

SUSTAINING WHEAT IN A CHANGING CLIMATE: POLICY RECOMMENDATIONS FOR EGYPT'S AGRICULTURAL SECTOR

Karem Rouby Islam¹; Rokaya Ragab Abdalla Ragab²

¹Universitas Islam Internasional Indonesia, Indonesia

²Pan African University, Institute of Water and Energy Sciences - PAUWES - Algeria

Email: islam.mohammed@uiii.ac.id

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Abstract:

This paper discussed the challenges facing the agricultural sector and food security in Egypt due to climate change, which are: desertification, sea level rise, and water resources, such as the resources of the Nile River, groundwater in the Nile Delta, groundwater reservoirs, in addition to rainfall. The researchers discussed the impact of all these factors on the wheat crop's agricultural area. The wheat crop is especially important to Egyptians, as they rely on bread, which is the main derivative of wheat. This paper also developed four solutions to confront the effects of climate change on wheat in Egypt, and the solutions represented in (1) Development of new wheat varieties that are more resistant to heat and drought, (2) Disseminate and improve sustainable wheat farming practices, (3) Generalizing the cultivation of the most productive wheat varieties, such as Misr 1 and 2 varieties, Sids12, and Giza 171, (4) Reducing the loss of the wheat crop in its various stages, starting from the harvest stage, through the transportation and storage stage, during the milling operations, and ending with distributing the final product to the consumer. The researchers evaluated the advantages and disadvantages of these solutions and chose the most appropriate and easiest to implement among them. The recommendations in this paper are designed to serve as a policy reference for agricultural sector decision-makers focused on climate change and sustainable food security.

Keywords: Policy Recommendations, Climate Change, Wheat, Agriculture, Sustainability

I. INTRODUCTION

The Egyptian Environmental Affairs Agency, affiliated with the Ministry of Environment, identified some key climate change risks facing Egypt in its report on the state of the environment. These risks are: (1) Increased sea level rise and its impacts on coastal areas. It is expected that sea level will rise by 100 centimeters by 2050 (WB & ADB, 2020)&(Ministry of Environment, 2023), which will lead to saltwater intrusion into groundwater, soil salinization, and deterioration of crop quality and productivity loss (Gamal et al., 2021). (2) Increased frequency of extreme weather events, such as dust storms, heat waves, floods, and decreasing rainfall (Wang et al., 2022)&(Ebi et al., 2020). (3) Increased desertification rates. (4)

Deterioration of agricultural production and food security (AbdelRahman, 2023). (5) Increased water scarcity rates, as the sensitivity of the Nile River sources to the effects of climate change has been monitored. Climate change will affect the rainfall pattern in the Nile basin and evaporation rates in watercourses, especially in wetlands (Fouad et al., 2023).

Recognizing Egypt's extreme vulnerability to climate change, international bodies like the UN and World Bank have raised concerns. The Nile Delta, pivotal to Egypt's economy and food security, faces potential inundation due to rising sea levels. Experts estimate a 50-centimeter rise could displace over 2 million people, flood 10,000 square kilometers of farmland, and inflict \$35 billion in damage to land, property, and infrastructure (Hala Abou-Ali, Amira Elayouty, 2023)&(McDonnell, 2022). Additionally, critical water storage facilities, like Lake Nasser, are at risk from increased evaporation and more frequent floods (Abd Ellah, 2020). Egypt is likely to face water shortages, declining agricultural production, and difficulties in cultivating certain crops (Hejazi et al., 2023). Agriculture, food, industry, and energy are all likely to suffer losses due to climate change, which underscores the severity of the threat facing Egypt.

The Challenges Facing the Agricultural Sector and Food security in Egypt Due to Climate Change:

1. **Desertification:** Egypt faces a dual threat: the alarming degradation of its agricultural lands and the creeping expansion of desertification. This complex phenomenon, characterized by "a decline in the productivity of cultivated land and the spread of barren desert-like areas", is driven by a confluence of factors, with climate change emerging as a primary culprit. Extensive research has established a clear bi-directional relationship between these forces; climate change exacerbates desertification through rising temperatures, altered precipitation patterns, and increased aridity, while the expansion of desertified areas further amplifies climate change through reduced carbon sequestration and albedo changes (IPCC, 2018). Egypt, as identified in the National Action Plan to Combat Desertification, is particularly vulnerable to this synergistic effect. The nation's arid climate and dependence on the Nile River make it acutely sensitive to fluctuations in water availability and temperature, leading to a decline in agricultural productivity and food security.
2. **Sea level rise:** Many studies have indicated that the rise in global temperatures, due to climate change, has led to serious threats such as sea level rise, which leads to the inundation of coastal areas in the world. A one-meter rise in sea level would inundate 12% of the agricultural land in the Nile Delta. The percentage would increase to 25% with a three-meter rise in sea level, and to 35% with a four-meter rise in sea level. This would lead to a change in the geographic distribution of agricultural lands, with a decrease in the area of agricultural land. In addition, coastal agricultural lands are exposed to degradation due to salinity and rising water levels, which can lead to the gradual loss of their productivity and their exit from the agricultural production cycle.

3. ***Climate change impacts on water resources in Egypt:*** Water is a precious resource that humanity needs to conserve. Egypt suffers from water scarcity and depends on more than 59% of the Nile River water for irrigation and other human activities. As temperatures rise, this will lead to increased evaporation and increased water consumption in all sectors, especially agriculture, which accounts for about 80% of total water resources. ***Nile River Resources:*** International studies point to several reasons for the potential decline in the Nile River's resources, including the decline in rainfall patterns in the Ethiopian highlands, which provide 85% of Egypt's Nile resources, and the equatorial highlands, which provide 15%. These studies suggest a potential decrease in the rate of water flow in the Nile River by about 20% by 2040. However, any decrease in the amount of water available will lead to disasters, because the current needs of the Nile Valley suffer from a deficit of 9 billion cubic meters. ***Groundwater in the Nile Delta:*** As long as the river's resources decrease, this decrease will affect the groundwater accumulated in the delta as a result of the river's infiltration. This decrease will occur at the same rate that the river's water decreases. ***Underground water reservoirs:*** The salinity of groundwater reservoirs in coastal aquifers increases as sea level rises. The infiltration of salinity under the soil leads to the pollution of groundwater sources in coastal areas and the deterioration of water quality. Surface reservoirs are also exposed to evaporation of their water, which comes out by capillary action due to severe drought. ***Rainwater:*** Coastal rainfall is decreasing due to the movement of rain belts northward. The depth of the northern rainy region does not exceed 50 kilometers to the south. The change in rainfall patterns will lead to a decrease in water in coastal areas.
4. ***Plant diseases and pests:*** Increased temperatures can affect the physiological functions of insect populations and disrupt their life cycle, leading to significant increases in their numbers. This can also lead to increased growth and reproduction of insect pests, weeds, fungi, and plant diseases. In many cases, this can lead to the spread of many diseases and pests, which can have a significant impact on agricultural production and productivity. It can also lead to increased growth of insects in irrigated areas and increased water requirements.

II. RESEARCH PROBLEM

While the world faces climate change, Egypt's future agricultural landscape is threatened by shrinking farmland and declining crop yields, leading to a potential decrease in overall food production. This coincides with a steadily growing population and its increasing demand for food, creating a potentially precarious situation. If food production cannot keep pace with population growth, the average amount of food available per person will inevitably shrink, jeopardizing Egypt's food security.

The wheat crop is one of the important grain crops in the Egyptian dietary pattern, and one of the crops that economic policy makers are interested in. It is grown in most governorates of Egypt, and the cultivated area represents one third of the area cultivated for grains (Yigezu *et al.*, 2021). Its products, especially bread, are considered the main component of the Egyptians' diet, as they contain mineral salts, starches, oils, phosphorus, and vitamins. Bread provides about 37% of

human needs for calories and about 45% of vegetable protein. Wheat straw is also used as animal feed (Nath *et al.*, 2023).

It is expected that climate changes will lead to a decrease in wheat productivity in Egypt by an average of 18% if the temperature rises by four degrees Celsius, and by a rate of 9% if the temperature rises by two degrees Celsius, and wheat water consumption is expected to increase by 2.5% with a temperature increase of two degrees Celsius (Mostafa *et al.*, 2021). The results of one study indicated a decrease in the total wheat production in Egypt during the period 2013-2019 as a result of the increase in temperature. An increase in the maximum temperature by 10% leads to a decrease in agricultural production by 27%. Pests and diseases also affect wheat productivity (iMMAP, 2022). The infection of wheat with yellow rust disease is a result of extreme fluctuations in temperature. Likewise, the rise in temperature will lead to the movement of winter grain production to the north, as these areas agree in temperature with the physiological needs for the crops to ripen, and this leads to changes in agro-ecological zones (Pequeno *et al.*, 2021). With the emergence of climate change problems represented by water shortages and rising sea levels, which leads to salinization of the lands of the northern Nile Delta, the area of agricultural lands will decrease in a way that negatively affects food security in Egypt (Omar *et al.*, 2021).

Even though Egypt has one of the highest per capita daily calorie intakes in the world—roughly 3,522,000 calories per person—roughly one-third of these calories and over 38% of daily protein intake are derived from wheat products alone. To meet this need, significant imports are needed to support local wheat production (Shi *et al.*, 2022). Egypt produces approximately 9 million metric tons of wheat yearly, but in order to meet the rising domestic demand, it imports an additional 12 to 13 million metric tons. Egypt now buys more wheat than any other country in the world, with \$5.2 billion spent on wheat imports alone (Abdalla *et al.*, 2023b).

Egypt's large wheat imports are a result of a supply-demand imbalance caused by population growth and limited agricultural land, water resources, and climate change. However, Egypt's per capita wheat consumption is unusually high, at more than twice the global average. In fact, Egypt's daily wheat consumption is estimated to be 1,153.830 calories per capita per day, which is more than twice the country's daily consumption of meat, seafood, eggs, milk, butter, and rice, estimated at 612,000 calories per capita per day (Abdelmageed *et al.*, 2019). This high level of wheat consumption is essential for meeting the nutritional needs of Egypt's population, which exceeds 100 million people. As a result, climate change-induced reductions in wheat yields could have a significant impact on Egypt's food security (Abdalla *et al.*, 2023a).

As climate change shrinks Egypt's wheat harvests, the country's reliance on cereal imports could spiral, jeopardizing both food security and national food sovereignty. This would worsen the situation Egypt faced in early 2023, when its dependence on foreign food left it vulnerable to global price shocks triggered by the Ukraine war. Rising temperatures, shifting seasons, shrinking farmland, and saltier soil due to climate change all threaten to disrupt domestic food

production, making Egypt even more dependent on unpredictable international markets and potentially leading to domestic food shortages (Mohiuddin, 2023).

Projections based on a high greenhouse gas emissions scenario suggest that agricultural production in Egypt will decline significantly by 2030 (The Egyptian Government, 2022). Wheat yields are expected to decrease by 10-12% (Gamal et al., 2021). Wheat is essential for food production and food security in Egypt. A decrease in wheat yields could lead to a shortage of food supplies in Egypt, which could lead to rising food prices, increased poverty, and hunger. It could also lead to disruptions in rural economies and livelihoods (Shehata et al., 2023).

III. RESULTS AND DISCUSSION (SOLUTIONS)

1) Development of new wheat varieties that are more resistant to heat and drought

Pros of this solution: Increase productivity and improve food security: Developing new wheat varieties that are more resistant to heat and drought can increase productivity, thus improving food security. Improve sustainability: Heat and drought-resistant wheat varieties can help improve agricultural sustainability by reducing the need for water and fertilizers. Addressing climate change: Heat- and drought-resistant wheat varieties can help address climate change by reducing the negative impact of climate change on wheat production. Reducing agricultural costs: Heat- and drought-resistant wheat varieties can help reduce agricultural costs by reducing the need for irrigation, the use of fertilizers, and agricultural chemicals. Improving wheat quality: Heat- and drought-resistant wheat varieties can help improve wheat quality by increasing its protein content and other nutrients.

Cons of this solution: High cost: The cost of developing new wheat varieties that are more resistant to heat and drought may be high, which may limit their accessibility. Health risks: Consuming genetically modified wheat can have health risks, due to insufficient evidence about its safety. Environmental risks: Heat- and drought-resistant wheat varieties may be associated with environmental risks, such as increased use of pesticides or resistance to pests.

2) Disseminate and improve sustainable wheat farming practices

Pros of this solution: Using drip irrigation instead of surface irrigation helps reduce water and fertilizer consumption and increases wheat productivity and sustainability. Using organic fertilizers instead of chemical fertilizers will contribute to improving soil fertility and enhancing wheat's resistance to pests and diseases, which will increase wheat productivity and sustainability.

Cons of this solution: The difficulty of developing sustainable agricultural practices that can be compatible with the traditional practices of ancient farmers, in addition to the difficulty of providing financial support and training to farmers to help adopt sustainable agricultural practices.

3) Generalizing the cultivation of the most productive wheat varieties, such as Misr 1 and 2 varieties, Sids12, and Giza 171

Pros of this solution: The most productive wheat varieties are able to produce larger amounts of grain per unit area than conventional varieties. The productivity of modern varieties reaches more than 6 tons per acre, while the productivity of traditional varieties ranges between 3 and 4 tons per acre. The most productive wheat varieties are distinguished by the high quality of their grains, as they contain a higher percentage of protein and other nutrients. The most productive wheat varieties are characterized by their resistance to diseases and pests that affect wheat, which reduces production losses.

Cons of this solution: More productive wheat varieties require greater amounts of water and fertilizer than traditional varieties. The popularization of more productive wheat varieties may lead to reduced genetic diversity in crops.

4) Reducing the loss of the wheat crop in its various stages, starting from the harvest stage, through the transportation and storage stage, during the milling operations, and ending with distributing the final product to the consumer.

Pros of this solution: Studies indicate that reducing crop losses during different production stages can increase agricultural productivity by up to 10%. Therefore, reducing crop losses is one of the most important factors that can help achieve food security and protect the environment. Using Modern harvesting techniques reduce crop losses during the harvesting stage, such as the use of harvesting machines that can harvest with greater precision and less damage to the crop. Using Modern storage technologies reduce crop losses during the storage stage, such as the use of modern storage silos that can maintain crop quality for a longer period. Controlling temperature and humidity in storage areas helps reduce crop losses, such as using ventilation and cooling systems to maintain appropriate temperatures and humidity. Using Modern manufacturing techniques reduce crop losses during the manufacturing stage, such as using modern processing systems that can process crops more efficiently and with less damage. Using Modern marketing systems reduce crop losses during the marketing stage, such as using modern cooling and transportation systems to maintain crop quality for a longer period.

IV. POLICY RECOMMENDATIONS

Based on the solutions described above, there are two solutions that the researchers prefer, due to their ease of implementation at the present time and without the need for a long time or high cost. These two solutions are considered the best from the researchers' point of view:

Reducing the loss of the wheat crop in its various stages, starting from the harvest stage, through the transportation and storage stage, during the milling operations, and ending with distributing the final product to the consumer.

This solution is easy and applicable, as it has been proven effective and does not require a long time. The Food and Agriculture Organization of the United Nations (FAO) conducted a study in 2019, estimating that reducing global wheat crop losses by 10% would increase global wheat production by 70 million tons. Also, a study conducted by Columbia University showed that reducing wheat crop losses in the United States by 10% would lead to savings of approximately \$1.2 billion annually. The Egyptian Ministry of Agriculture conducted a study in 2022 and made several recommendations to reduce losses from the wheat crop in Egypt. It was estimated that implementing these recommendations would lead to reducing losses by 10%. Strategies for implementing this solution: The Egyptian government can organize training courses for farmers on how to use loss-reducing techniques, such as using modern harvesting and storage machines, applying pest and disease control techniques, providing technical guidance to farmers through publishing publications and brochures, or establishing direct communication channels with farmers, Such as social networking pages. It is important that educational efforts focus on farmers across Egypt, including large and small farmers, and farmers in rural and urban areas. These efforts must also be continuous and diversified, reaching all farmers and covering all aspects related to reducing wheat crop losses.

Generalizing the cultivation of the most productive wheat varieties, such as Misr 1 and 2 varieties, Sids12, and Giza 171

The solution of varieties is simple, easy, and distinctive for several reasons: This solution does not require any complicated techniques or equipment, and can be easily applied by farmers. This solution can be easily understood by farmers and does not require specialized training. As we mentioned previously, the most productive varieties have many advantages, such as: higher productivity, better resistance to diseases and pests, better tolerance to difficult environmental conditions. In addition to these reasons, generalizing the cultivation of the most productive varieties has many other advantages, such as: increasing agricultural productivity, and thus increasing Income for farmers and providing food for the population. Achieving food security, in addition to reducing dependence on imports, thus preserving the state's food sovereignty. Strategies for implementing this solution: The Egyptian government can provide soft loans to farmers who grow new varieties, or by providing direct support to farmers, such as providing seeds for free or at reduced prices. Establish a fair seed distribution system across the country, so that seeds are readily available to farmers in all regions, including rural and remote areas. In addition to these measures, the Egyptian government can also work with seed production companies to reduce the cost of new varieties.

Regarding the other two solutions: Development of new wheat varieties that are more resistant to heat and drought, and Disseminate and improve sustainable wheat farming practices.

Despite these solutions having advantages, they have many disadvantages, such as high cost, environmental and health risks, long time for research centers to reach accurate results about new

wheat varieties, in addition to the difficulty of convincing traditional farmers of these new practices, and therefore it is necessary to the government in Egypt must make sufficient efforts to raise awareness among traditional farmers of the importance of sustainable wheat cultivation methods and new types, while providing them with adequate training. In addition to allocating a budget for research centers to work on this project and provide the appropriate environment. With effort, these solutions can become applicable on the ground.

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