V- SUMMARY AND CONCLUSION

The current study aims at using remote sensing and GIS techniques in precision farming of the area which located in Kalubia Governorate which lies at the south eastern part of the Nile Delta, situated between longitudes 31^0 05` and $31^0$ 25` east ,and latitudes 30^0 07` and $30^0$ 35` north. The Governorate is right adjacent to the northern side of Cairo and has an area of approximately 224,000 feddans. The investigated area represents the southern part of the Governorate with an area of 89512.86 feddans. To realize the objectives of this study, the row data of Enhanced Thematic Mapper (ETM+), SPOT5 and Hyperion images were manipulated and enhanced using remote sensing and GIS techniques. Through these images, an explanatory maps could be achieved. Eighteen soil profiles were dug to represent the different mapping units. The soil profiles were carefully described. The morphological description was carefully noted. Soil samples were collected for laboratory analyses. The soil analyses aimed at evaluating the physical and chemical properties to extract the spatial variability of soil characteristics.

The main results which obtained from conducting the current study could be summarized as follow:

Four landscapes could be identified 1- The flood plain, 2- Hummocky areas 3-Hilly area and 4-Turtle back.

1-**Flood plain:** consists mainly of the following landforms:-, decantation basins, overflow basins, recent river terraces, levee and swale.

The soil texture differs from one unit to another due to inherited geological formation. The flood plain soils vary between clay, sandy clay, clay loam, silt clay loam and silt loam. Calcium carbonate ranges between 5.50 and 24.25 g kg^{-1}. Organic matter varies from ٣.22 and 12.07g kg^{-1}. The high values indicate continuous addition of organic matter. Cation exchangeable capacity (CEC) ranges between 10.5 and 57.17 $cmole_c$/ kg. The high values are more attributed with high organic matter and clay contents. Exchangeable sodium percentage (ESP) varies between 1.9 and 15.69. The high values indicate high sodicity. Gypsum varies between 6.51 and ٢٠.٠٠ g/ kg. The high values indicate high salinity and/ or gypseferrousness. Soil pH ranges between 8.0 and 8.4. Total soluble salts differ widely from one location to anther the EC of the paste extract ranges between 0.83 and 7.64 dS/m.

2- **Soils of hummocky area** consist mainly of the following landform units: high hummocky areas, moderate hummocky areas and low hummocky areas. The soil texture differs from one unit to another due to the inherited geological formation, varying between sandy clay loam, sandy loam, loamy sand and sand. Calcium carbonate ranges between 2.35 and ٢٥.٦٧ g/ kg. Organic matter contents vary from 4.43 and 8.99 g/ kg The CEC ranges between 6.09 and ٩.٨٥ $cmole_c$/ kg. The ESP varies between 7.53 and 24.60. Gypsum content varies between 9.75 and 16.24 g/ kg. Soil pH between 7.1 and 8.2. Total soluble salts values differ widely from location to another, where the EC ranges between 0.٨٩ and 1.٣١ dS/m.

3- **Soils of hilly area:** these soils have well-defined natural elevation (small heaps, piles, or mounds) smaller than mountains. They may formed from rocks or unconsolidated materials. Soil texture varies between sandy clay loam, sandy loam and loamy sand. Calcium carbonate content range from 0.00 to 11.00 g/ kg in the different layers of the studied soil profile. Gypsum content is ranging between 4.9 and 10.0 g/ kg. The soil pH values vary between 7.9 and 8.0 Organic matter content ranges between 8.0 and 15.0 g/ kg and decreasing with depth regularly. Cation exchange capacity varies from 11.0 to 17.4 cmolc/ kg soil. The ESP values range between 2.47 and 7.73 Soil salinity values revealed that, the electric conductivity (EC) is low. It ranges between 0.91 and 1.00 dS m^{-1}.

4-**Soils of turtle back:** Their soil texture differs due to inherited geological formation (sub-deltaic deposits), varying between loamy sand and sandy loam. Calcium carbonate ranges between 20.0 and 55.1 g/ kg. Organic matter varies from 0.0 to 6.0 g kg^{-1}. The CEC ranges between 7.20 and 10.98 $cmol_c$ kg. The ESP varies between 45.53 and 90.00. Gypsum content varies between 30.0 and 36.1 g/ kg. Soil pH value ranges between 8.4 and 8.6. Total soluble salts values differ widely and have a wide range and the EC varies between 12.0 and 72.40 dS/m.

Soil classification

Soil Taxonomy was done on the USDA Soil Taxonomy System **(USDA 1975)** and its update issue (USDA 20١٠). The American Soil Survey Staff (2003) is applied up to the sub-group for mapping unit, while to family level for the profile description. Matching geomorphologic units with soil characteristics and soil taxonomy, the final soil map was produced. Soil map is reduced to scale 1: 250000 from base map of 1: 50000. Geomorphologic units represented by profiles numbers and their taxonomy could be summarized follows:

Taxonomy of geomorphologic units:

Unit	Taxonomy
Soils of Flood plain: 1- soils of decantation basins	Typic Haplargids
2- Soils of overflow basins	Typic Haplargids, Vertic Torrifluvents
3- Soils of recent river terraces	Typic Haplargids,Vertic Torrifluvents, and Typic Torrifluvents
4- Soils of levee	Aquic Haplargids
5- Soils of swale	Typic Haplargids
Soils of hummocks	TypicTorripsamments
Soils of hilly area	Typic Torrifluvents.
Soils of turtle back	Typic Haplsalids

Spatial variability analyses of soil characteristics:

The characterization of the spatial variability of soil characteristics is essential to achieve a better understanding of complex relations between soil properties and environmental factors. Modeling of spatial dependence on soil data can be used to estimate characteristics at un-sampled locations, leading to better recommendations for the application.

The spatial variability analyses were conducted for weighted values of soil profiles concerning Calcium Carbonates, Electrical Conductivity, Exchangeable Sodium Percent, Organic Matter, macro nutrients (Nitrogen, Phosphorous, and Potassium) and micro nutrients (Iron, Zinc Manganese, and Copper).

Precision Farming:

The main objectives of adopting precision farming is to realize land and water use efficiency ,determine the profitability of precision farming environmentally and economically on the farming system level (Experimental farm-Faculty of agriculture –Banha University).

Two field practices were carried out in two successive seasons, the first season practices (2009) and the second one (2010) as follows:

First season practices of traditional farming TF (2009)

- Analyzing of the traditional/common information

- In summer 2009 Maize grains were sown at 21 May. Plant was harvested at 12 September. During this period, the plant growth and field conditions were observed accurately day by day without any interference to recognize the effect of traditional farming on plant growth and its yield.
- After harvesting Characteristic of the experimental field soil have been determined to can evaluate the fertility status and calculate the precised amounts of the fertilizers based on the grid soil sampling. The results showed a positive correlation

between soil characteristics and the yield of the first season (2009).

-Yield map under traditional farming: The variation in yield levels for maize is clearly monitored. Characteristics were analyzed to display yield map and potential fertilizers application.

- Second season practices of PF (2010):

-Variable Rate Technology and application (VRT and VRA): Variable rate technology was applied in limited scale. Handy GPS was used to locate the plots boundary. The GIS system used this positional information from the GPS to access data about the field at specific location. Information is then sent to the operator about the field conditions. Using predetermined calculations allowed the required amount of fertilizers to be distributed.

-Mapping soil characteristics of the experimental field: Geostatistical analyst was used to provide spatial soil characteristics. Kriging interpolation technique used grid sample points to produce continuous surfaces of fertility and some soil properties by filling gabs between points.

-PF management practices: The average of the field soil characteristics was determined to decide the fertilizer application levels for all eighteen locations (plots 1-18). The obtained information was combined with regular field survey, accurate identification and diagnosis of the existing problems for a successful crop management program. The variation in N and P recommendations associated with their costs for the field unit are calculated.

- **Water consumption use:** The surface energy balance algorithm for land (SEBAL) model was used for estimating crop (ET_c) with the aid of thermal bands of satellite images (+ETM) and mapping spatial distribution and seasonal variation of ET_c on the experimental field scale under local climatic conditions of Klubia governorate. The ET_c ranged from 3.15 to 6.5 mm per day. Irrigated maize in the investigated field, with no apparent water stress, evaporates at a maximum rate of 3.15 - 5.4 mm per day, almost the same as Penman-Monteith results. The results showed that total water consumption averaged 571.5 mm for maize grown without water deficit. So total water consumption use for maize in the investigated field under PF using the advanced techniques is determined by 2307.33 m^3 compared with 2996.53 m^3 water under TF saving an amount of water equal to 689.20 m^3.
- **PF Yield mapping:** Yield data are sent to the on-board computer where measured yield is matched with its appropriate field position and NDVI obtained from satellite images. The obtained data were transferred to a yield map using Arc GIS software. It is noticed that, there is a dramatically change in plots yields after applying PF where.
- **Correlation Analysis of NDVI vs. Maize yield:** A positive correlation was obtained between NDVI and the yield.
- **Economic and Environmental profitability of PF on the experimental farm level:** The economic profitability of precision farming is as variable as field conditions. In highly uniform fields, better knowledge of soil and plant parameters

is not as likely to result in greater economic return as it is in fields with variable conditions. the costs of applying PF were lower than TF, the productive area increased achieving high returns where, total returns were increased from 2084.46 to 2794.42 LE (34.06 %). The economic profitability (Returns-costs) recorded 1110.96 LE for TF and 1952.74 LE for PF respectively representing an increase of (56.90 %). From the environmental point of view NPK application decreased in all zones. This decrease in fertilizers use reduce the environmental hazards especially pollution by excessive nitrate.

- **Economic and Environmental profitability of PF on the studied area level:** Cultivated area with maize crop was identified using the hyperspectral imagery. The total cultivated area with maize has been defined by 19107 feddans. Applying Precision Farming on the study area level had led to both economic and environmental profitability

(a) Economic Profitability:

Economic profitability has been realized as follows:

(1) Yield under TF = Cultivated area*Yield (Ardab)/feddan

=19107 x 20

= 382140 Ardab. (1 Ardab maize = 140 kg)

(2) Return under TF = yield x price

= 382140 X 98 (price of 1 maize Ardab = 98 LE)

= 37449720 LE.

(3) Yield under PF = Cultivated area*Yield/feddan

=19107 x 27.8

=531174.6 Ardab.

(4) Return under PF = yield x price

= 531174.6 x 98

= 52055110.8 LE.

(5) Yield difference between PF and TF = 531174.6 – 382140

=149034.6 Ardab.

(6) Net return = yield x price

= 149034.6 x 98

= 14605390.8 LE.

(b) Environmental profitability:

Under TF the amounts of applying fertilizers on the studied area were 2292840 kg N (120 Kg N/Fed) and that equals to 6687450 kg urea (350 kg/ Fed.). For phosphorous the total added amounts were 129927.6 kg P (6.8 kg P/Fed) and that equals to 1910700 kg single super phosphate (100 kg/ fed. and that are large amounts of fertilizers causing an Environmental hazards especially for nitrogen represented in the pollution with nitrate. On the other side the amounts of fertilizers have been decreased in PF practices to record 540345.96 kg N and that equals to 1175080.5 kg of urea. Four phosphorous the total added amounts are 60951.33 kg P (3.19 kg P/Fed) and that equals to 1024517.34 kg single super phosphate (53.62 kg/ fed). The saved fertilizers amounts are 1752494.04 kg N (**5512370** kg urea) and 68976.27 kg P (**886182.66** kg super phosphate) and that is clear this is going to make the environment be more clean and safe.

Precision Farming Spatial model (PFSM)

The study developed precision farming spatial model to identify the most appropriate areas/fields for precision farming based on the interaction among physical /chemical soil properties using spatial analysis tools in ARCGIS environment. The model input included six variables i.e., EC, ESP, CEC, Gypsum content, $CaCO_3$ content and OM content.. The model resulted in five precision farming classes 1-Farms does not meet the requirements of precision farming 2-Farms below the threshold of precision farming 3-Farms meet the threshold of precision farming practices 4-Farms above the threshold of precision farming practices 5-Farms meet the requirements of precision farming.