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Review

Climate Changes and Its Impacts on Agricultural production and water resources in Egypt

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The implications of climate change on the direction and magnitude of future rainfall change in the Nile Basin are largely seen uncertain. However, the implications of higher temperatures on the agricultural water use in Egypt could be serious, as losses are likely to increase from the Nile and the extensive system of irrigation canals, and possibly from crop water use. Various vulnerability assessment studies of the implication of climate change on the Northern Delta cities—which are highly vulnerable to sea level rise, salt-water intrusion, soil salinization problems, and marine pollution—predict enormous socio-economic losses, if no action is taken. Moreover, the Northern coastal zone shall be exposed to serious impacts affecting its water and agricultural resources due to increased frequencies and severity of dust storms, and loss of biodiversity. Sea level rise would destroy the weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands in the Nile Delta. Besides its serious impact on vast areas of valuable agricultural land which shall be inundated, sea level rise would severely change the water quality and hence the lagoons production of fresh water fish. To adapt with those serious impacts, it is significant to maintain the balance between productivity and environmental protection and integrated crop and land management strategies to sustain the agricultural production and food security. Importantly, there is an imperative need for adopting multi-disciplinary and long-term research to investigate irrigation with marginal water to sustain long-term agricultural productivity.

Keywords: NSAS Nubian Sandston, WUA Water User Association, IYR International Year of Rice, RICM Rice Integrated Crop Management, TMY Theoretical Maximum Yield, ET Evapo Transpiration, SLR Sea Level Rise.

INTRODUCTION

The most significant constraints to rice production in the Mediterranean climate areas include: low temperature, water scarcity, biotic stresses, unsatisfactory grain quality, high production costs and the population's concerns about the harmful effects of rice production on the environment. As rice plants originate from subtropical and tropical zones, they are easily damaged by low temperatures at any growth stage from germination to ripening (Peng SB et al.,

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1994). Several experiments point out that a potential yield of 10 tons/ha requires a density of at least 250 seedlings per m2. The cool weather and strong winds during stand establishment in Mediterranean climate areas may cause partial stand loss and seedling drift, which lead to poor crop establishment. In many temperate areas, the emergence rate quite often does not exceed 30 to 40 percent of the planted seeds. Therefore, to achieve an acceptable crop stand, rice growers usually use about 200 kg/ha of seed. This low rate of crop emergence is due primarily to the effect of anaerobic conditions on germination occurring under low temperatures. To avoid low temperatures during crop establishment stage, some growers end up with delays in crop planting. However, a delay in crop establishment leads to the occurrence of reproductive stages of the crop during periods of low temperatures during the autumn that causes the death of pollen cells at meiosis stage and subsequent grain sterility. Damage to rice yield caused by spikelet sterility could be one of the most severe in years. Poor crop establishment under Mediterranean conditions could be overcome by developing new high-yielding varieties with good tolerance to low temperatures during germination, better land leveling and water management (Shastry SV et al., 1996).

As a result, agronomists are continually creating strategies that increase the rice yield per unit of water input (FAO, 2002a). According to the estimates of the World Resources Institute, 15 percent of the water losses due to evaporation, leaching or any other inefficiency can be saved through more sensible use. Water problems can also be tackled by providing new rice varieties which are more suitable to the various conditions of water management (FAO 1988).

A more consistent reduction in water consumption could be achieved by developing profitable varieties suitable for discontinuous irrigation in all climate conditions. These conditions of water management will also contribute to the alleviation of methane emissions from rice. Non-flooded conditions, however, can lead to increased competition from weeds and increased soil salinity. The constraints on rice yield caused by weed growth and soil salinity must also be addressed as new varieties are developed (Consultative Group on International Agricultural Research, 1971-1996).

1.1 GENERAL CONSTRAINTS CONCERNING RICE PRODUCTION IN THE NEAR EAST NORTH AFRICA

1.1.1 Climatic:

- *Low temperatures*: Low temperature is one of the major constraints in the cold seasons especially for late rice sowing varieties.
- *High temperatures*: At another development stage, strong heat causes high percentage of sterility which may reach to 100% at temperatures of 39° in the dry season;
- *Hygrometry of air, dry and hot winds:* Low air hygrometry and dry hot winds in dry seasons affect flowering. Hot winds dry up panicles and can cause sterility of spikelets.
- *Rain:* Rain constitutes a constraint mainly during the grain maturity stage. It is responsible for the dryness of the rice grain which affects greatly the final rice yield.

1.1.2 Soil and Water:

- *Salinity of Soils:* Soil salinity constitutes an important constraint to rice plantation in many countries in the Near East North Africa. The use of improper irrigation without drainage could encourage water logging, resulting in salinity buildup and other mineral toxicities.
- *Irrigation Water*: Causes degradation of soils because of high charges of sodium bicarbonates which lead to a long term phenomena of iodination which may result in destructing the superficial layer of soil and organic matter and facilitating the rising of pH.

2.1 ENVIRONMENTAL IMPACTS:

Irrigation can have negative effects on the physical environment. The principal environmental risks associated with irrigation come from weaknesses in the control of the quality and quantity of effluent water. Excessive irrigation and poor drainage raise the water table, bring soluble salts to the surface and may adversely affect yields on irrigated land. Data on land degradation due to salinization and water logging are limited. It has been estimated that about 24 percent of the irrigated area worldwide is affected by salinization, though many observers regard this estimate as too high. Most of this area is in the top five irrigators of the world: India, Pakistan, China, the United States and the states of the former Soviet Union (FAO, 1989).

- Most irrigation systems are created for a primary public health objective: to improve human nutrition. Their success in attaining this objective is sometimes reduced by negative impacts on health. These are of two main types. Diseases borne by water related vectors, especially mosquitoes and snails, may increase because the irrigated environment supports much greater populations of these vectors. Secondly, water provided for irrigation is often used for many other purposes: drinking, cooking, washing, and recreation. Gastroenteric and other diseases are often transmitted among human populations through these uses (FAO, 2002_b).
- The major challenges in growing rice is to develop farm water reservoirs for water harvesting, as well as selection of drought tolerant varieties, good land leveling, sub-soiling, which are requisites for proper irrigation scheduling to increase water use efficiency (Guerraetal., 1998).
- Generally speaking, the sustainable increase in rice production in the Near East North Africa Region requires strategies that must focus on the following: the

formulation of appropriate government policies to support the development of rice production programs, increasing rice yield through development and dissemination of hybrid rice and rice integrated crop management systems, improving post-harvest technology through research and extension, and the provision of infrastructure and accessibility to inputs.

- The International Year of Rice (IYR 2004) offers an important opportunity to use a collective approach towards resolving the increasingly complex issues that affect the sustainable development of rice and rice-based production systems. This has important technical, political, economic and social dimensions, including enhancing the role of rice in meeting human needs.
- The application of Rice Integrated Crop Management (RICM) systems has increased rice yield and reduced cost and environmental degradation through more efficient rice yield and reduced cost and environmental degradation through more efficient application of inputs. The development and dissemination of RICM systems in the near east North Africa region could help to lower production costs per ton of paddy and to minimize environmental degradation(Kropff MJ et al., 1994).

3.1 UTILIZATION OF RICE BIOMASS TO INCREASE EMPLOYMENT AND INCOME WHILE REDUCING POLLUTION:

- Agricultural residues are used in a broad sense to include wastes from agriculture and agro-industries. They consists of unutilized excesses or/and residues from growing and processing of raw agricultural products such as fruits, vegetables, poultry, fish, trees and rice straw. Residues are those end products of production and consumption that have not been used or recycled. They are none product flows of materials and energy whose economic values, at the present level of knowledge, are less than the cost of collection and transformation for use, and they are therefore discarded as wastes. The volume of composition of these residues could be reduced through technological means for converting them into some usable product if the values of subsequent product exceed the costs of conversion. This could help in solving the problem of unemployment through establishment of small project for converting the agricultural wastes.
- If residues can be utilized for human benefit, they are no longer wastes but become new resources. Utilization of all or portion of the wastes offers the possibility of burning such residues into beneficial use, as opposed to the current methods of disposal and relocation. The success of residue utilization depends mainly on the beneficial use, adequate market, suitable technology to process the residue under different conditions, and an overall enterprise that is socially and economically feasible. In addition, it will reduce the environmental pollution in Egypt.
- The generation of residues from agriculture and agro industry is a function of many factors. The quantity and quality of the residues will depend upon the type of the raw materials, the production processes, the price of input and product, the regulation affecting product quality and use, and any constraints imposed upon disposed of residues.
- The residues are the by-products of production and processing after the values in the products that have been extracted suggests a rational approach to better utilization of the residues to increase their value from residue utilization to commercially marketable levels and to make it profitable for producers (RRTC Rice Research and Training Center, 2005).
- Efforts are needed to develop technologies and institutional arrangements to utilize better the residue from agricultural production. The need is to consider residues as potential resources rather than as undesirable wastes.

4.1 IN THE NEAR EAST North Africa AND ASSOCIATED COUNTRIES, RICE IS GROWN MOSTLY UNDER IRRIGATED CONDITION.

- The stagnation in the expansion of rice harvested area in most of the countries observed during the 1990-2004 period suggests that in the near future this trend may not change substantially. Also, the expansion of rice area in Egypt is not sustainable in the longer term due to the limited water resource in the country and the increased demand for water from other sectors of national economy. Therefore, in the future, the substantial and sustainable increase in rice production in the Near East region will depend greatly on the increase in the productivity of the rice production systems or yield increase.
- Concerning the major climatic factors during rice growing season in selected locations such as Egypt, Iran and Mauritania, data shows that the climatic conditions in most rice growing regions/provinces in the Near East and associated countries are favorable for high crop yield. Several scientists used different methods to estimate the theoretical maximum yield (TMY) for rice grown under different climates. The estimated TMY of rice planted in Japan under the climate that has an average daily solar radiation of 400 cal/cm 2/day and with a grain-filling period of 40 days, for example, is 23.8 tones of rough rice per hectare (Consultative Group on International Agricultural Research 1971-1996). In 1977, IRRI scientists provided different estimations, which showed that in tropical climate areas the TMY varies from 4 to 22 t/ha, while in the temperate climate areas, it varies from 8 to 30 t/ha .
- The highest recorded yield of indica varieties was 10.3 t/ha, which was obtained from the IR8 planted at the IRRI's experimental farm, Los Banos, Philippines during the 1965 dry season (De Datta, 1981). The Egyptian rice yield in 2005 was the highest not only in the region but also in the world, comparable to the Australian rice yield. This

yield of 10 tons/ha, however, is still below the yielding potential of improved japonica varieties. The highest recorded yield of japonica rice was 14.7 tons/ha which was produced in Riverina, Australia in 1992 (Kroft et al., 1994). Therefore, there are still large yield gaps in rice production in the Near East and associated countries. The narrowing of the yield gap could substantially increase the productivity of the rice production systems in the region.

4.1.1 According to Duwayri et al. (1999), the rice yield gap has three components:

The first component of the yield gap is the difference between the potential yield of existing varieties and the theoretical maximum yield. It is also called the potential yield gap and it could be narrowed with the development of rice varieties with higher yielding potential.

The second component of the yield gap is mainly due to factors, which are generally not transferable, such the environmental conditions and some built-in component technologies available at research stations. This gap therefore, cannot be narrowed or is not exploitable.

The third component of the yield gap is mainly due to differences in management practices. This gap is also called the yield gap at field level. It exists as farmers use sub-optimal crop management practices. The closing of this gap component could be done by adoption of improved crop management practices and systems.

In summary, the development and use of new generation of rice varieties to narrow the Gap A and the development and use of improved crop management systems to narrow the Gap C are the technical opportunities for increasing the productivity of the rice production systems in the Near East North Africa and associated countries.

5.1 EFFICIENT WATER USE IN IRRIGATED AGRICULTURE:

In 1989, there were about 233 million hectares of irrigated land in the world; 73 percent of which are found in developing countries, representing 21 percent of all the cropped land in these countries. East and South Asia have the largest area under irrigation so far, 131 million ha. About 22 million ha of irrigated land are located in West Asia and North Africa, 16 million ha in Latin America and about 3.5 million ha in sub-Saharan Africa (FAO, 2003. Food Outlook 2003).

A few countries dominate in irrigation. China and India together possess about half of the developing world's irrigated land. There are others, notably Egypt and Pakistan, whose aridity makes it impossible to support more than a small fraction of their existing populations without irrigation.

In the arid regions of West Asia and North Africa, new irrigation development has been very limited in recent years, essentially because the accessible water sources have already been tapped and the remaining sources are expensive to develop. In sub-Saharan Africa, a contrary situation exists: the irrigated agriculture sector is modest, with a focus on commercial nonfood crops such as cotton and tobacco, because in many countries rain fed production potential is still abundant (Shariati, M.R. 2003).

5.1.1 Climate Change and Impacts on Nile Water Availability in Egypt

- There is low confidence in implications of climate change on the direction and magnitude of future rainfall change in the Nile Basin.
- However the implications of higher temperatures for agricultural water use in Egypt (and also upstream in Sudan) could also be very high, as losses are likely to increase from the Nile, the extensive system of irrigation canals, and possibly from crop water use.
- Using alternative irrigation under drip irrigation can minimize the adverse effects of marginal water in soil, plant pollution and soil salinity buildup and save about 50% from fresh River Nile water.

5.1.2 Coastal Resources

- Highly vulnerable to Sea level rise, excessive population densities, erosion problems, marine pollution
- Vulnerability assessments of Alexandria City predicted losses exceeding $30 Billion and loss of 200,000 jobs over the year 2050, if no action is taken.
- Increased impacts on water and agricultural resources in the coastal zone due to increased frequencies and severity of dust storms, loss of biodiversity and tourism

5.1.3 Mediterranean Coastline

- Sea level rise
- Impact on human settlements
- Impact on touristic villages in Northern coast (e.g Marina), thus impacting economy
- Impact on agricultural areas (saltwater intrusion)

5.1.4 Delta Region

- The data in table 1 indicates the risks through sea level rise on the costal zone in Alexandria, Al-Burullus, and Port Said, which is already subsiding at approximately 3-5mm/year around the Nile delta.
- Low-lying Nile delta region, which constitutes the main agricultural land of Egypt and hosts most of the population, industrial activities and commercial centers, is highly vulnerable to various impacts of climate change.
- Rising sea level would destroy weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands in the Nile Delta of Egypt (Mediterranean Sea).

Table 1: Sea Level Rise and Land Subsidence Rates In The Nile Delta For The Past 3 Decades

Region	Alexandria (West Delta)	Al-Burullus (Middle Delta)	Port-Said (East Delta)
SLR (mm/yr)	1.6	2.3	5.3
Subsidence (mm/yr)	0.4	1.1	3.35

Kropff M J *et al*., 1994

Table 2: Projected Average Annual Sea Level Rise (Cm) Relative To Year 2000 Sea Level

City	Scenario	2025	2050	2075	2100
Port Said (East Delta)	CoRI	13.25	26.5	39.75	53.0
	B1	18.12	39.5	64.3	72.5
	A1F1	27.9	68.8	109.6	144.0
Al-Burullus (Middle Delta)	CoRI	5.75	11.5	17.25	23.0
	B1	8.75	19.5	32.25	35.0
	A1F1	14.75	37.5	60.3	79.0
Alexandria (West Delta)	CoRI	4.0	8.0	12.0	16.0
	B1	7.0	16.0	27.0	28.0
	A1F1	13.0	34.0	55.0	72.0

Shastry SV *et al*., 1996

- One third of Egypt's fish catches are made in the lagoons. Sea level rise would change the water quality and affect most fresh water fish. Valuable agricultural land would be inundated**.**

- The data in table 2 indicates that there are three scenarios for the sea level rise which will increase gradually from year 2025 up to 2100:the first indicates that the highest increase shall be in Port Said region where the increase in sea level rise shall be 13 cm each 25 years, the second shows the increase might reach to18 cm, while the third scenario predicts that the increase will be 6 cm.

5.1.5 Impact of Climate Change on Agricultural Resources

- The Nile delta region which is considered as the most fertile land of Egypt, is highly vulnerable to the impacts of sea level rise, salt water intrusion, and soil salinization.
- Reduced irrigation supplies from the Nile.
- Shortage of water resources delays many agricultural developmental plans.

6.1 FOOD AND ENVIRONMENTAL PROTECTION

6.1.1 Improving the legal environment for agricultural

Law is essential to any national agricultural marketing system. An inappropriate legal framework can distort and reduce the efficiency of the market, increase the cost to the participants and severely stunt the development of a healthy private sector. Despite this, programs to reform agricultural marketing systems have often been based on an inadequate understanding of the relationship between law and the way in which marketing systems function.

The policy-makers should beware of over-simplistic models based on the mistaken belief that fewer rules mean more efficient markets. Those drafting laws need to find ways of moving away from highly prescriptive legislation designed to maximize state control, towards legislation designed to enable efficient private sector involvement. However, the greater degree of freedom for the private sector resulting from legal reforms may also increase the potential for market manipulation and thus create a need for new and more sophisticated regulatory mechanisms.

Table 3: Change In Major Crops Production (Excess Or Deficit) In Egypt By The Year 2050 Due To Climate Change.

Crop	Base Yield (ton/ fed)	Area (Million/fed)	Yield (Million ton)	Change	Deficit or Excess(Million ton)
Wheat	2.175	2.123642	4.629216	-18	-0.833259
Maize	2.718	1.683108	4.576779	-19	-0.869588
Cotton	1.099	0.815350	0.903090	+17	+0.153525
Sorghum	2.086	0.33868	0.705404	-19	-0.134027
Barley	0.888	0.179792	0.124212	-18	- 0.022358
Rice	3.263	1.291342	4.241457	-11	-0.466560
Soybean	1.167	0.050381	0.058888	-28	-0.016488

Peng SB *et al.,*1994

6.1.2 Analyzing the legal environment

Conducting a comprehensive analysis of the legal environment for agricultural marketing in any country is potentially a huge task. In theory it would be necessary to examine every relevant legal rule, how the rule is implemented and enforced, how it interacts with other parts of the regulatory system (e.g. existing market customs and practices and economic and political forces), how it is perceived by the people subject to it, and the effects it produces on human behavior. From this, an assessment could be made of the impact of the rule on the performance of the various aspects of the marketing system. Accurate empirical assessment of the economic and social impact of particular legal rules or administrative arrangements is likely to be impossible or extremely difficult in light of the complexity of regulatory systems for agricultural marketing, the number of variables involved, the variability between markets, areas and commodities, and the dynamic nature of markets.

The difficulties inherent in obtaining comprehensive empirical data do not mean that a rigorous evaluation of the legal framework will not be productive and should not be attempted. Low is one of the primary determinants of market performance and can be a powerful tool for implementing policy. If there is no rational evaluation of how a rule functions and what its impact is, national policy development is not possible. We should be able to outline and approach which could be adopted in evaluating the legal environment for a particular agricultural marketing system.

Law provides the foundations for the operation of agricultural marketing systems and is essential for the development of more sophisticated system. Legislation is probably the most important tool available to governments for regulating a marketing system and changing how it functions in order to achieve politically desirable goals.

7.1 BALANCE BETWEEN PRODUCTIVITY AND ENVIRONMENTAL PROTECTION.

No one disputes that Earth's climate is changing or that atmospheric concentrations of greenhouse gases have increased as a result of human activities. The concentrations of carbon dioxide, methane and nitrous oxide are higher now than at any time during the last 420,000 years.

7.1.1 Climate Change Effects

Analysis of the impacts of climate change suggests that agro-ecological systems are the most vulnerable sectors. Agriculture in low latitude developing countries is expected to be especially vulnerable because climates of many of these countries 'are already too hot. Further warming is consequently expected to reduce crop productivity adversely. These effects are exacerbated by the fact that agriculture and agro-ecological systems are especially prominent' in the economies of African countries and the systems tend to be, less capital and technology intensive. Predictions of impacts across regions consequently suggest large changes in the agricultural systems of low latitude (mostly, developing) countries (Nguyen VN et al., 1994).

7.1.2C1imate Change Effects on Egyptian Agriculture

Any attempt to assess the future of Egyptian agriculture must consider the complex interactions between the factors that determine the use of the land, the choice of cropping systems and the socioeconomic characteristics and limitations (RRTC Rice Research and Training Center, 2001).

Table 3 indicates that climate change could decrease national production of many crops (ranging from -11% for rice to -28% for soybeans) by the year2050 compared to their production under current conditions. While, the yield

Table 4: Change In Evapotranspiration of Major Crops (Millions M3) Due To Climate Change (Millions Feddan) IN EGYPT

Crop	Area (Million feddan)	Total ET (Millions m3)	Change	Deficit of Excess
Wheat	2.123642	2730.313		-27.303
Maize	1.683108	2890.968	+8	+231.28
Cotton	0.81535	2358.324	+10	+235.832
Sorghum	0.33868	811.642	+8	+64.93
Barley	0.179792	109.673	-2	-2.19
Rice	1.291342	4703.449	+16	+752.551
Soybean	0.050381	271.851	+15	+40.777

RRTC Rice Research and Training Center, 2001

of cotton would increase in comparison with current climate conditions. At the same time, water needs for summer crops will increase up to 8% for maize and up to 16% for rice by the year 2050 compared to their current water needs.

Adaptation of the previous crops to the climate change were studied. Future adaptation strategies to climate change may involve the development of new more heat-tolerant cultivars, new crops (more cotton cultivation as alternative to some maize). Changing practices of cotton crop (optimum sowing date, cultivar, water amount and plant population density) can be used to improve the benefit from the positive impact of climate change on cotton productivity to about 29%.

Consumer crops (i.e. sugar cane and rice crops) and changing practice (optimum sowing dates, more water, and nitrogen amounts use and cultivars for suitable agroclimatological regions) can be adopted. Vulnerability results as shown in table 3 were obtained from average values of three years for each crop.

Modification of cropping pattern (i.e. partially growing wheat after cotton in the same year and land), reducing or keeping on the current area under cultivation with some high water consumer crops(i.e. sugar cane and rice crops), and changing practice. Optimum sowing dates, more water and nitrogen amounts use, and cultivars for suitable agroclimatological regions can be adopted.

The lowest productivity will be on the maize production (-19%), andtherice production(-11%) as well. While there will be a positive reaction on the cotton production (+17%). According to these results, we recommend adopting new cropping system that depends on the increase of the cotton cultivation as an alternative to some of the maize cultivated areas.

8.1 EFFECT OF CLIMATE CHANGE ON WATER NEEDS IN EGYPT

- The only chances to increase the Nile river water are outside of Egypt and subject to international politics.
- Egypt and Sudan has identified several water conservation projects to increase the annual water budget for both countries:

Jonglie canal 7BCM/year
Bahr el.Ghazal 7BCM/year
Machar swamps 4BCM/year
Total 18BCM/year

- The area utilized in Egypt amounts to 12.5 million feddans (8.4 agriculture and 4.7 inhabited), representing only 5% of Egypt total area (1 million Km^2).
- The population reached about 90 million. Egypt's rapid growth population combined with greater per capita consumption due to increasing living standards has led to growth in domestic food consumption.
- As agriculture production could not cope, the result was an increasing dependence on food imports.
- There is an urgent need to increase agricultural production.
- Although there is potential for further development of new lands through the National Program for Horizontal Expansion, the main contribution to such increase in agricultural production must come from productivity improvements in the old lands.

8.1.1 Effect of climate change on evapotranspiration for some Egyptian crops

- Egypt is truly the gift of one great river, the Nile.
- Egypt civilization can be said to be the civilization of the Nile river system.
- The Nile flow is the main source of the life in Egypt. It provides the country with 96% of its water. The 1959 Nile agreement between Egypt and Sudan allocated 55.5 BCM to Egypt.
- Compared to the water demand, Egypt's share has become very limited and is already almost fully exploited.

The potential impact of climate change on some field crops production and ET in Egypt was carried out by FAO in 2003 (Food Outlook 2003).

Table 4 showed that, the Nile system downstream of Aswan including the Nile Valley and Delta, and their fringes is a complex system in terms of water quantity and quality. The ET along the river Nile and Naser Lake reached 2 billion m^3 a year according to high temperature degree during the summer season. In the Delta region, the highest loss due to ET comes from Rice Crops. While half of this loss comes from the cotton, and the Barely estimates shows the lowest.

9.1 INTEGRATED CROP AND LAND MANAGEMENT CONCEPTS, STRATEGIES, AND TECHNICAL OPTIONS.

- Plant Breeding And Genetics
- Land use, management and degradation
- No burning
- Higher plant populations
- Improved varieties
- Annual intercropping system
- More attention should be given
- Agrochemical
- Organic manure
- Composts
- Organic foliar fertilizers
- Natural pesticides

9.1.1Major measures under consideration for 2017-2027 include:

- *Deep mining of non-renewable groundwater*
- *Desalination*
- *Biotechnology applications to agriculture*
- *International cooperative Nile Basin projects*
- *Water pricing*.

10.1 Activities to sustain the process of agricultural development

10.1.1 The following activities may assist farmers to become more innovative:

- Visits to farmers in other localities where new technologies are adopted and implemented;
- Training farmers to carry out simple experiments;
- Giving farmers a minimum of very basic scientific ideas about soils and agriculture to help them orientate their experiments in useful directions;
- Encourage farmers not to be reliant on outside assistance, and to share their experiences and the results from their experiments with other farmers.

10.1.2 Egypt water demands is divided among the different sectors as follows:

- Agricultural use 84.4%
- Industrial use 10%
- Municipal use 5%
- Other uses 0.60%

CONCLUSION

The implications of climate change on the direction and magnitude of future rainfall change in the Nile Basin are largely seen imprecise and uncertain. However, it is widely agreed that the implications of higher temperatures on the agricultural water use in Egypt could be serious, as losses are likely to increase from the Nile and the extensive system of irrigation canals, and possibly from crop water use. Various vulnerability assessment studies of the implication of climate change on the Northern Delta cities—which are highly vulnerable to sea level rise, salt-water intrusion, soil salinization problems, and marine pollution—predict economic losses exceeding $30 billion and losses of 200,000 jobs by the year 2050, if no action is taken. Moreover, the Northern coastal zone shall be exposed to serious impacts affecting its water and agricultural resources due to increased frequencies and severity of dust storms, and loss of biodiversity. Sea level rise would destroy the weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands in the Nile Delta. Besides its serious impact on vast areas of valuable agricultural land which shall be inundated, sea level rise would severely change the water quality and hence the lagoons production of fresh water fish which constitutes one third of Egypt's fish catches. Notably, despite the fact that the Nubian Sandstone System is one of the largest regional aquifers in in the world, its water is mostly non-renewable. Given the scarcity of water in the region, there is an enormous risk that the resources in this aquifer system would be considered limited. To adapt with those serious impacts of climate change, it is inevitable to maintain the balance between productivity and environmental protection and integrated crop and land management concepts, strategies, and technical options in order to sustain the agricultural production and food security.

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Moreover, the Northern coastal zone shall be exposed to serious impacts affecting its water and agricultural resources due to increased frequencies and severity of dust storms, and loss of biodiversity. Sea level rise would destroy the weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands in the Nile Delta. Besides its serious impact on vast areas of valuable agricultural land which shall be inundated, sea level rise would severely change the water quality and hence the lagoons production of fresh water fish which constitutes one third of Egypt's fish catches.

Notably, despite the fact that the Nubian Sandstone System is one of the largest regional aquifers in the

world, its water is mostly non-renewable. Given the scarcity of water in the region, there is an enormous risk that the resources in this aquifer system would be considered limited. To adapt with those serious impacts of climate change, it is inevitable to maintain the balance between productivity and environmental protection and integrated crop and land management concepts, strategies, and technical options in order to sustain the agricultural production and food security.

The rapid growth population and economic growth are exerting pressures on the existing water resources, to face these challenges: A more efficient use of the available water resources, Development of additional water resources, Improvement of water quality to protect public health and environment.

In essence, using alternative irrigation under drip irrigation can minimize the adverse effects of marginal water in soil, plant pollution and soil salinity build up and save about 50% from fresh water. Socio-economic evaluation must be implemented to identify the impact of reusing marginal water on soil, plant, environment and human health. There is an imperative need for adopting multi-disciplinary and long-term research to investigate irrigation with marginal water to sustain long-term agricultural productivity of potential land and water resources.

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