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Knowledge extension study of the effects of climate change on sustainable development in Nineveh Governorate/Iraq

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Abstract

The study aims to shed light on the impacts of climate change in Nineveh Governorate, from an agricultural cognitive guidance perspective that links agricultural community awareness with sustainable development. Climate change poses an environmental, economic and social challenge that affects various sectors, especially agriculture, which is the main pillar of agricultural development in Nineveh Governorate. The study shows that the manifestations of climate change, including rising temperatures, lack of rainfall, increasing droughts, and deterioration of natural resources, lead to a decline in agricultural productivity and a decline in food security in addition to its impact on population migration and increasing pressures on infrastructure and services. The study included the causes of climate change, its types and effects, in addition to ways to confront the phenomenon of climate change.

On the other hand, the study highlights the importance of agricultural awareness and guidance in raising farmers' knowledge of adapting to these changes by adopting modern irrigation methods, rationalizing water consumption, diversifying crops, and conserving environmental resources. It also emphasizes the role of governmental and private institutions in developing sustainable strategies that enhance society's resilience to climate change.

Accordingly, the study concludes that sustainable development in Nineveh Governorate cannot be achieved without integrating the environmental and climate dimensions into development plans, and activating the role of agricultural knowledge guidance as a basic means of increasing awareness among agricultural communities of the dangers of climate change and ways to confront it.

Keywords: Nineveh Governorate, Iraq, sustainable development, governmental and private institutions

Introduction

The process of acquiring and generating knowledge expresses all the activities that the agricultural extension agent seeks in order to be able to obtain and acquire knowledge which comes as a result of carrying out a number of processes extending between serious research and creativity (Al-Joboury, 2023:9) ^[5], as the agricultural extension agent is considered a teacher and guide who lives among the farmers and works on expanding their knowledge to improve their ideas and aspirations which increases their capacities and skills and develops their abilities in agricultural work in general (Reda, 2009:341) ^[20]. Therefore, the relationship between agricultural extension and knowledge is a complementary relationship, as it is a means to transfer modern agricultural knowledge and skills to farmers, which contributes to developing their knowledge in the field of climate changes that have become of direct impact on them. In recent times countries and societies in all parts of the world have already witnessed escalating effects of climate change, including rising temperatures, drought, floods, shortages, severe and repeated natural disasters and rising sea level. The countries most exposed to climate change are the most affected among which is Iraq (Al-Qudsi, 2023:56) ^[7]. And Iraq is among the countries where the negative effects of climate changes appeared clearly, starting from the decline of water levels, the drop in the

percentage of rainfall and its types, and the rise in temperatures and long waves of drought, and the increase of desertification, and the shrinking of arable lands, to the migration of farmers from their areas to the urban centers (Jawhar and Amin, 2023:383) ^[14]. And as it was classified among the most fragile countries in the Middle East and North Africa region, the climate changes have had clear and tangible negative repercussions as we mentioned previously. Therefore, the problem of climate changes is considered one of the most dangerous issues and environmental challenges facing the world in general and the Arab region in particular, and the real danger of the problem lies in the destructive effects that this phenomenon has produced and will produce, and it is agreed upon in general that climate change is caused by human activity including industrial production, car exhausts and cutting trees (Ati and others, 2021:38) ^[11]. Therefore, the reality of sustainable development through the close relationship that links it with climate change, and this is due to the fact that the latter has become the main nerve of any economic renaissance, is generally affected by climate changes on the basis that the effectiveness of sustainable development programs is embodied within an environmental context that requires balance.

And because sustainable development is development that takes into account the environmental, human, and

developmental aspects, it emphasizes the symbiotic relation existing between protecting the environment and its rehabilitation on one hand and between development and poverty eradication on the other.

Where (Abdel Hamid, 2024:254) ^[1] indicated the effect of climate changes on economic and social activities and on achieving the Sustainable Development Goals 2030 in the Arab Republic of Egypt where the study comes within the broad global concern with issues of the effect of climate changes whether economically or socially on many main sectors that represent the basic tributaries of sustainable development. And also (Jawhar and Mohammed Amin, 2023:382) ^[14] mentioned climate change and its effect on achieving sustainable development in Iraq, that climate changes are among the most important natural problems facing the world at the present time.

Therefore agricultural extension plays a vital role in the life of the individual and the farmer through providing the necessary information and guidance to improve agricultural production and increase his income and improve his standard of living and preserve the available natural resources in the local areas and develop them, and that is through raising the awareness of farmers and teaching individuals the nature of these resources and preserving them with the least possible amount of damages and harm to the environment through guiding farmers about the nature of climate changes and what are its causes and its harms as well as what is sustainable development and what future goals it includes and thinking of the coming generations. And due to the accelerating effects of climate changes on society in the countryside and the city we deemed it necessary to conduct the study to clarify the effects of climate changes on sustainable development in Nineveh Governorate.

Concept of climate change

Defining the phenomenon of climate change requires first defining what is meant by the term climate, as researchers have agreed that climate is the average state of the atmosphere and is defined as: the main characteristics that distinguish the state of the atmosphere in a particular region, and that the science that studies, describes and analyzes the elements of climate and links them to a period that may be long or short is called climatology, which is: the means that studies and analyzes this phenomenon by finding a scientific explanation for its differences. Climate change means: It is a term for changes in the characteristics of the Earth's climate resulting from current increases in the percentage of gas concentrations generated by combustion processes in the atmosphere, which occur as a result of human activities that raise the temperature of the atmosphere. Climate change is known for its negative impacts on human health and the environment, such as increased reproduction of infectious insects, rising sea levels, floods, droughts, and depletion of water resources. Muhammad also defines it as climate change that is directly or indirectly attributed to human activity that changes the chemical composition of the atmosphere at the global level and which is in addition to the variability in natural climate observed over similar time periods.

Causes of climate change

Over millions of years, the phenomenon of climate change

formed a natural issue to which various ecological systems adapted; however, with human development over time, it carried many negative effects resulting from global warming and rising Earth's temperature due to gas leaks. This phenomenon has drawn scientists' attention to investigate and study its causes and factors, concluding that there are two types of factors and causes, represented as natural factors and human factors, which we will clarify in light of the following points.

First: Natural causes

Scientists confirmed that natural factors play a significant role in climate change, particularly solar activity. Among these factors are:

- Volcanic eruptions, which are a source of greenhouse gases in enormous quantities (volcanoes in Iceland and Chile).
- Dust storms in arid and semi-arid regions suffering from vegetation degradation, low agriculture, and rainfall (World Islamic Charitable Organization, 2023:9).
- Sunspot phenomenon, occurring approximately every 11 years due to disruption of the sun's magnetic field, increasing the thermal energy of emitted radiation.
- Cosmic rays resulting from the explosion of some stars, striking the Earth's upper atmosphere and forming radioactive carbon
- Tectonic processes (Continental Drift Theory) (Jawhar & Amin, 2023:386) ^[14].
- Dust storms in arid and semi-arid regions suffering from vegetation degradation, low agriculture, and rainfall; examples include Al-Khamasin winds, which raise suspended dust in the air (Ibrahim, 2021:229) ^[12].

Second: Human causes

- Climate change occurred due to accumulated human activity, misuse of available resources, increasing energy consumption patterns, and greenhouse gas emissions from various sectors such as agriculture, transport, industry, electricity, and other sectors (Saleh, 2024:21) ^[21].
- Changes in atmospheric components by increasing the concentration of certain gases (greenhouse gases) causing global warming.
- Changes in the Earth's surface, exacerbating desertification due to vegetation removal, urbanization, and agricultural land destruction; all this affects the albedo coefficient and the distribution of energy on Earth, as solar radiation distribution is linked to changes in the albedo rate (Albedo), which is the rate of solar radiation reflected from materials to space; human practices like urbanization and deforestation change the albedo, affecting energy distribution on Earth, thus influencing the Earth's climate. Desertification, for example, alters climatic characteristics of the affected area and may extend its impact to larger regions, affecting regional climate.
- Increased concentration of particles in the air from human activities related to fuel burning in construction, desertification, fires, and industry, reducing solar radiation and thus lowering temperature.
- Human activities that affect climate include

communications technologies used to alter the physical properties of the upper atmosphere in the ionosphere; these projects are carried out by major countries to improve communications for civilian and defensive purposes, where devices emit high-energy waves with high frequency, changing ions (21), (Al-Saadi, 2015:373) ^[8].

Types of climate change

Climate changes are divided according to their nature and source into two main types:

Regular climatic variations

These are changes that occur in the atmosphere periodically; their magnitude and timing can be determined, such as changes in atmospheric temperature, where temperature has a daily maximum during the day and minimum at night, *i.e.*, there is a daily temperature variation during summer and a decrease in winter, *i.e.*, there is a seasonal temperature variation whose value and timing can be determined, but the causes remain uncertain, such as the semi-daily variation in atmospheric pressure lasting approximately two years.

Irregular climatic variations

These are changes in the atmosphere whose magnitude and timing are difficult to determine, such as higher or lower temperatures in summer or winter for a period, then returning to normal

This type can be divided into two

A) Naturally irregular changes

These are natural changes varying in temporal regularity; among natural oscillations affecting climate, astronomer Milutin Milankovitch (1879-1958) determined their effect based on Earth-Sun relationships as follows:

- Change in Earth's orbital shape around the Sun.
- Oscillation of Earth's axis relative to Earth's orbit around the Sun.
- Tilt of Earth's rotation axis around the Sun.
- Movement of Earth's axis

B) Unnaturally irregular changes

These are changes resulting from human activity; if such irregular changes persist for over a century and across large areas covering at least half of Earth's surface, and can be distinguished from natural changes, they can be classified as climate changes (Al-Waili, 11:2023) ^[10].

Impacts of Climate Change

According to the Intergovernmental Panel on Climate Change report (IPCC) issued in August 2021, many observed climate changes are unprecedented over hundreds of thousands of years, and some recorded changes cannot be stopped, such as the continuous rise of sea levels. The report predicts that climate changes in the coming decades will increase in all regions; global warming of 1.5 °C will lead to more heat waves, longer warm seasons, and shorter cold seasons. At 2 °C warming, maximum temperatures will often reach critical levels for agriculture and health. However, climate change is not just about rising temperatures; it leads to multiple changes varying by region and worsening with rising temperatures, including changes

in humidity, drought, wind, snow and ice, coastal areas, and oceans. Examples identified by the UN Climate Action Programmed include:

- **Rising temperatures:** (*e.g.*, African countries) with higher greenhouse gas concentrations, surface temperatures rise; 2011-2020 was the warmest decade, with each decade since the 1980s warmer than the previous; nearly all land regions experience more hot days and heat waves, increasing heat-related illnesses, making outdoor work harder, and causing wildfires.
- **Severe storms and floods:** (Bangladesh, Pakistan) destructive storms have become more intense and frequent; higher temperatures cause more evaporation, worsening heavy rainfall and floods, often destroying homes and communities, causing fatalities and economic losses.
- **Increased drought:** Climate change alters water availability, making it scarcer in more regions; global warming worsens water shortages in water-poor areas, increasing agricultural drought risks, affecting crops, weakening ecosystems, and causing destructive sandstorms and expanding deserts, reducing arable land, putting populations at risk of irregular water supply (droughts in Somalia, Kenya).
- **Rising ocean temperatures:** Oceans absorb most heat from global warming; ocean temperature rise in the past two decades has increased volume, and melting ice sheets raise sea levels, threatening coastal and island communities; oceans also absorb CO₂, preventing its release into the atmosphere; higher CO₂ levels make oceans more acidic, endangering marine life and coral reefs.
- **Threat of species extinction:** Climate change threatens land and ocean species; higher temperatures exacerbate species loss; species are currently being lost at a rate 1000 times higher than any time in human history; a million species are at risk in coming decades (*e.g.*, polar bear, gorilla, giant panda); wildfires, extreme weather, invasive pests, and diseases are additional threats; some species may survive, others may not (Global Center for Philanthropy Studies, 2023:13-14) ^[13].
- **Food security threats:** Climate threats are major causes of food insecurity and system collapse, including crop diseases, forest fires, wild plant death, impact on evergreen trees, and reduced agricultural productivity due to insufficient water.
- **Water security threats:** Freshwater sources are affected by warming and climate change, threatening water security.
- **Thermal impacts on human health: First:** Increase in cardiovascular and respiratory diseases due to higher effort resisting temperature changes.

Second: Increase in pathogenic viruses

Third: Induction of genetic mutations in viruses, creating resistance to current prevention and control measures (Khalaf, 2022:9) ^[16].

Agriculture both affects and is affected by climate change; no sector is more climate-sensitive than agriculture. Agricultural and food production in developing countries is negatively impacted, especially in regions already exposed to climate variability with low income, high hunger, and

poverty; adapting agriculture to climate change is costly but essential for food security, poverty alleviation, and ecosystem services; reducing and eliminating agricultural greenhouse gas emissions is also necessary (Kawthar & Wahiba, 2022:11) ^[15].

Methods to address climate change

Mitigation

Human intervention to reduce greenhouse gas sources or enhance sinks and mitigate alongside adaptation, contributing to the goal expressed in Article 2 of the UNFCCC: stabilizing greenhouse gas concentrations in the atmosphere at a level preventing dangerous human interference with the climate system. This level should be reached in a timeframe allowing ecosystems to naturally adapt, ensuring food production is not at risk and supporting sustainable economic development.

Adaptation

Responding to climate changes and living with them, such as developing crop varieties tolerant to salinity and high temperatures, optimal use of water resources via rationing and consumption policies. Broad adaptation is needed to reduce climate risk exposure; barriers, limits, and costs remain not fully understood. Adaptation is key to avoiding climate change impacts on food production, requiring significant investments by farmers, governments, scientists, and development organizations. Investment priorities are determined based on the most vulnerable to climate risks, though attention to agricultural climate risks is still limited.

Concept of sustainable development

The term sustainable development is widely used in economic, social, and political circles, but its adoption and implementation differ among contexts, as each analyzes the concept according to its framework (Al-Shammari *et al.*, 2017:44) ^[9]. Sustainable development is the use of natural resources while maintaining their continuity and preventing depletion (Al-Hiyali & Al-Mawla, 2024:23) ^[3]. Edward Barbier defines it as activities aiming to maximize social welfare while preserving natural resources and minimizing environmental harm. Kamel Raziq defines it as development considering environmental, human, and developmental aspects, emphasizing the link between environmental protection and poverty alleviation (Al-Taher, 2013:53) ^[22]. Sustainable development involves intergenerational and intragenerational justice, balancing economic, human, and environmental goals to preserve wealth components and ensure continuous income across generations (Al-Joboury, 19:2011) ^[6].

Primary objectives of sustainable development

- **Economic development goals:** Increase economic growth, GDP, national income, average income, standard of living, industrial-agricultural economic structure, infrastructure (electricity, drinking water, sewage, transport, storage, communications), and labor productivity, raising sector output (industry, agriculture) and national GDP.
- **Social development goals:** Address unemployment and poverty as critical issues leading to security, political, and social problems; provide employment, increase

production, develop healthcare and education, empowering individuals in economic and non-economic sectors.

- **Environmental development goals:** Achieve environmental cleanliness, positively affecting water, air, soil, expanding green economy, reducing desertification, and preserving material and biological resources (Al-Joboury, 2020:62-63) ^[4].

Dimensions of sustainable development

Sustainable development relies on multiple dimensions: environmental (protection), economic (growth), social (justice). Formula: Economic Growth + Environmental Protection = Sustainable Development. Some add technical and administrative dimensions to optimize energy and resource use.

- **Economic:** Continuity and maximization of economic welfare over time via access to food, housing, transport, health, and education.
- **Environmental:** Respect environmental limits; exceeding limits degrades ecosystems (Al-Shammari *et al.*, 2017:52) ^[9].
- **Social:** Meet basic needs of current and future generations, ensure decent living via healthcare, education, food, equality, justice, fair wealth distribution, fight poverty, provide employment and social security.

Elements of sustainable development

Sustainable development is based on different dimensions, the most important of which are the economic dimension, the environmental dimension, and the social dimension, and it is necessary to have elements within each dimension that define its characteristics. These elements are represented in the economic dimension through the provision of the main production elements, foremost among them stability, organization, knowledge, and capital; the environmental dimension, which depends on biodiversity represented by humans, plants, forests, animals, birds, fish, and others created by God on the surface of the earth, in the depths of the seas, or in the atmosphere; and finally, the social dimension, represented by good governance through the pattern of policies and regulations and the extent of partnership among the main sectors, namely the government, the private sector, and the civil society sector (Al-Salem, 32:2008) ^[2].

Development is based on four fundamental elements

- Productivity (human ability to produce).
- Equality (equal opportunity without discrimination).
- Sustainability (avoiding harm to future generations via resource depletion, pollution, public debt).
- Empowerment (development is by people, not just for them).

Sustainable development aims to develop economic and agricultural means that meet present needs while being long-term sustainable, especially as current environmental protection programs, requiring high costs, have become inefficient due to human activities causing environmental damage. This contradiction explains the urgent need for a new sustainable system requiring cultural, agricultural, and economic reforms (Muhammad *et al.*, 37:2015) ^[17].

Advantages and disadvantages of sustainable development

- **Advantages:** Material progress, improved living standards, technological advances reducing human hardship, global interconnection via information and communications.
- **Disadvantages:** Rapid advancement and material growth may create instability in satisfying needs (Al-Shammari *et al.*, 2017:55) ^[9].

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