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LIST OF ACRONYMS

ALES	: Automated Land Evaluation System
CCRS	: Canadian Center for Remote Sensing
DEM	: Digital Elevation Model
DSS	: Decision Support System
EIA	: Environmental Impact Assessment
ES	: Expert Systems
ETM	: Enhanced Thematic Mapper
EU	: European Union
FAO	: Food and Agriculture Organization
FCC	: False Color Composite
FESLM	: Framework for Evaluating Sustainable Land Management
FTP	: File Transfer Protocol
GCPs	: Ground Control Points
GIS	: Geographic Information System
GPS	: Global Position System
INRM	: Integrated Natural Resource Management
ISSS	: International Soil Science Society
JARS	: Japanese Association for Remote Sensing
LECS	: Land Evaluation Computer System
MicroLEIS	: Micro Land Evaluation Information System
MSS	: MultiSpectral Scanner
MUR	: Map Unit Record
NASIS	: National Soil Information System
NATSGO	: National Geographic Database
NCSS	: National Center for Soil Science
NDVI	: Normalized Deference Vegetation Index
NRC	: National Research Council
NRM	: Natural Resource Management
OIF	: Optimum Index Factor
PCA	: Principle Component Analysis
RMSE	: Root Mean Square Error
RS	: Remote Sensing
RSQI	: Relative Soil Quality Index
SALTMOD	: Salt Modeling software
SAR	: Synthetic Aperture Radar
SCR	: Soil Characterization Record
SDSS	: Spatial Decision Support System
SIR-A	: Shuttle Imaging Radar

SIS	: Soil Information System
SLM	: Sustainable Land Management
SOTER	: Soil and Terrain Database
SQI	: Soil Quality Index
SSURGO	: Soil Survey Geographic Database
STATGO	: State Soil Geographic Database
TM	: Thematic Mapper
TUR	: Taxonomic Unit Record
UTM	: Universal Transverse Mercator
VB	: Visual Basic
VDEMINT	: Vector Digital Elevation Model Interpolation

5- SUMMARY AND CONCLUSIONS

The study aimed at assessing the land resources of El-Behira Governorate through integrating the up-to-date information technologies represented by GIS, RS and modeling to build up geo-referenced database at multi spatial scale (El-Behira Governorate, Wadi El-Natrun District and Wadi El-Natrun Farms), in order to characterize and evaluate the available land resources, quantify the changes of land use, evaluate the suitability of soil units for specific uses for Wadi El-Natrun District, assign the sustainable development of Wadi El-Natrun farms and study the profitability of agriculture farm production.

1. El-Behira Governorate (macro scale level):

- The digital analysis of Landsat TM7 satellite image acquired in December 1999 indicated that the dominant land use/ land cover classes are alluvial cultivated land (3901.14 km^2), sandy soil (1659.56 km^2) and calcareous soils (1655.07 km^2).
- The alluvial cultivated land is distributed all over the governorate expect Wadi El-Natrun district which is dominated by sandy and calcareous soils. The fish farms are spread over two districts namely Abu Homos and Idko in the northern part of the governorate.
- The delineation of the waterways from the satellite image indicated that the total length of the main irrigation network is 601.5 km, the longest one is Sahil Marqus (104.56 km), and the shortest one is Abdel Kader canal (10.84 km). The total length of the main drainage network is 584.39 km, the longest one is Shubra Khit drain (68.34 km) and the shortest one is El-Riko drain (7.53 km).

- El-Behira Governorate has 13 districts, which covers 9247.86 km^2, Wadi El-Natrun district is the largest one and has about 31.28% of the total area of the governorate and El-Rahmania is the smallest one and covers about 1.0% of the total area.
- El-Behira Governorate could be divided into four main physiographic units: foreshore plain having 10.42%, young alluvial plain covers 37.95%, old alluvial plain occupies 27.44% and the structural plain represents 21.44% of the total area of the governorate.
- There are five main aquifers at El-Behira Governorate, namely, the Nile Delta aquifer, the Holocene aquifer, the Pleistocene aquifer, Wadi El-Natrun aquifer and the Moghra aquifer
- Land elevations ranged from sea level to 20m ASL for the northern part, and -20m BSL to 210m ASL for the southern part. El-Behira Governorate is characterized by an almost flat slope, which ranges from 0-2% covering about 98% of the total area. The dominant aspect is the north facing direction, which represents about 62.42% of the total area.
- Based on the soil map of Egypt at scale 1:100,000; El-Behira Governorate could be classified into three orders, namely, *Entisols*, *Vertisols* and *Aridisols* having areas of 4648.09 km^2, 2297.40 km^2 and 1775.1 km^2 respectively. The rock outcrops occupies 572 km^2 and is found in the southern part of the governorate. The high sand dunes occupy 430 km^2 to the south.

2. Wadi El-Natrun District (meso scale level):

- The most informative bands combination are TM2 (green), TM3 (red), and TM4 (near infrared), which have the highest Optimum

Index Factor (OIF) for both El-Behira Governorate (88.95) and Wadi El-Natrun District (32.3).

- Change detection of cultivated areas was identified and quantified using two satellite images (MSS acquired in July 1985 and Landsat TM7 acquired at December 1999). The analysis of the two images showed that the area reclaimed in this period (14 years) was about 18533 feddans.
- Based on the hybrid digital processing of Landsat TM7 image, field truth and laboratory analysis of soil profiles, the dominant soil orders are *Entisols* and *Aridisols*. The prevalent taxonomic soil units are *typic torripsamments*, having about 56% of the total acreage, followed by *Petrocalcic petrogypsids* having about 21% of the total acreage, then *Typic calcigypsids* having about 10% of the total acreage. Other taxonomic units had a small areas ranged between 0.29 - 3.00%.
- Wadi El-Natrun district is covered by 12 topographic map sheets at scale 1:50,000. The study is concentrated on the part of the district bounded by Alex-Cairo desert road to the north having total area 2413.04 km^2. This part is considered undeveloped, and have little agricultural activities.
- Elevations resulted from DEM analysis ranged from -20m BSL and 20m ASL in the northern part covering about 13.00% of the total acreage, the southern part is considered to be very complex in elevation and varied from 20m to 210m ASL. The highest elevation represents Gabal Hadid. The slope is almost flat (0-2%) and covers about 91% of the total area. It is noticeable that

the directions facing north (N, NE, NW) are the dominant aspect classes and represent 37.12% of the total area.

- There are seven main catchment areas (drainage basins). Drainage basin No. 2 has an area of about 304.7 km^2, followed by Wadi Raqabit El-Hit drainage basin, which covers about 216.74 km^2 of the total acreage. Moreover, there are other five main drainage basins, which occupy about 231.72 km^2.
- Land capability was carried out using MicroLEIS 2000 software, where classes were class S2 represented about 80%, S3 occupied about 14%, and class N has about 6% of the total acreage. The main limitations are soil and erosion risk.
- Land suitability classes for six specific land uses, namely, wheat, corn, alfalfa, citrus, olive and peach. The best suitability classes for wheat, corn and alfalfa were S4, and had 80% of the total acreage, whereas the suitability class for olive was S2 and peach S3 representing 57% of the total acreage. The limitations were texture, depth, salinity, calcium carbonate content, sodium adsorption ratio and drainage.
- Relative Soil Quality Index (RSQI) was calculated, and the table below indicate that the cultivated soil has RSQI classes I, III, V, whereas the non-cultivated soils has RSQI classes III and V.

Soil units	RSQI	RSQI class
Cultivated Soil Units		
Typic petrocalcids	99.58	I
Typic Calcigypsids	76.03	III
Calcic Petrogypsids	52.47	V
Typic Torripsamments	52.62	V
Non-Cultivated Soil Units		
Typic Psammaquents	76.45	III
Aquic Haplocalcids	74.58	III
Typic Haplocalcids	53.17	V
Calcic Haplosalids	30.86	V
Typic Aquisalids	29.28	V

- The effect of agricultural practices on soil quality indicates that RSQI of *Typic Torripsamments* and *Calcic Petrogypsids* soil units has been greatly increased, which means that the agricultural practices has improved the soil quality. On the other hand, RSQI for *Typic Calcigypsids* and *Typic Petrocalcids* soil units was greatly decreased (< -10), which could be attributed to the dependence of soil quality on %sand, Kh, and SP%. These soil properties are affected by the addition of sand in the trees pits, which lower the RSQI for these units.
- The effect of crop type on soil quality indicated that olive improved the characteristics of *Typic Torripsamments* unit, due to the longer period of plantation. Peach, citrus, grape, Guava, clover and vegetables also improved the soil quality, but at a lower extent. Regarding *Calcic Petrogypsids* unit, citrus had the greatest increase. Concerning *Typic Petrocalcids* unit, ĆRSQI had greatest decrease for citrus, grape and peach, due to the addition of sand in the trees pits. Vegetables were planted on a lower soil quality unit, due to land leveling and removal of the fertile topsoil, then cultivation.
- Before reclamation there were 3 RSQI classes (I, III, and V). The dominant RSQI class was V, which characterized about 91% of the total number of the farms in the study area. On the other hand after reclamation, another two RSQI classes (II and IV) had been created, and characterize 15% and 27% of farms, respectively. Class V decreased to 21%, and the dominant class was class III, which characterized 33% of the total farms in the study area.

- The most important water bearing formations in Wadi El-Natrun District and its vicinity are the Pleistocene aquifer, the Pliocene aquifer and the Miocene aquifer

3. Wadi El-Natrun farms (micro scale level or farm level):

Soil and water characterization:

- There were 44 agricultural production farms having a total area of 5463 feddans, as well as one recreational resort named Abu Shady farm having an area of about 300 feddans, with 40 rooms capacity for tourism, and 3 fish farms.
- The dominant soil units were *Typic Calcigypsids* (1.28%), *Typic Torripsamments* (60.88%), *Calcic petrogypsids* (22.15%), and *Typic Petrocalcids* (15.69%). The farm elevation ranges from _10.25 m B.S.L. to 160.00 m A.S.L.
- The quality of well water samples collected from the farms was C1, C2 and C5. The main limitations were chloride, sodium, nitrate, and salinity.
- There are high correlation between well water quality and the distance form the lakes. This means that, by going away from the lake, the quality of well water improves significantly. This conclusion was affirmed by correlating water quality variables with distance from lake, which indicates a significant negative correlation for the all variables.

Sustainability indicators:

- Seven groups of indicators were involved in the assessment of sustainable development classes (SDC's). It is obvious that the main SDC's are classes II, III and IV.

- The main limitations are education and health, which prevail in almost all farms. Standard of living limitation was found in only 3 farms, because the workers are uneducated and earn low salary.
- Natural resources limitation was found in one farm due to the deterioration of soils and water characteristics, as this farm is located in the depression, and is very close to the salt marches.

Farm economic analysis:

- The farms were classified according to acreage into 3 classes, namely, class I (small, < 20 feddans), class II (medium, 20-100 feddans) and class III (large, > 100 feddans)
- It is clear that large farms had the highest gross annual income (16,252 L.E./feddan/year), followed medium farms (11,572 L.E./feddan/year), then small farms (7,113 L.E./feddan/year). This is due to the larger farm acreage, as well as the dependence of the larger farms on the cultivation of fruits, which have a high economic return, and the operational expenses are low, as the growth season is limited to 3-4 months/year.
- Class III (large farms) had the highest net farm income, followed by class II (medium farms) and class I (small farms), due to the larger cultivated acreage, the presence of farm machinery, the technical consultations, and the trained labor. The production of large farms is used mainly for export. Concerning profit, 62% of class I farms (nos. 1, 6, 13, 16, 17, 25, 26, and 29) had negative income (losses) due to use of low quality irrigation water (C5), and planting low quality soils (class V due to soil salinity), as well as cultivating low cash crops (vegetables and field crops).

Based on the analysis findings, the following specific conclusions could be drawn for Wadi El-Natrun district:

1- National development plan should pay a great attention to this area, as an integrated agricultural-industrial-touristic complex, and considered as an important source of national income.

2- All governmental authorities should be cooperated in such a way to provide the district with the necessary infrastructure (roads, educational facilities, medical care facilities, ... etc.), in order to flourish it, and make it a paradigm for sustainable development, and a gravity-center for investment.

3- Environmental Impact Assessment (EIA) studies are vital for any development project to be carried out, in order to maintain the natural resources of the area, and protect it from degradation, pollution, and deterioration.

4- A buffer zone (1.5 - 2 km) should be created around lakes, and no activities should be carried out in this area, in order to preserve it from pollution and deterioration.

5- The quality and quantity of deep aquifers have to be carried out and taken into consideration for future land reclamation and agricultural development projects.