ECONOMIC IRRIGATION WATER PRODUCTIVITY MAPS FOR

EGYPTIAN GOVERNORATES

by

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ABSTRACT

Rational decision making for water management issues requires reliable estimates of the economic value of water. Given the importance of the water resources and agricultural sector to regional economies, and the importance of irrigation to the agricultural sector, it is necessary to understand the economic performance of water use in crop production. Certainly, net return per unit of water is useful for evaluating the economic performance of water use in crop production. Actually, estimates of the economic value of water are essential for an efficient and equitable allocation of scarce water across locations, uses, users and time periods .

The main objective of this study is developing geographic information maps for irrigation water and cultivated crops at the Egyptian governorates. The study is carried out by: i) developing a Geographic Information System and Bata-base for water and cultivated crops at the Egyptian governorates, ii) developing information maps for main Egyptian crops under; cereal, fiber, legumes, vegetables, herbalism, and forages category.   These maps illustrate the cultivated area, cost and revenue, water requirement, net return, and economic value of irrigation water for these crops in each governorate of Egypt , and finally, iii) the developed maps was analyzed to distinguish the most water economic value crops.

Keyword: economic value, irrigation water, Egyptian governorates, Geographic Information System.

INTRODUCTION

In Egypt, agriculture is entirely dependent on irrigation from the Nile as rainfall is not significant except in a narrow strip along the Mediterranean coast. In 2008, agriculture accounted for 13.22% of Gross Domestic Production (GDP) and 34% of total employment power. Agriculture in Egypt is the largest user of water consuming. Egypt's agriculture plays an important role in the economy of the country (Mapxl, 2011; MWRI 2005; FAO Aquastat 2008**)**. The total area of irrigated land in year 2000 was approximately 7.7 million

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feddans and expected to be 11 million feddans by the year 2017 due to horizontal expansion and the implementation of the two mega projects of El-Salam Canal at North Sinai and Toshka at south valley (Attia, 2009). Total cultivated area increased from 7,945,574 in year 2001 to 8,432,186 in year 2008. In year 2006/2007, 231.6 thousand feddan were reclaimed. In year 2007/2008 only 22 thousand feddan were reclaimed (CAPMAS, 2011).

The main features of the water policy of Egypt are improving the efficiency of the present use of water resources to year 2017 and 2050 by achieving some measurements such as maximize the economic, social and environmental return from water resources, making the best agricultural, social and environmental use of the available water resources by means of irrigation improvement and changing crop patterns (MWRI, 2005; MWRI, 2010).

One of the main pillars of the agriculture strategy up to 2017 and 2030 are rationalization of irrigation water use through adopting several measures such as; adjusting the cropping pattern through indicative measures to reduce cultivated areas of rice and sugar cane - being the highest water consuming cropsand taking into consideration the revenues per unit of water when working out the indicative cropping patterns (Siam and Moussa, 2003; MALR, 2005; MALR 2009).

The value of water should reflect the economic, environmental, cultural and religious values of the society (El-alatfy and Kotab, 2011). Rational decision making for water management issues requires reliable estimates of the economic value of water. Actually, estimates of the economic value of water are essential for an efficient and equitable allocation of scarce water across locations, uses, users and time periods. Information on water's economic value enables decision makers to make informed choices on water development, conservation, allocation, and use when growing demands for all uses are made in the face of increased scarcity (Ward and Michelsen, 2002; Perry et al. 1997; McNeill, 1998). Conceptually correct and empirically accurate estimates of the economic value of water are essential for rational allocation of scarce water across locations, uses, users, and time periods.

Given the importance of the water resources and agricultural sector to regional economies, and the importance of irrigation to the agricultural sector, it is necessary to

understand the economic performance of water use in crop production. The main objective of the current study is developing geographic information maps that provide the researchers and decision makers with data and information about irrigation water and cultivated crops at the Egyptian governorates.

METHODOLOGY

2.1 Enhasment of DSS-EVIW Geographic Information System

A Decision Support System for Economic Value of Irrigation Water (DSS-EVIW) developed by El-Gafy and El-Ganzori, 2012, Figure 1 shows the frame work of DSS-EVIW, was modified to produce, beside the economic value maps of irrigation water, geographic information maps that provide the researchers and decision makers with data and information maps about irrigation water and cultivated crops at the Egyptian governorates. These produced data and information include:

- The cultivated area of main crops in each governorate of Egypt
- The cost of cultivating each crop which includes preparation of the agricultural land, seeds, irrigation, fertilization, agricultural service, pests' resistance, harvest, transportation of the crop, public expenditures, and rent of the land
- Total revenue from each crop which includes the value of the main crop and the value of the secondary crop
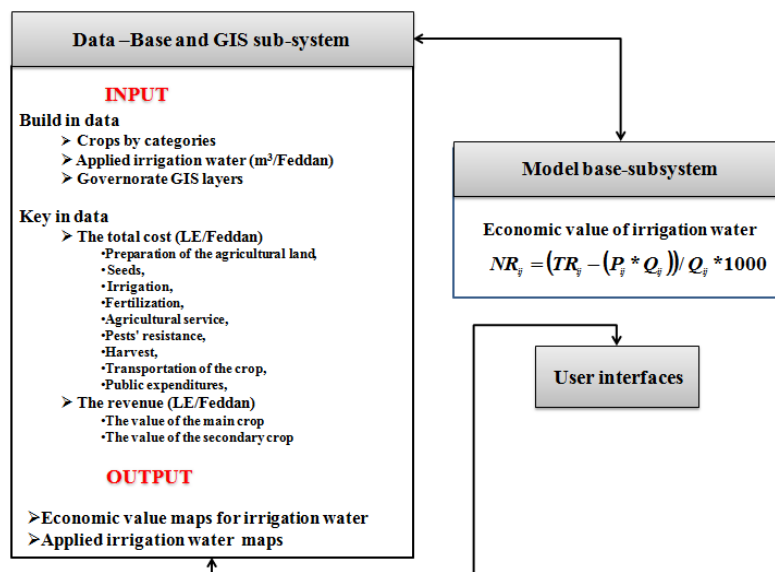- Water requirement for cultivating the crops
- Net return from each crop

Figure 1: Frame work of DSS-EVIW (El-Gafy and El-Ganzori, 2010)

2.2 Database

Database was developed to store data and connect the developed Geographic Information System within DSS-EVIW. The designed database is equiped to allow for any future expanstion to include new crops. In addition, it has an easy-to-use graphical user interface. The database is constructed in different tables that have their major entity fields and other related information. in the design of the database structure the relationships among the different tables are setled, which is presented using the Entity Relation Diagram (ERD). To fulfill all the objectives of the database different forms, queries and macros are developed to view, edit, modify the data, compute the economic value of irrigation water and connect the input data and information and the output of running the system with the developed Geographic Information System.

The main input data and information for the DSS-EVIW are divided into two main forms that are the built in data and the key in data. The built in data includes the different crops by categories and their cultivated season and the water applied per feddan for each crop at lower, upper, and middle Egypt. The key in data includes information about the costs and revenues of crop production per feddan. The costs data include the costs of preparation of the agricultural land, seeds, irrigation, fertilization, agricultural service, pests' resistance, and harvest, transportation of the crop, and public expenditures**.**

2.3 User interfaces

User friendly interfaces were designed and implemented to conete the database, DSS-EVIW and the developed GIS. The user interface were developed to facilitate the process of data entry and display the output of the system. Figure shows the main screen of the system. The main screen is a window that briefly describes the system and allows the user to start navigating it. Figure 3 shows the data entry screen through which the user can select the crop for which it is required to develop its map. The crops through the previous screen were categorized into four main categories that are cereal, forages, herbalism, legumes, fibber, vegetables, and sugar and oil crops. When the crop is selected, the crop water system screen will appear as shown in Figure 4.

Figure 4 illustrates the rice system screen, as an example. Through this screen,the user will be able to inter the required data. The input data include the costs of preparation of the agricultural land, seeds, irrigation, fertilization, agricultural service, pests' resistance,

harvest, transportation of the crop, public expenditures, rent of the land, and total revenue per feddan could be loaded. Moreover, through this screen the method of displaying the result could be chosen. The user of the system has the chance to display the results in the form of a map or a report.
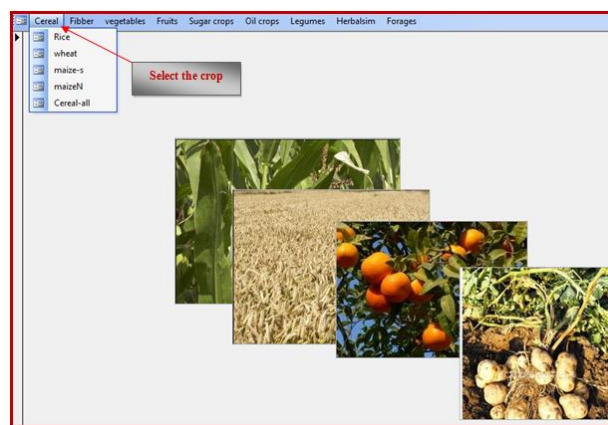

Figure 2: Main menu screen of the system
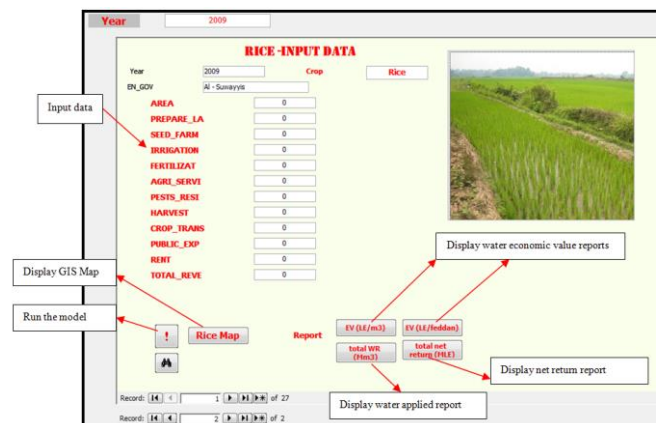

Figure 3: Developed screen to select the crop

Figure 4: Rice system screen (example screen)

3. RESULTS AND DISCUSSION

3.1 Producing information maps

Running the system results in producing maps that facilitate the decision-maker in determining the following information for each crop; annex Figures a-1 to a-14 illustrates examples of the produced maps for wheat crop for 2008. that illustrate:

- Economic value of irrigation water (LE/m^3)
- Water requirement (m^3/feddan)
- Cultivated area (feddan)
- Cost of :
    - transporting (LE/Feddan)
    - agriculture service (LE/ Feddan)
    - irrigating (LE/feddan)
    - fertilizing the wheat crop (LE/ Feddan)
    - harvesting (LE/ Feddan
    - pests (LE/ Feddan)
    - preparing the land (LE/ Feddan)
    - rent of land (LE)
    - seeds (LE/ Feddan)
    - cultivating of land (LE/feddan)
- Total revenue (LE/feddan)

3.2 Analysis the economic value of irrigation water maps

Figure (5 to 12) shows examples of the developed economic value of irrigation water maps for different crops under cereal, fibber, legumes, sugar crops, oil crops, herbalsim, vegetables, and forages categories. The detailed analysis of the developed maps showed the following:

Cereal crops:

From analysis of cereal crop maps at each governorate it concluded that: in Giza governorate, the economic value per unit of water applied for barely and sorghum reached the highest value with values 1.96 LE/ m^3 and 0.55 LE/ m^3 respectively. In Beheira governorate, the economic value per unit of water applied for wheat and rice reached the highest value with a value 2.49 LE/ m^3 and 0.49 LE/ m^3 respectively. In Dakahlia

governorate, the economic value per unit of water applied for summer and nili maize reached the highest value with values 0.90 and 0.94 LE/ m^3 respectively. Figure (5) shows, as example, the water economic value map of wheat crop.

Fibber crops:

From analysis of fibber crop maps at each governorates it concluded that: In Dakahlia and Kafr el – Sheikh Governorates, the economic value per unit of water applied for cotton and flax reached the highest value at with values of 0.79LE/ m^3 and 2.28LE/ m^3 respectively. Figure (6) shows, as example, the water economic value map of cotton crop.

Legumes :

From analysis of legumes crop maps at each governorates it concluded that: In Ismailia, Gharbia, Alexandria, Sharqia, Monufia, Minya governorates, the economic value per unit of water applied for fenugreek, broad bean, green peas, lentil, dry beans, chickpea, lupin, reached the highest value with values 1.64 LE/ m^3, 2.08 LE/ m^3, 2 LE/ m^3, 1.83 LE/ m^3, 1.0 LE/ m^3, 0.86 LE/ m^3, 1.93 LE/ m^3 respectively. Figure (7) shows, as example, the water economic value map of broad bean crop.

Sugar crops:

From analysis of sugar crop maps at each governorates it concluded that: *:* in Al - Minya and Aswan governorates, the economic value per unit of water applied for sugar beet and sugarcane reached the highest value with values 2.05 LE/ m^3 and 0.57 LE/ m^3 respectively. Figure (8) shows, as example, the water economic value map of sugarcane crop.

Oil crops:

From analysis of oil crop maps at each governorates it concluded that: in Giza, Monufia, and Alexandria governorates, the economic value per unit of water applied for peanut, sesame, soybeans and sun flower reached the highest value with values 1.62 LE/ m^3, 0.82 LE/ m^3, 0.47 LE/ m^3, and 1.29 LE/ m^3 respectively. Figure (9) shows, as example, the water economic value map of peanut crop.

Forages crops:

From analysis of forages crop maps at each governorate it concluded that: in Gharbia and Giza governorates, the economic value per unit of water applied for long_clover and

tahrish reached the highest value with values 2.19 LE/ m^3 and 2.85 LE/ m^3 respectively. Figure (10) shows, as example, the water economic value map of long clover.

Herbalism crops:

From analysis of herbalism crop maps at each governorates it concluded that: in Bani Swaif, Aswan, and Asyut governorates, The economic value per unit of water applied for basil, henna, and roselle reached the highest value with values 1.12LE/ m^3, 0.29 LE/ m^3, and 1.13 LE/ m^3 respectively. Figure (11) shows, as example, the water economic value map for henna.

Vegetables crops

From analysis of vegetables crop maps at each governorates it concluded that: : in Giza governorate, the economic value per unit of water applied for winter cabbage, summer potato, okra, potato summer, and summer zucchini reached the highest value with values 1.99 LE/ m^3, 4.83 LE/ m^3, 2.9 LE/ m^3, 4.84 LE/ m^3, and 1.77 LE/ m^3 respectively. In Sharqia governorate the economic value per unit of water applied for Potato nili reached the highest value with a value 1.91 LE/ m^3. In Bani Swaif governorate the economic value per unit of water applied for Tomato nili reached the highest value with a value 4.63 LE/ $m^{3.}$ In Monufia governorate, the economic value per unit of water applied for winter tomato and winter eggplant reached the highest value with values 4.76 LE/ m^3 and 10.03 LE/ m^3 respectively.

In Asyut governorate, the economic value per unit of water applied for cabbage winter and winter pepper reached the highest value with values 2.34 LE/ m^3 and 4.53 LE/ m^3 respectively. In Beheira governorate, the economic value per unit of water applied for onion reached the highest value with value 3.75LE/ m^3. In Suhaj governorate, the economic value per unit of water applied for winter zucchini and cucumber reached the highest value with values 3.58 LE/ m^3 and 1.28 LE/ $m^3$6.48 LE/ m^3 respectively. In Kafr el - Sheikh governorate, the economic value per unit of water applied for summer eggplant and tomato summer reached the highest value with values 2.26 LE/ m^3 and 5.49 LE/ $m^3$6.48 LE/ m^3 respectively. In Sharqia governorate, the economic value per unit of water applied for summer pepper and garlic reached the highest value with values 1.24 LE/ m^3 and 6.48 LE/ $m^3$6.48 LE/ m^3 respectively. In Al – Behairah governorate, the economic value per unit of water applied for quintalob reached the highest value with value 1.96 LE/ m^3. In Dakahlia governorate, the economic value per unit of water applied for watermelon

reached the highest value with value 3.26 LE/ m^3. Figure (12) shows, as example, the water economic value map of summer tomato.
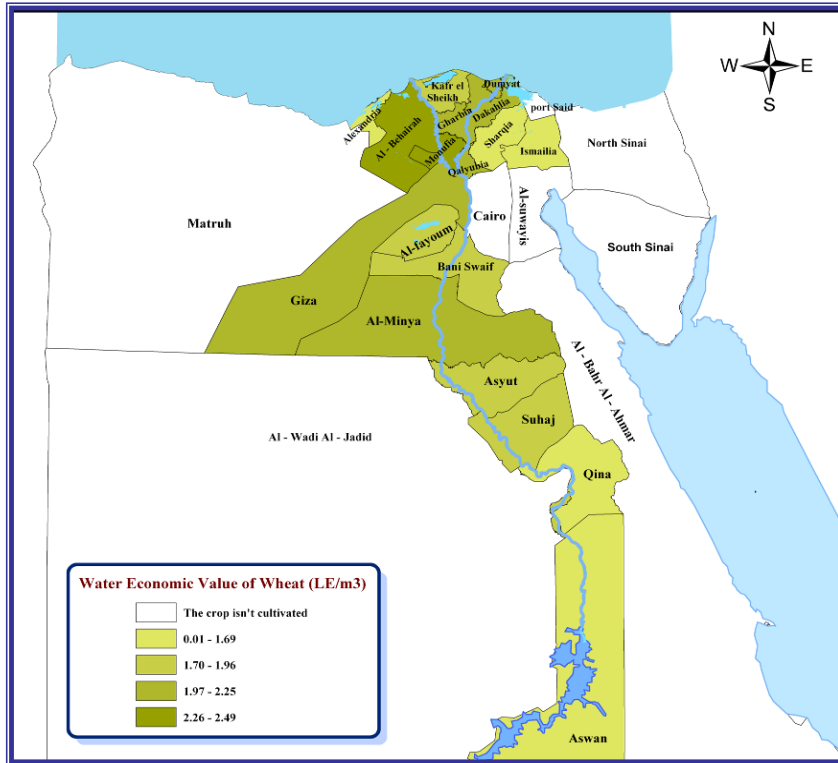

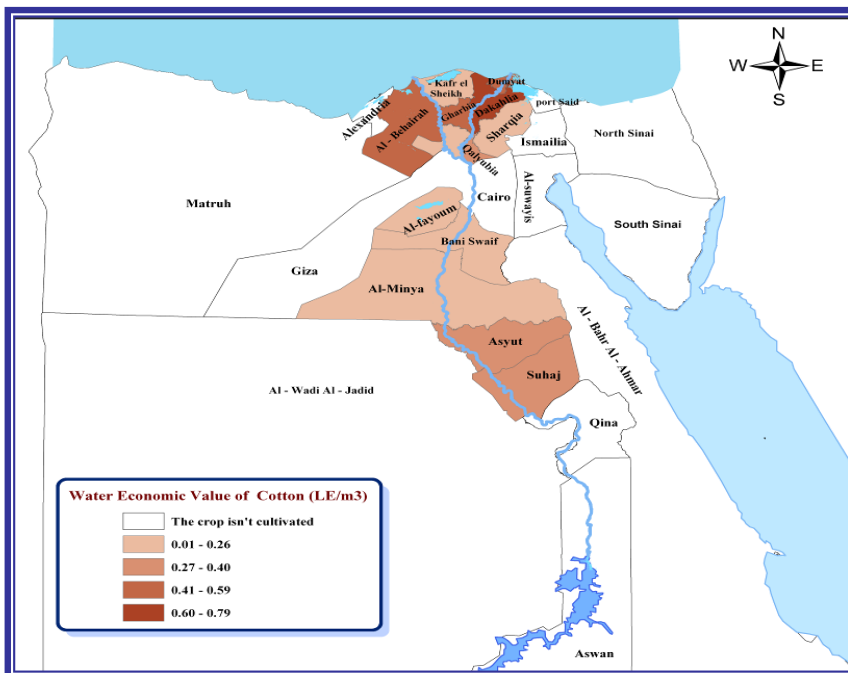**Figure (5)** Developed water economic value map of wheat LE/m^3 (2008)

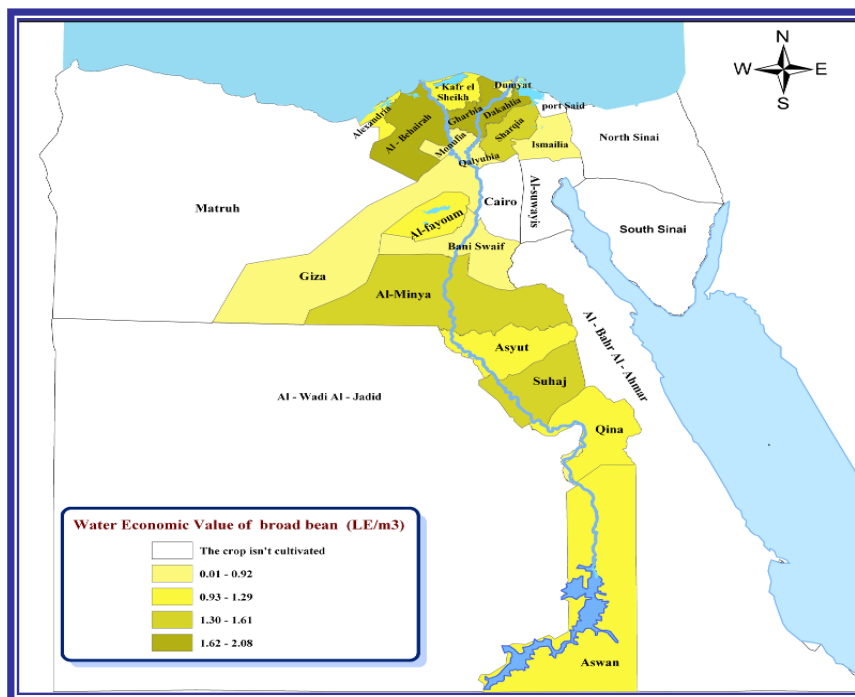**Figure (6):** Developed water economic value map of cotton LE/m^3 (2008)

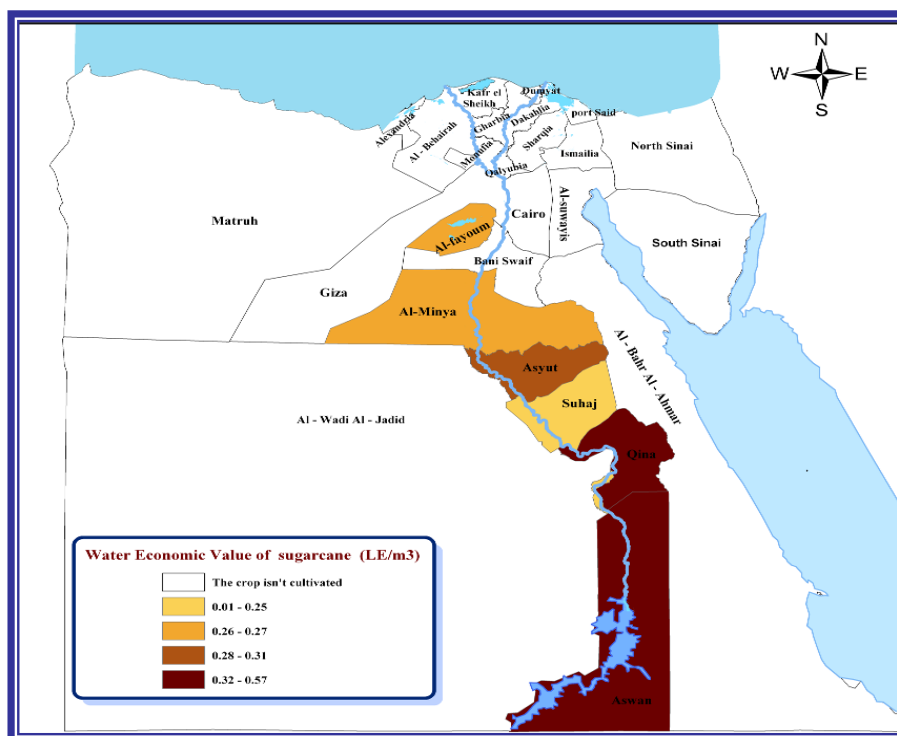**Figure (7):** Developed water economic value map of broad bean LE/m^3 (2008)

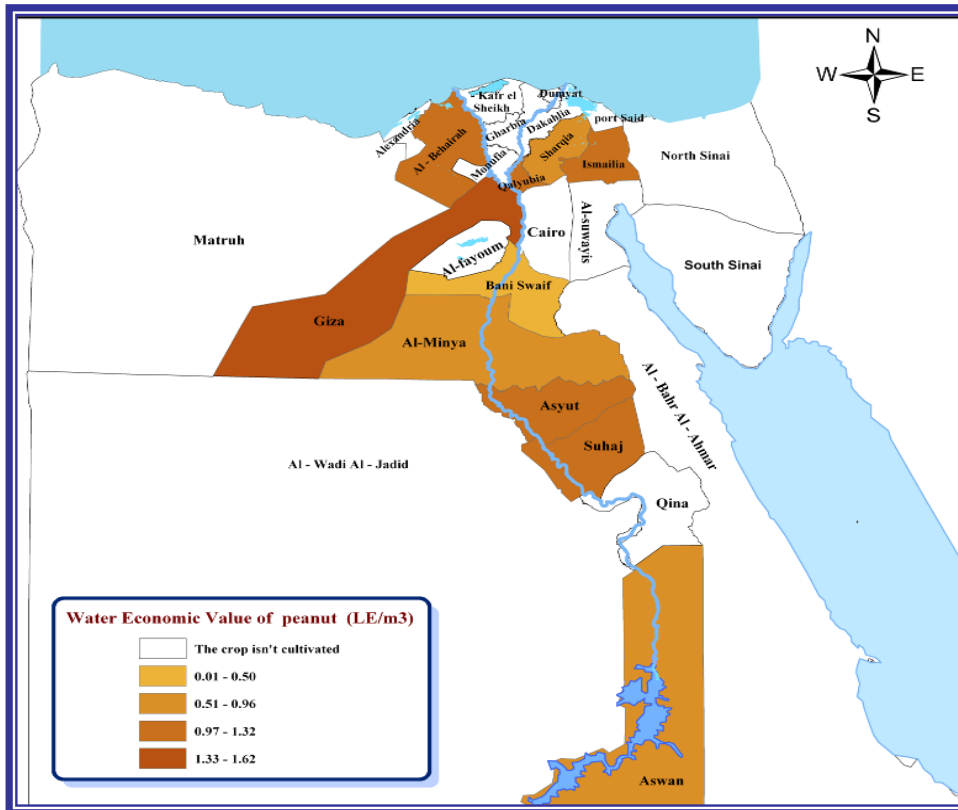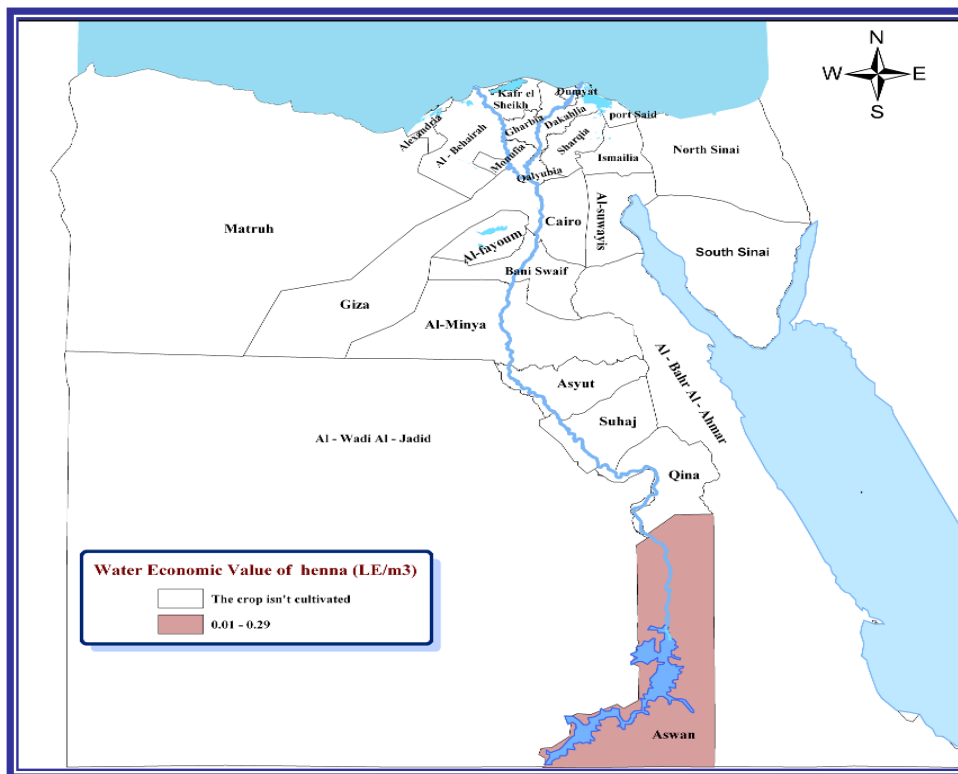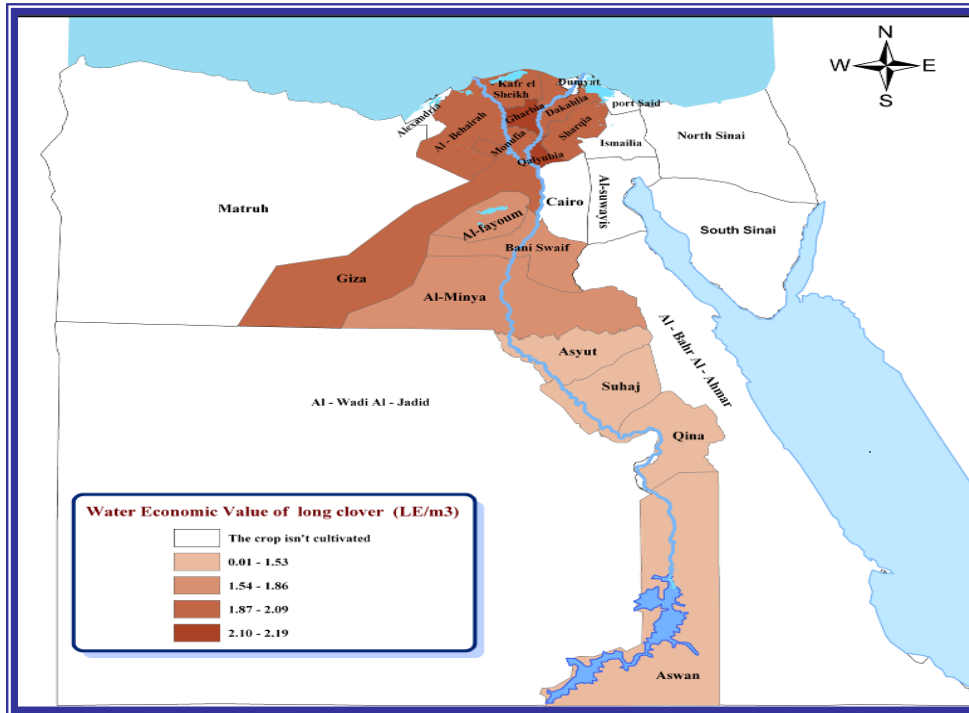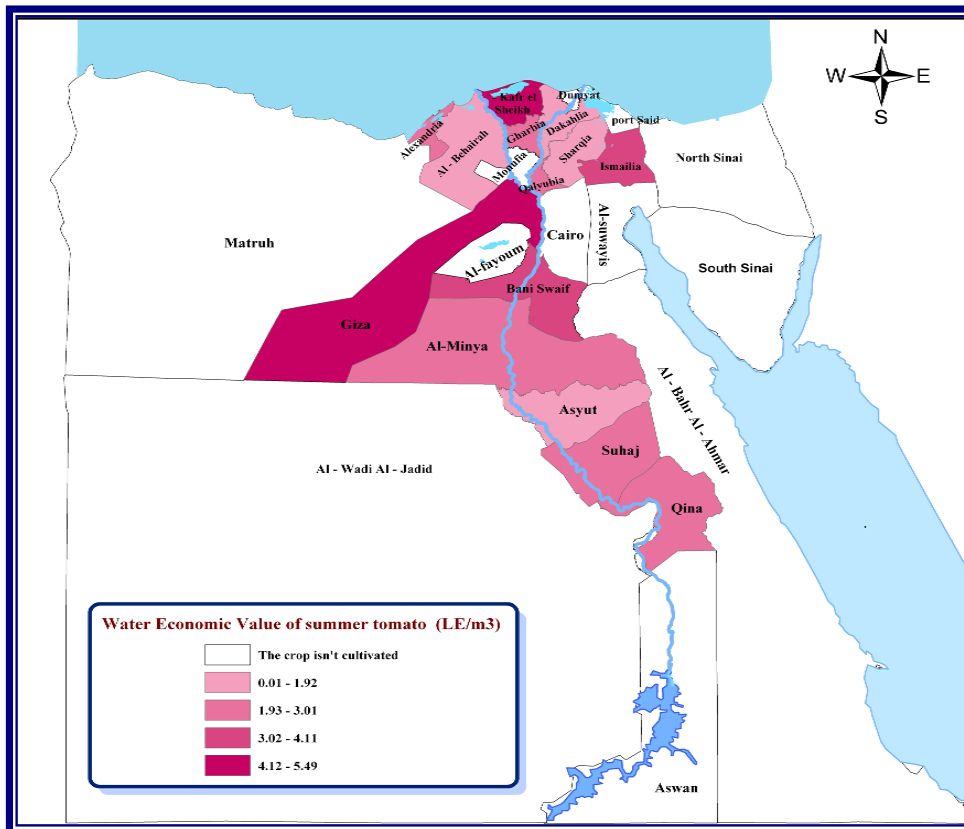**Figure (8):** Developed water economic value map of sugarcane LE/m^3 (2008)

Figure (9): Developed water economic value map of peanut LE/m^3 (2008)

Figure (10): Developed water economic value map of henna LE/m^3 (2008)

Figure (11): Developed water economic value map of long clover LE/m^3 (2008)

Figure (12): Developed water economic value map of summer tomato LE/m^3 (2008)

4. CONCLUSION:

The study developed geographic information maps that provide the researchers and decision makers with data and information maps about irrigation water and cultivated crops at the Egyptian governorates. These data and information include: cultivated area of main crops in each governorate of Egypt, cost of cultivating each crop which includes preparation of the agricultural land, seeds, irrigation, fertilization, agricultural service, pests' resistance, harvest, transportation of the crop, public expenditures, and rent of the land, total revenue from each crop which includes the value of the main crop and the value of the secondary crop, water requirement for cultivating the crops, and net return from each crop.

Moreover, economic value maps of irrigation water for crops under cereal, fiber, legumes, vegetables, herbalism, and forages categories were developed. These crops are the most important cultivated crops in years 2008. These maps are useful tool to demonstrate the economic irrigation water productivity for the researchers in the field of agriculture and water resources management to evaluate the economic performance of water use in crop production.

The analysis of the developed maps showed that the net return per unit of water applied for: 1) wheat reached the highest value generated from water use in cereal category in Beheira governorate with value 2.49 LE/ m^3, 2) flax reached the highest value generated from water use in fibber category in Kafr el – Sheikh governorate with value 2.28 LE/ m^3, 3) broad bean reached the highest value generated from water use in Legumes category in Gharbia governorate with value 2.08 LE/ m^3, 4) sugar beet reached the highest value generated from water use in sugar category in Al - Minya governorate with value 2.05 LE/ m^3, 5) peanut reached the highest value generated from water use in oil category in Giza governorate with value 1.62 LE/ m^3, 6) roselle reached the highest value generated from water use in herbalsim category in Asyut governorate with value 1.13 LE/ m^3, and 7) tahrish reached the highest value generated from water use in Forages category in Giza governorate with value 2.85 LE/ m^3, and 8) winter eggplant reached the highest value generated from water use in vegetables category in Monufia governorate with value 10.03 LE/ m^3.

From the study it is observed that economic values of irrigation water of the presented crops in the study are varied from governorate to other due to the variations in the costs and revenue of the crop production and the quantity of irrigation water. Research should focus on optimizing water allocation over the entire farm to maximize water returns, through making the best agricultural, social and environmental use of the available water resources by means of irrigation improvement, changing crop patterns, and improving the efficiency of the use of water resources. Changing cropping patterns should be on the basis of economic value of water in order to rational use of scarce water recourses considering socio-economic, environment, and political issues.

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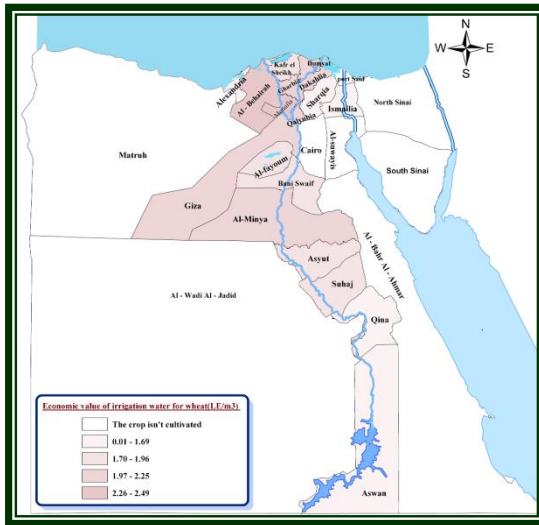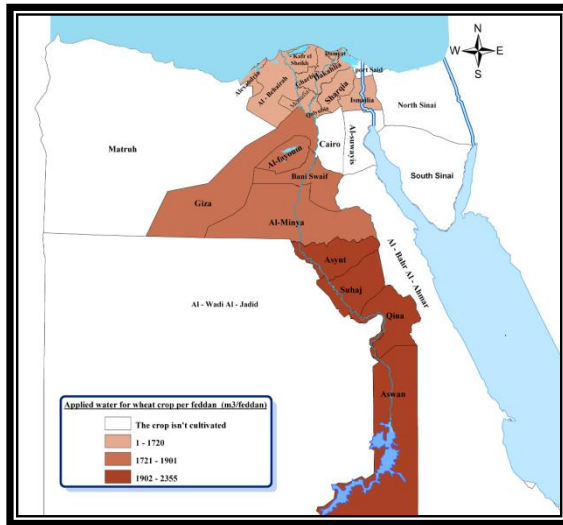
Figure (a-1): Economic value of irrigation water (LE/m^3)
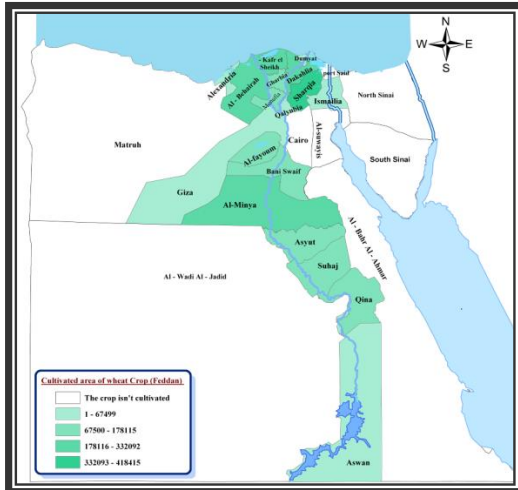
Figure (a-2): Water requirement (m^3/feddan)

Figure (a-3): Cultivated area (feddan)
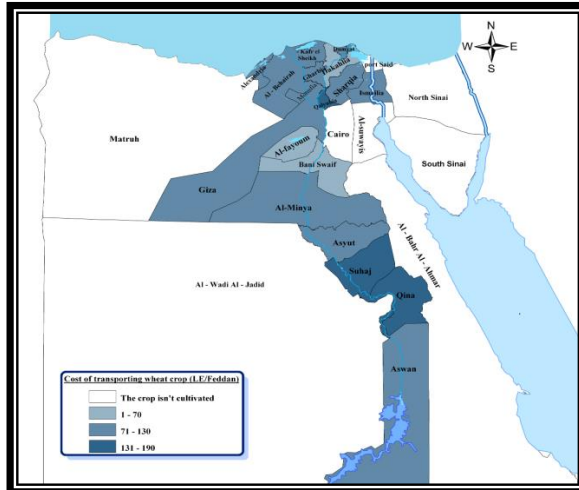
Figure (a-4): Cost of transporting (LE/Feddan**)**
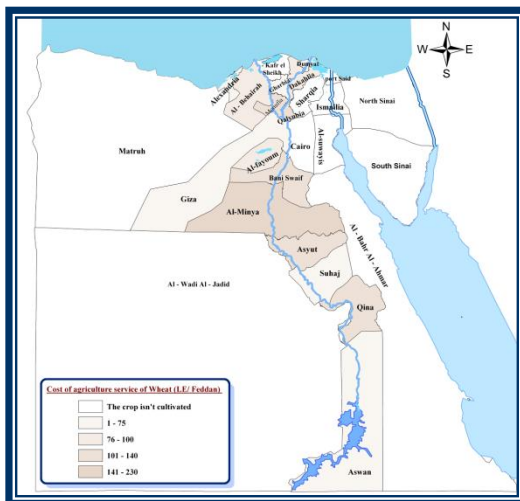
Figure (a-5): Cost of agriculture service (LE/ Feddan)
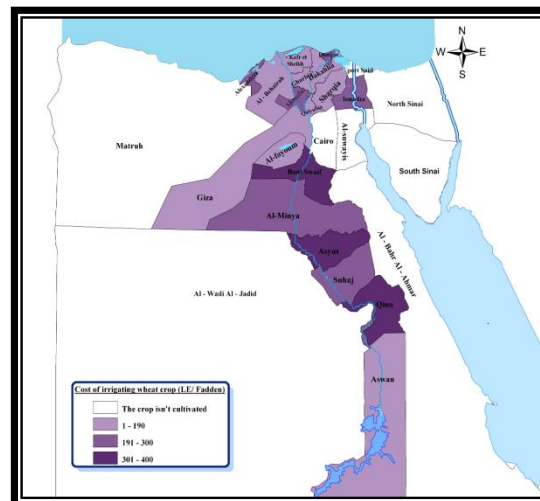
Figure (a-6): Cost of irrigating (LE/feddan)

Figure (a): Developed GIS for wheat crop

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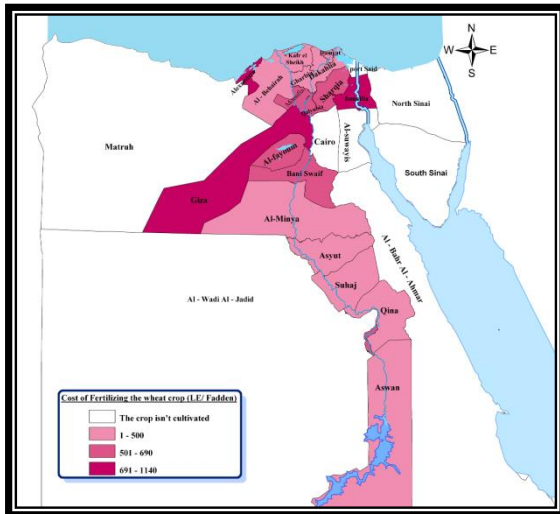
Figure (a-7): Cost of Fertilizing (LE/ Feddan)
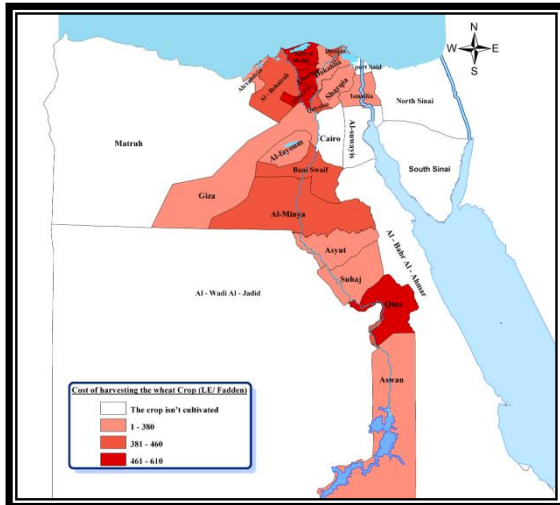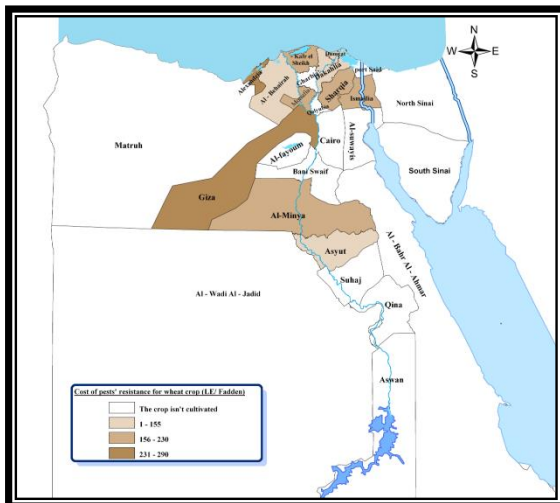

Figure (a-8): Cost of harvesting (LE/ Feddan)

Figure (a-9): Cost of pests (LE/ Feddan)
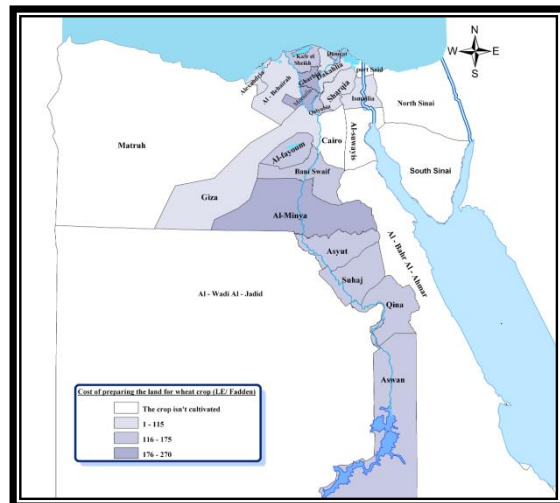
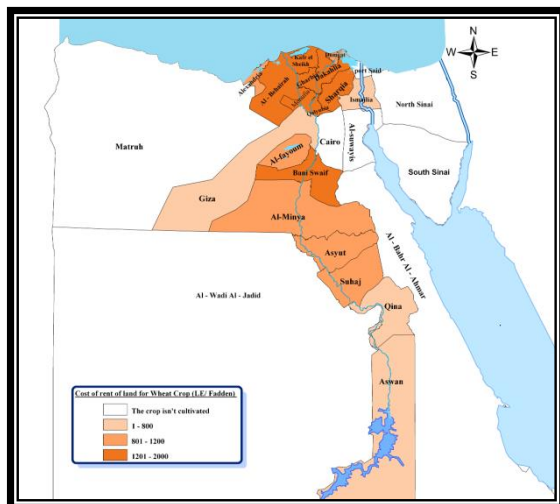
Figure (a-10): Cost of preparing the land (LE/ Feddan)

Figure (a-11): Cost of rent of land (LE/Feddan)
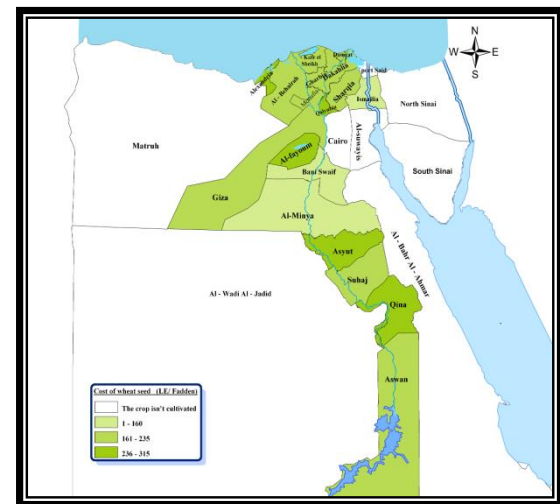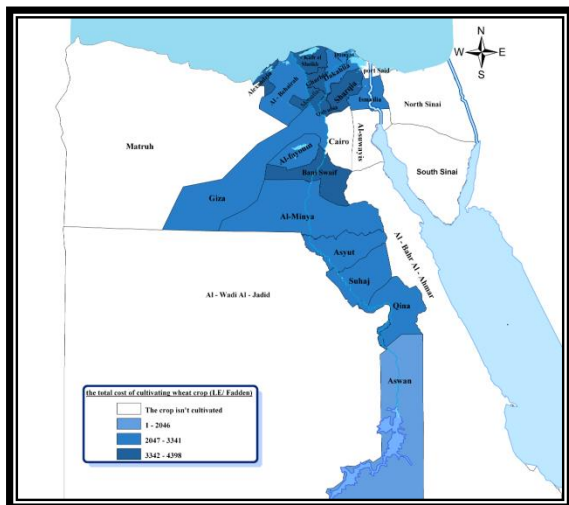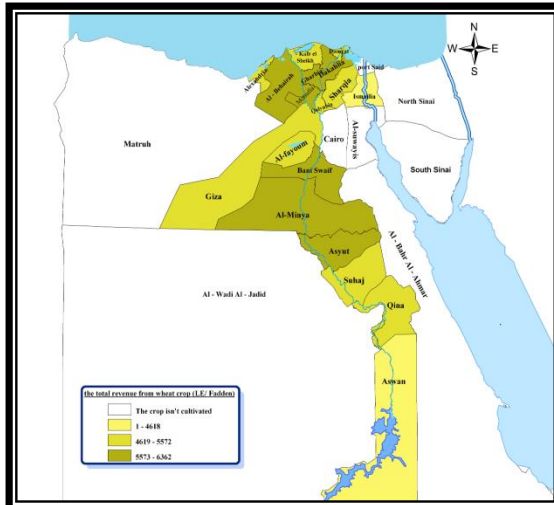

Figure (a-12): Cost of seeds (LE/ Feddan)

Figure (a): Developed GIS for wheat crop (continued)

Figure (a-13): Cost of cultivating of land (LE/feddan)

Figure (a-14): Total revenue (LE/feddan)

Figure (a): Developed GIS for wheat crop (continued)