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The Effect of Climate Change Scenarios on the Egyptian Coastal Zone and the Nile Delta Resources

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***Abstract*— Climate change scenarios has a great influence on the Egyptian coastal zone and delta region due to the IPCC (Intergovernmental Panel on Climate Change) report. According to these scenarios climate change will have a negative effect on delta resources that will cause a shortage in agriculture and livestock production. Also, The delta region will suffer from different phenomena such as land desertification, sea level rise, and seawater intrusion. As a result of that there will be shortage in the cultivated land which will decrease the available feed sources for livestock. The expected air temperature rise will affect livestock population in the same region. In this research, we were able to determine the relation between livestock population and different parameters such as available agricultural land, total available land, average air temperature, and comfort temperature. We have used dimensional analysis and linear regression analysis technique for the effective parameters in order to estimate an equation that helps us to predict the expected livestock population in the future under the effect of climate change scenarios. According to these scenarios climate change will have a negative effect on delta resources that will cause a shortage in agriculture and livestock production. Also, in this paper we suggested an adaptation strategy to overcome the effect of climate change scenarios negative effect on the coastal zone management of the Egyptian delta region and its resources.**

***Keywords*— Climate change scenarios**; **Egyptian delta**; **livestock**; **sea level rise**; **adaption strategy.**

I. UNTRODUCTION

A. Ccoastal zone management

Coastal zone management can be defined as a group of coastal problems and their solutions under the umbrella of sustainable development; also, those solutions must coincide with the environmental friendship concept and social goals. The problems will include coastal water resources management, shoreline erosion, environmental impact assessment, air pollution, overpopulation, health risks, the economy, tourism, agriculture, and the coastal ecosystem. The problems and their solutions must include the climate change scenarios, threats, and perform reliable assessment management plans that combine legal and institutional frameworks to match the desired environmental and social goals]1[.. Coastal zone management in Egypt includes many major issues; these issues are the protection against shoreline erosion, land stress and land degradation, coastal water resources management, ecosystem protection, and climate change effects.

B. Climate change

In the last decade, climate change became such an important issue for the decision-makers and researchers all over the world because rapid climate change was accelerated through the recent years in spite of the global efforts to reduce greenhouse gas emissions. The fluctuations of solar radiation activity can be assumed to be an additional source of climate change effects besides the greenhouse gas emissions. In coastal zones, climate change is such a sensitive matter because it increases the threats of storm waves and surges that will expose shorelines to be eroded and near urban areas to be destroyed [2]. Also, many problems related to climate change will affect coastal zones with negative impacts such as sea level rise, seawater intrusion, environmental pollution, land stress, economic depression, ecosystem degradation, population displacement, and the decrease in agricultural production [3], [4]. The rate of average annual sea level rise at the delta coast ranged from 1.6 mm to 5.3 mm in the period 1943 to 2000. The expected sea level rise will range from 13 cm in 2025 to 144 cm in 2100, which will cause much more than 11.75% of the low land of the delta to be sunk [5], [6].

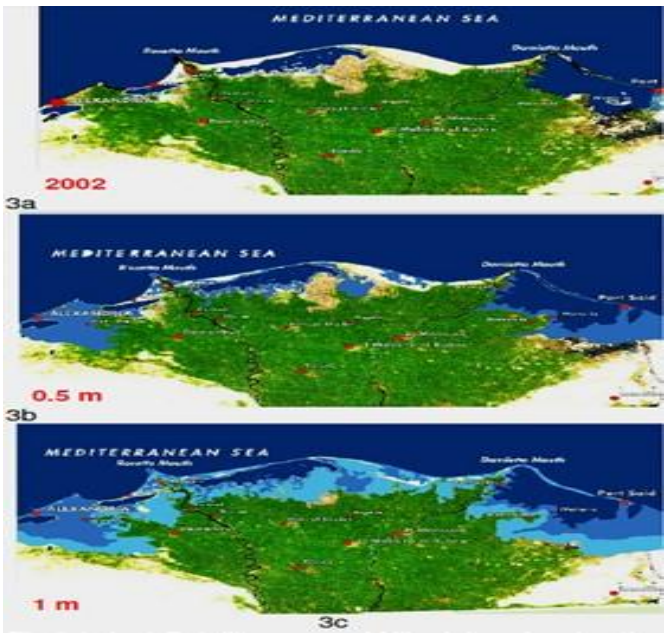

Fig.1, SLR in the Nile delta and Rosetta [7]

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C. Egypt future climate change scenarios

The general concepts of the future climate change scenarios in Egypt are as follows:

1. Temperature rise will vary from 3.1 to 4.7° C by 2060 [8[,] 9[.

2. Rain precipitation will be decreased by 10% to 40%.

3. The sea level rise will be of average value of 50 cm at year 2050 to 1 m at year 2100.

D. Case of study description (Nile delta coast)

The Nile delta coast is 240 km from Alexandria to Port Said, and this region is highly populated, almost 1600 capita per square kilometer. Also, this coast contributes a large section of the Egyptian economy, such as tourism, fishing, commercial goods trading through ports, agriculture, and industrial activity]10[. In the delta the Nile River distributes into two main branches: Rosetta on the west and Damietta on the east. Also, it contains most of the fertile farms that provide almost 40% of the agricultural production in Egypt. It contributes 60% of fish catch. Half of Egypt's industrial production comes from the delta, and the delta contains many of the important cities in Egypt, such as Alexandria, Damietta, and Ras El Bar. It has been suffering from increased severity and frequency of sandstorms, dense haze, and flooding. These extreme events have had negative socio-economic impacts on almost all sectors. The delta contains many lakes, such as Lake Burullus, Lake Idku, and Lake Mariout. It also contains many of the Egyptian irrigation network conduits, such as the Ell Esmalia and El Mahmoudia canals, as shown in fig. 2]11[.

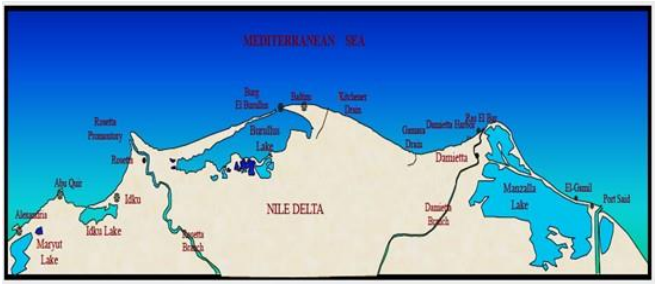

Fig.2 The Nile Delta coast]11[.

E. Impact of climate change scenarios on agriculture

Climate change will negatively affect the inflow for the Nile River branches in the Nile Delta and also on the recharge of the delta aquifer. This situation will create stress on the available water needs for irrigation processes in the delta region and will increase the needs for groundwater withdrawal from the delta aquifer to face the shortage of the water needs.

According to the climate change scenarios of sea water level rise, there will be a decrease in the fresh water table near the sea that will ensure more sea water intrusion. According to another study [12], for the delta coastal aquifer, it was found that the sea water intrusion will be increased due to the sea level rise, and this will be southwards into fresh groundwater aquifers. According to previous study at the year 2016 [4], they found that as a result of climate change scenarios and sea level rise by a range of 0.5 by the year of 2050, almost 12% to 15% of the delta agricultural land will sink under the sea, and the other parts will suffer from high salinity and increasing of the water table level. Egypt's population is almost 97 million capita right now and is expected to reach 117 million capita by the year 2030. By the year 2050, Egypt's population is expected to reach 150 million capita. The agricultural land is 8.4 million acres, and according to the effort of the agriculture ministry, the reclaimed lands will reach 3.1 million acres. This will make the total agricultural land 11.5 million acres at the end of year 2030. This expected situation will lead to a shortage of the cultivated agricultural land of about 3.2% compared to the year 2011 and a 1.92% change compared to the year 2013[11], as shown in figure 3, while figure 4 represents the cultivated land through the years.

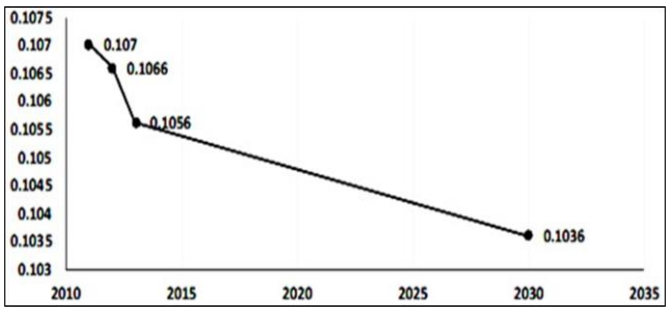

Fig.3 Average per capita from cultivated land by acres]12[.

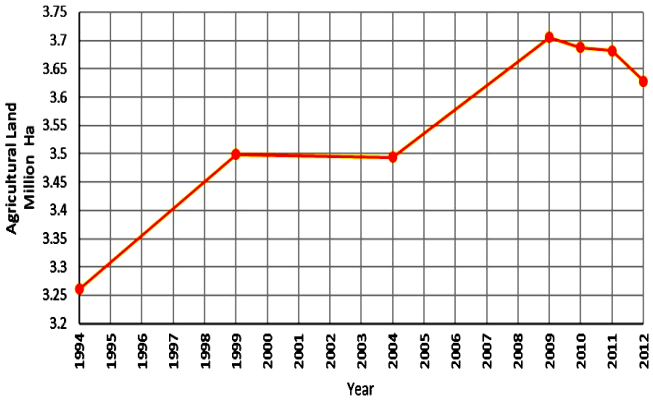

Fig.4 The cultivated land through years.

For the case of a 0.5 m mean sea level rise, about 1800 square kilometers (7.5%) of delta land will be submerged. For the case of a 1.5 m mean sea level rise, all the delta coast major cities would be displaced, and 5700 square kilometers (24%) of delta land will be submerged as shown in the table. 1, [13], [14].

TABLE 1. EXPECTED SUBMERGED LAND DUE TO MEAN SEA LEVEL RISE [13]

SLR value	Expected Submerged land (square kilometers)	Percentage of Delta area
0.5m	1800	7.5%
1.0m	4500	18.9%
1.5m	5700	23.9%

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The global warming and the expected increase in the atmospheric temperature, beside the lowering of the atmospheric pressure, will affect the water consumption of the major crops in Egypt with a negative impact [15]. Due to the increase in the evapotranspiration rate of the crops, that will lead the farmers to increase the irrigation water needs to avoid the crops wilting, this situation will lead to stress on available water resources in the delta region and will decrease the person's share in the available water resources [16]. According to the climate change scenarios of global warming and atmospheric temperature rise between 1.5°c to 3.5°c, the major crop production will be decreased from 11% to 18% for crops such as wheat, barley, corn, maize, and rice, while the harvest will be decreased from 25% to 50% for crops such as soybeans, sunflowers, tomatoes, and sugarcane. [4], [17]. Figure 5 represents the crop production for the main crops without taking climate change effects into account.

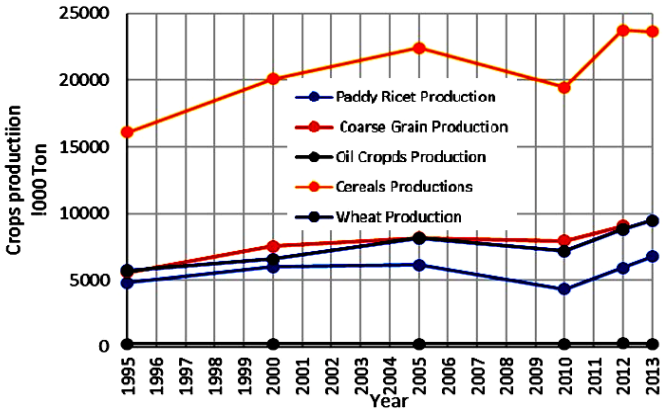

Fig 5 represents the crops production for the main crops without taking climate change effect[4].

II. THE STUDY DATA

Livestock populations in Egypt include different types, such as cattle, buffalo, sheep, goats, camels, asses, and poultry, as shown in figure (6) [18],]and table (2) [19]... These livestock different types are distributed along the Egyptian agricultural land; the majority of it can be found in the Egyptian delta region, as shown from figure 7 (cattle and buffalo density distribution) and figure 8 (chicken density distribution) [20].

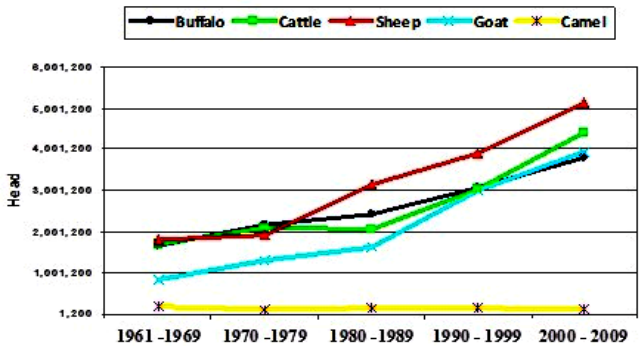

Fig. 6 Ruminant population in Egypt from 1961 to 2009. Index mundi (2011) based on FAO database [18].

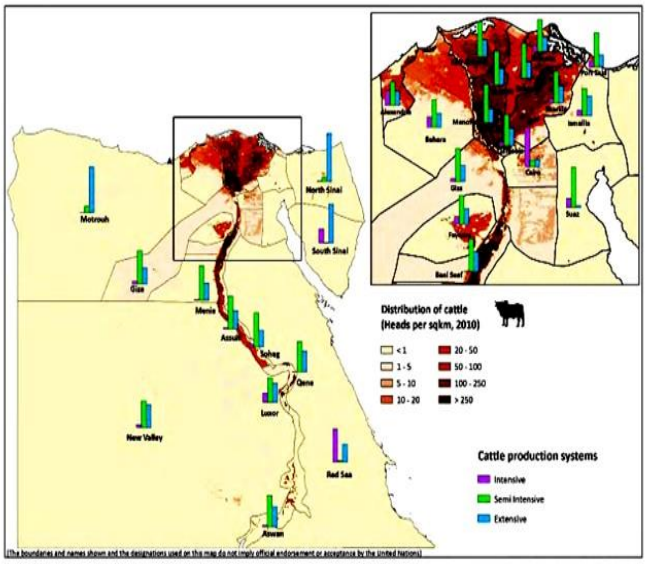

Figure 7. Cattle and buffalo density and production system distribution in Egypt [20].

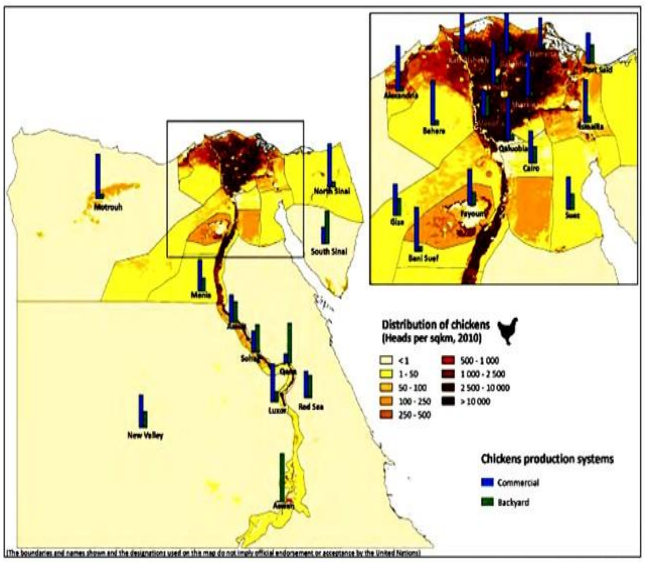

Figure 8. Chicken density and production system distribution in Egypt [20].

Climate change according to many previous studies may affect livestock population and its production in many different ways. The expected temperature rise as a result of climate change scenarios will cause heat stress in the delta region; this heat stress will decrease livestock growth, productivity, and fertility that may cause death eventually. Also, heat stress will decrease livestock productivity, such as growth rate, daily solid gained, and feed consumption; on the other hand, heat stress will affect animal reproduction negatively [21]**.** because it will decrease its fertility [22]. Also, the heat stress as a result of temperature rise will cause serious damage to the animal's immune system because their resistance to diseases will decrease with the increasing of the air temperature [23], [24].

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TABLE 2 LIVESTOCK POPULATION 2000-2009 (IN MILLIONS EXCEPT FOR CAMELS AND HORSES IN THOUSANDS) FAO STATISTICS, 2011[19].

Item	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cattle	3.53	3.80	4.00	4.23	4.37	4.50	4.61	4.93	5.02	5.00
Camels	141	134	127	135	135	120	148	84	107	110
Buffaloes	3.38	3.53	3.55	3.78	3.85	3.90	3.94	4.11	4.05	4.00
Horses	45	53	62	62	62	62	54	66	66	67
Sheep	4.47	4.67	5.11	4.94	5.04	5.10	5.39	5.47	5.50	5.50
Goats	3.43	3.50	3.58	3.81	3.89	3.92	3.96	4.21	4.47	4.55
Asses	3.05	3.10	3.10	3.15	3.15	3.20	3.27	3.32	3.36	3.35
Poultry	89	91	92	95	95	95	97	98	96	96

III. STUDY METHODOLOGY

The study of the expected climate change scenarios on the livestock population will be predicted by using dimensional analysis for the effective parameters. The effective parameters will include available agricultural land, total available land, average air temperature, and comfort temperature. This will help us to correlate a relationship between livestock population in the delta region and the mentioned parameters.

A. Dimensional analysis

N= Live stock number, (Unit less)

A_A=available agriculture land area, (m^2) (L^2)

A_T = total available land area, (m^2) (L^2)

Ta=average air temperature, (°C)

Tc= and comfort temperature. (°C)

$$(N) = \Phi (A_A/ A_T , Ta/Tc) \quad (1)$$

We were able to make a linear regression analysis by using the available data of the available agricultural land and livestock population for previous years as shown in figure 4 and table (1). We also used the expected temperature rise according to climate change scenarios for the Egyptian delta region.

IV. STUDY RESULTS

B. Effect of land degradation on livestock population

As mentioned before, in order to find the effect of land degradation as a result of Nile delta inundation on livestock population (N), linear regression analysis has been done. Through this regression analysis, we were able to find a mathematical relationship between livestock population and the dimensionless group as shown in equations 2 and 3 and figure 8.

$$(N)=f\left(\frac{\text{Agricultur al land (Aa) /Total land(At)}}{\text{Average temperature (Ta/comfort temperature(Tc)}}\right) \quad (2)$$

$$N = 1200.8 \left(\frac{Aa\ /At}{Ta/Tc}\right) - 37.824 \quad (3)$$

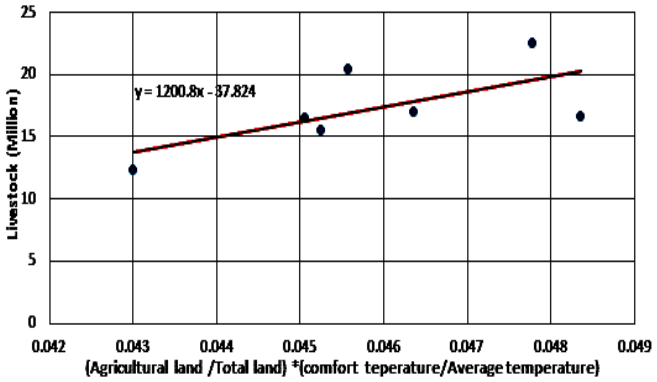

Fig. 8 Regression analysis between livestock population and (Agricultural land /Total land) *(comfort temperature/Average temperature)

According to regression analysis we were able to predict livestock population from year 2030 to year 2100 as shown in figure (9).

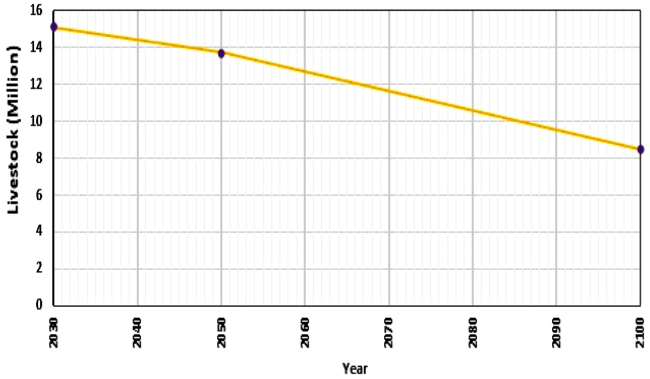

Fig. 9 livestock population prediction according to Regression analysis

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V. RESULTS ANALYSIS

According to results, livestock numbers will be decreased in the future with the decreasing of cultivated land and with the increasing of atmospheric temperature, as it was stated before that the shortage of cultivated land and temperature rise will be yielded from the expected climate change negative effect. The number of livestock will reach 15, 13.72, and 8.5 million by the years 2030, 2050, and 2100, respectively. Those events will happen due to the fact that the source of livestock feed will be decreased as a result of sea level rise that will cause the inundation of the cultivated land in the Egyptian northern delta, especially in the coastal region. Also, temperature rise will negatively affect the livestock growth processes and on its fertility; those circumstances will be reflected negatively on livestock productivity and will cause it to be decreased. On the other hand, livestock will suffer from different diseases due to the weakness of the immune system as a result of temperature rise; the expected number of livestock will not be enough for the needs of the country's future population that will reach 150 million capita by the year 2050. For these reasons, an adaptation strategy must be established to overcome the expected effect of climate change scenarios on livestock populations.

A. Adaption policy strategy for climate change effect on livestock:

An adaptation strategy must be created in order to overcome the expected effect of climate change on livestock population as follows:

1. A new reclaimed land in the eastern desert must be added to the recently cultivated land near the coastal zone beside the delta region in order to overcome the expected shortage in cultivated land; this shortage will take place due to sea level rise and seawater intrusion. These new reclaimed areas will provide a new source for both animal feed and the residents population.

2. Livestock must be bred in an air-conditioned corral that will be equipped with electrical fans in order to maintain the internal temperature within the suitable thermal comfort degree (less than 30°C); this air temperature will provide the optimum atmospheric conditions for animal growth processes and their fertility; also, it will suit their immune system that will help them to recover from any expected diseases that will be yielded from heat stress or temperature rise.

3. Regular health care must be provided to the animal in order to eliminate any possibility of severe diseases that may result from any expected heat stress in the future.

4. Another source of protein must be added beside livestock production; that possible source for protein could be algae that can be grown in greenhouses in fresh or brine water, such as spirulina and dunalilla salina. Algae is not only a good source of protein and vitamins, but also it can be used in many pharmaceutical products; also, it can be used as a supplementary source of feed for animals and fish ponds.

So, in order to avoid that, we have to reclaim new cultivated land in the western desert of higher levels than the expected sea level rise. Also, we can use another source of food supplements, such as algae that can be bred in greenhouses. To mitigate the effect of thermal stress on livestock health and productivity, we have to breed livestock in air-conditioned corrals.

VI. CONCLUSIONS

At the end of this research, we were able to detect the effect of climate change and its scenarios according to IPCC reports on Egypt's coastal zone and delta resources. The effect included shortening of cultivated land that will cause the decreasing of livestock population eventually, that will take place due to many reasons such as thermal stress, sea level rise, and the sinking of parts of the delta region. As mentioned before, the cultivated land is expected to be decreased from 3.52 hectares in the year 2030 to reach 3.49 and 3.28 hectares by the years 2050 and 2100, respectively. This will result in a decrease in livestock population from 15 million head in the year 2030 to 13.72 and 8.5 million head by the years 2050 and 2100, respectively.

VII. ACKNOWLEDGMENT

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