of the topics covered by the study because of their importance in explaining the role of desertification in food security.

5. The Concept and Factors Leading to the Occurrence of the Phenomenon of Desertification

5.1. The Concept of Desertification

The Frenchman "Aubréville" is considered the first to approach scientifically the term "desertification" in 1949 when he described the phenomenon of the spread of degraded lands in southern Tunisia near the Sahara Desert by regenerating deserts. The text of the translation of his research is published in French as stated in the English language references: These Are Real Deserts That Are Being Today. He added that continued deterioration leads to the continued generation of deserts (Tahoun, 2012).

It is also a complete or partial deterioration of the elements of ecosystems that results in a decline in the productive capacity of their lands and their transformation into areas similar to desert areas. This is due to excessive exploitation of their resources and poor management methods applied by humans, in addition to the negative impacts of other unsuitable environmental factors, particularly climatic conditions such as high temperatures, lack of rain, winds, soil salinity, and others.

Desertification is the decline or deterioration of the biological productive capacity of the land due to the pressures of its use, which may ultimately lead to the creation of semi-desert conditions. It is one of the common aspects of the deterioration to which ecosystems are exposed. Desertification is a self-accelerating process, as if it feeds itself, and with its development the costs of reclamation increase dramatically. When drought becomes severe in areas prone to desertification due to misuse of land, they are connected to each other to include all extended areas (United Nations, 1978).

5.2. Factors Leading to the Phenomenon of Desertification in the Arabian Peninsula

Desertification is considered a complex and intertwined problem that is caused by a group of factors that vary between human factors on the one hand and physical factors on the other hand. The following are some of the main factors that

contribute to the occurrence of the phenomenon of desertification (Jahan, 2013):

- **Water shortage:** Water shortage is considered one of the most important factors that lead to desertification, as most of the Arabian Peninsula is located in a dry desert area that is poor in water resources. Statistics indicate an increase in the demand for water in the Arabian Peninsula from 6 billion cubic meters in 1980 to more, and from 26 billion cubic meters in 2010, which led to a water deficit amounting to about 20 billion cubic meters (Aliyan, 2014).
- **Climate changes:** Desertification areas are affected by climate changes, such as increased temperatures and weather fluctuations. These changes affect the distribution of rain and plant growth, which increases the possibility of desertification occurring. The temperature in the UAE reaches 45 degrees Celsius with an average of 30 degrees Celsius in summer. In winter, the average temperature is 20 degrees Celsius, and some rain falls in winter, ranging from 60-110 mm per year, while the evaporation rate is very high, reaching about 2980-4050 mm per year. The humidity rate varies from one month to another, as it is about 79% from May to September and decreases from October to May to about 54% (Balbaa & Nassim, 1998).
- **Wind**: Strong winds play a role in transporting sand and dust and their accumulation in certain areas, which contributes to soil degradation and increased aridity. Wind processes are active in the southern Mesopotamian plain, and are manifested in frequent sandstorms and dust storms. Two types of dusty weather are recognized in Kuwait. The first is the result of dust storms that originate in southern Iraq and flow towards Kuwait through northwesterly movement. The second usually occurs in calm and very hot weather when thermal instability of air masses near the ground leads to a rise in small dust particles into the atmosphere. Desertification in Kuwait is recognized by the significant deterioration of natural vegetation, the increase in mobile sand activities such as the development of the new Barshan dunes, and the change of immobile sand sheets into mobile ones. The average sand creep rate in Kuwait was calculated with 14 m^3/m^3/year. Overgrazing, sand and gravel extraction, off-road traffic, and application of inappropriate measures to control quicksand are the main causes of desertification in Kuwait (Khalaf, 1989).
- **Human activities:** Human activities contribute significantly to desertification. Among these activities are unsustainable agricultural destruction and the use of inefficient irrigation methods, leading to groundwater depletion and soil degradation. Encroachments on forests and other ecosystems also contribute to the worsening phenomenon of desertification.
- **Increased population growth:** Increased population and urban growth in arid regions lead to increased demand for natural resources and agricultural land. This results in unsustainable exploitation of resources, which leads to land degradation and increased desertification. The size of the population in the Arabian Peninsula will reach between 106 and 129 million people in 2030, and it was about 44 million people in 2000. This means that there is a necessity for providing the increasing needs for water for domestic uses, urban life, drinking, and food (Al-Ashram, 2012).

These are some of the main factors that contribute to the phenomenon of desertification, and emphasis must be placed on sustainable development and taking measures to reduce these factors and preserve arid lands and natural environments.

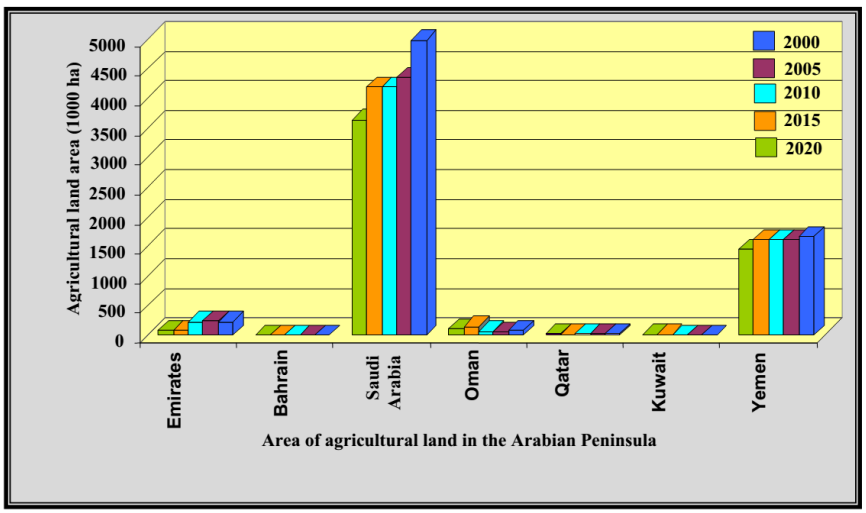
6. Development of Agricultural Land Area

Table 1 and Figure 2 show the development of the area of agricultural land in the Arabian Peninsula during the period from 2000 to 2020.

Table 1. Development of the Area of Agricultural Land in the Arabian Peninsula (1000 hectares) during the Period from 2000 to 2020

Years / Country	2000	2005	2010	2015	2020
Emirates	232.64	247.83	233.51	77.25	89.8
Bahrain	5.42	4.69	4.34	4.34	4.1
Saudi Arabia	4987	4357	4192	4192	3637.4
Oman	76.39	63.61	71.7	154.53	107.93
Qatar	22.6	27.1	29.2	14.4	24
Kuwait	5.12	8.81	10.14	15.94	14
Yemen	1668.4	1609.4	1609.5	1609.5	1452
Total	6998	6318	6150	6068	5329

Source: Arab Organization for Agricultural Development, Annual Book of Agricultural Statistics, various issues.



Source: The researcher's work based on Table 1.

Figure 2. Area of agricultural land in the Arabian Peninsula

Table 1 and Figure 2 show that the largest countries in terms of agricultural land area in the Arabian Peninsula are Saudi Arabia, the Emirates, Yemen, and Oman; and the least countries in terms of agricultural land area are Qatar, Bahrain, and Kuwait. The total area of agricultural land in the Arabian Peninsula was 6998 hectares in 2000, and the area decreased to 6150 hectares in 2010, at a rate of 87.8% over the year 2000, and the decrease reached 5,329 hectares in 2020, at a rate of 76.1% over the year 2000.

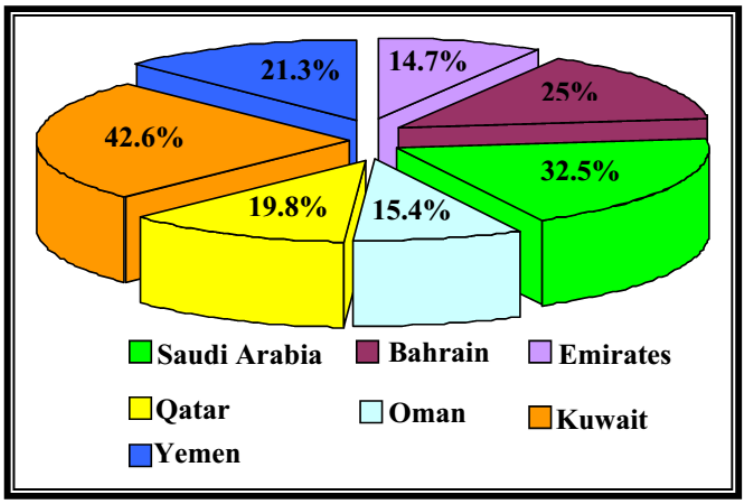
6.1. Development of Degraded Areas

Table 2 and Figure 3 show the geographical area of the country, the area of degraded lands, the percentage of the total area of the Arabian Peninsula, and the percentage of the geographical area of the country.

Table 2. Area of Degraded Lands (million hectares) and Percentage of the Country's Area during the Period from 2000 to 2017

Years / Country	Total area (million hectares)	Degraded area (million hectares)	Percentage of the general total(%)	Percentage of the total area of the country (%)
Emirates	8.36	1.23	0.4	14.7
Bahrain	0.08	0.02	0.006	25
Saudi Arabia	215	70.05	22.6	32.5
Oman	30.95	4.79	1.5	15.4
Qatar	1.16	0.23	0.07	19.8
Kuwait	1.78	0.76	0.25	42.6
Yemen	52.8	11.28	3.6	21.3
Total	310.13	88.36	28.5	28.5

Source:
- Arab Center for Studies of Dry Zones and Arid Lands, Kuwait, 2018, p. 61.
- Arab Organization for Agricultural Development, Arab Agricultural Statistics Yearbook, 2023.



Source: The researcher's work based on Table 2.

Figure 3. Percentage of degraded land area out of the total area of the country%

It is clear from Table 2 and Figure 3 that an area of 88.36 million hectares is subject to deterioration at a rate equivalent to 28.5% of the total area of the Arabian Peninsula. This area is concentrated in Saudi Arabia with an area of 70.05 million hectares and a rate of 22.6% of the total area of the Arabian Peninsula. Then comes Yemen is in second place with an area of 11.28 million hectares and a percentage of 3.6% of the total area of the study area, while Kuwait ranks first in terms of deteriorated area with a percentage of 42.7% of the total area of the country. It is followed by Saudi Arabia with a percentage of 32.6% of its total area. The last rank is occupied by the United Arab Emirates, with a percentage of 14.7% of the total area of the country.

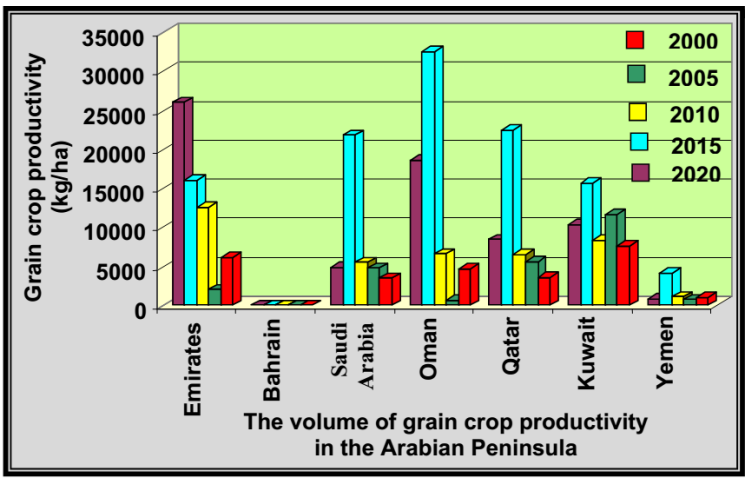
Monitoring land degradation through satellite images from 2000 to 2017 during the 17 years included in the archive showed that the human factor had a clear impact in accelerating the rate of land degradation as a result of its expansion of agricultural intensification and depletion of groundwater. The analysis showed that changes in vegetation cover are an indicator of degradation. Its area in the Arabian Peninsula is 88.36 million hectares, constituting about 28.5% of the total area.

6.2. Development of total grain crop productivity:

Table 3. Total Productivity of Cereal Crops in the Arabian Peninsula (kg/ha) during the period from 2000 to 2020

Years / Country	2000	2005	2010	2015	2020
Emirates	6166.67	2000	12549	16061.53	26022.8
Bahrain	0.00	0.00	0.00	0.00	0.00
Saudi Arabia	3466.1	4758	5497	21786.89	4860.39
Oman	4713.18	615	6581	32544.13	18624.14
Qatar	3517.86	5632	6512	22447.98	8425.23
Kuwait	7619.23	11630	8372	15664.9	10318.2
Yemen	1032.88	720	1092	4129.95	833.91
Total	26515.92	25355	40603	112635.38	69084.67

Source: Arab Organization for Agricultural Development, Annual Book of Agricultural Statistics, various issues.



Source: The researcher's work based on Table 3.

Figure 4. Total productivity of cereal crops in the Arabian Peninsula

Table 3 and Figure 4 show a variation in total grain productivity in the countries of the Arabian Peninsula. In 2000, Kuwait was the country with the highest productivity, amounting to 7619.23 kg/ha, followed by the UAE, with a total productivity of 6166.67 kg/ha. Bahrain lacks productivity due to the absence of cereal crops in all years of the study. In 2010, the UAE ranks first with a productivity of 12549 kg/ha, followed by Kuwait with a total productivity of cereal crops estimated at 8372 kg/ha. In 2020, the UAE maintains first place as the total productivity of cereal crops was 26022.80 kg/ha, and Oman ranked second with 18624.14 kg/ha. The total productivity of cereal crops in the Arabian Peninsula was 26515.92 kg/ha in 2000, and it rose to 40603 kg/ha and 112635.38 kg/ha in 2010 and 2015 respectively, by a rate of about 50% compared to the year 2015. Total productivity in the Arabian Peninsula decreased to 69084.67 kg/ha in 2020, by a rate of about 50%.

It is clear from the above that the decline in productivity for the group of grain crops in the Arabian Peninsula was due to the lack of sufficient investments in agricultural research and in the provision of agricultural technologies such as machines, fertilizers, control materials, and high-production varieties, as well as the lack of sound agricultural management. All of the previous factors contribute to increasing the food

gap that countries suffer from. The Arabian Peninsula.

7. The impact of desertification on food security

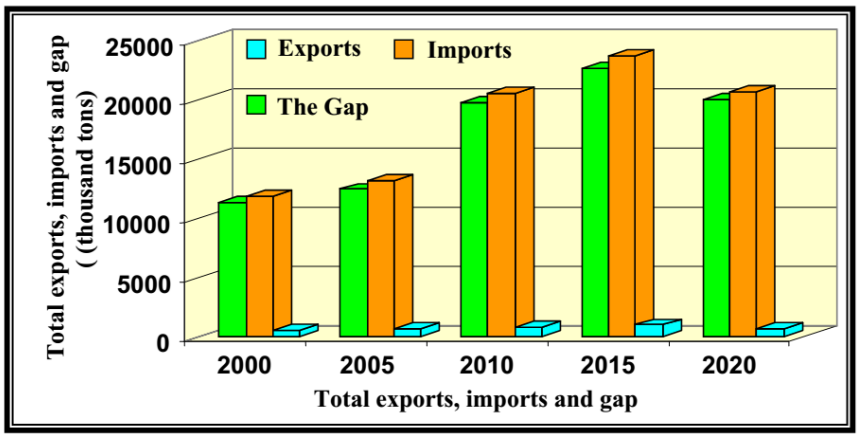
Desertification directly affects food security through the deterioration of vegetation cover and the scarcity and decline of agricultural area and food crops, thus reducing the volume of exports and increasing the volume of imports.

7.1. Development of the volume of grain exports and imports and the food gap.

Table 4. Evolution of the Volume of Exports and Imports and the Food Gap of Grains in the Arabian Peninsula (1000 tons) during the Period from 2000 to 2020

Years / Country	2000		2005		2010		2015		2020	
	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS	EXPORTS	IMPORTS
Emirates	312.41	1183.23	465.28	1715.09	622.40	2776.28	585.39	2602.40	382.85	3485.94
Bahrain	6.23	126.09	3.34	98.90	0.35	134.43	2.33	206.39	16.70	286.42
Saudi Arabia	5.66	7096.65	62.77	8278.06	46.07	12079.21	16.77	13911	41.26	8623.13
Oman	147.57	474.17	129.01	483.32	78.09	684.68	211.56	1243.73	34.23	1368.00
Qatar	0.00	183.28	0.83	179.44	8.88	517.24	22.72	692.10	0.84	788.23
Kuwait	28.87	705.86	8.14	658	8.14	888.66	96.50	1108.25	116.71	1347.00
Yemen	24.19	2112.41	82.97	1780.95	47.57	3454.50	82.78	3871.23	48.25	4712.34
Total	524.93	11881.69	752.34	13193.76	811.5	20535	1018.05	23635.1	640.84	20611.06
The gap	11356.76		12441.42		19723.5		22617.05		19970.22	

Source: Arab Organization for Agricultural Development, Annual Book of Agricultural Statistics, various issues.



Source: The researcher's work based on Table 4.

Figure 5. Evolution of the Volume of Exports and Imports and the Food Gap from Cereal Crops in the Arabian Peninsula

Table 4 and Figure 5 show the following:

- **Exports**: Total grain exports in the countries of the Arabian Peninsula increased by 69.7% between 2000 and 2005, while they rose to 79.7% between 2010 and 2015, and total grain exports decreased to 640.84 thousand tons in 2020, at a rate of 62.9% from 2015.
- **Imports**: Total grain imports increased to 13,193.76 thousand tons, a rate of 90% over the year 2000. Total grain imports increased to 23,635.1 thousand tons in 2015, at a rate of 86.8% over the year 2010. The volume of total grains in the Arabian Peninsula decreased to 20,611.06 thousand tons. In 2020, at a rate of 87.2% compared to 2015.
- **The gap (deficit):** It means the disproportion between the quantities of food needed and the population, which leads the country to import food from abroad, or the food gap is defined as net imports of major food commodities.

The total deficit in the Arabian Peninsula was 11,356.76 tons in 2000, and it increased by 91.2% and 57.5% in 2005 and 2010, respectively, reaching about 50.2% and 56.8% in 2015 and

2020 respectively.

It is clear from the previous analysis that the fluctuations witnessed in the global agricultural commodity trade, especially grain crops, in recent years, include fluctuations in food prices and the degree of their availability, the tendency of some major exporting countries to ban their exports for fear of not being able to feed their people, the measures taken by the main producing countries in Confronting the Corona pandemic, as well as the effects of the Russian-Ukrainian war. All countries were affected by it, including the countries of the Arabian Peninsula as importing countries, which affects food security in the countries of the study area.

Cases of undernourishment and hunger are linked to many factors that affect nutritional conditions, such as high prices, natural disasters, and instability. In recent years, the phenomenon of hunger and undernourishment has increased due to instability, unsuitable natural conditions, the spread of drought waves, increased desertification, and vulnerability to international conflicts.

8. Findings and Recommendations:

8.1. Results

- The problem of desertification is a dynamic phenomenon that is subject to the influence of geographical and human factors.
- Man is primarily responsible for most cases of desertification in the study area, as a result of his mismanagement of soil and water, as well as the inappropriate use of the natural resources found in the Arabian Peninsula.
- Most of the lands of the study area fall within the desert and dry climate, which has a major impact on the spread of the phenomenon of desertification.
- Decreasing areas of land allocated for agriculture due to desertification factors.
- Decreased grain exports and increased imports, which led to an increase in the food gap in the Arabian Peninsula.
- The degraded agricultural areas in the Arabian Peninsula amounted to about 88.36 million hectares, representing 28.5% of the total area of the region.
- There is a close relationship between desertified areas and the decline in cultivated areas and their productivity. This has a negative impact on food security, and is evident from the size of the food gap in the study area.

8.2. Recommendations

- Providing and managing land resources in a scientific manner with the aim of increasing agricultural production to match the increase in population and not allowing them to deteriorate or desertify, and thus leave them out of agriculture.
- Providing different types and varieties of plants and crops in order to increase their productivity.
- The necessity of maintaining local food security and not being exposed to negative global influences.
- The necessity of cooperation with Arab countries in the fields of agricultural production and marketing.
- Providing complete and continuous coverage of degraded lands, which helps monitor urgent changes.
- The budget for spending on scientific research, innovation and biotechnology in the field of using genetic engineering to improve crop productivity must be increased.
- Scientific institutions capable of developing the agricultural and irrigation sectors must be built.
- Forming a global and national partnership in the field of climate change, adaptation to it, and agricultural production technologies.
- Food security must be considered an integral part and one of the most important requirements for the region’s national security.
- The necessity of planting plants or trees that are suitable for the conditions of dry areas.
- The need to benefit from remote sensing systems in monitoring desertification and agricultural lands through establishing a unified information network in all countries of the Arabian Peninsula, and preparing

integrated studies on these areas through cooperation among them.

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