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SUSTAINABLE AGRICULTURE DEVELOPMENT OF SIWA OASIS, WESTERN DESERT, EGYPT

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ABSTRACT: *Siwa oasis is a natural depression about 23m below sea level. It occupies an area of 1050 km2. Siwa depression covers some 250,000 feddans, of which about 23095 feddans are currently cultivated in 2010. Agriculture represents the main source of the Siwan economy, essentially focused on cultivation of dates and olives which cover about 93.4% from the cultivated area. The total number of inhabitants in Siwa was about 23,745 residents in 2010. It suffers many environmental problems: water logging, soil salinization, the inefficiency of disposed drainage water systems; deterioration in land productivity, Agriculture represents the basis of the Siwan economy.*

The article aims to improve the social and economic of Siwa, through improve environmental conditions is conducive to improving soil and Groundwater, which leads to increased productivity, and thus increase the income of farmers and social indicators to achieve sustainable development. The rate of change depends on the extent of progress in reduce the Environment problem; using the development of mathematical models the Autoregressive Integrated Moving Average (ARIMA) with geographic information systems (GIS) and Remote Sensing (RS) that lead to the assessment of sustainable agriculture development, as well as its impact on social and economic of the Siwan community.

The present social and economic impact of environment problem (2010): the cultivation of olive in Siwa Oasis loses annually about 64.83 Million LE against 40.67 Million LE of date palm, which amounts to 105.50 Million LE annual. The future economic impact of environment problem (2030): The cultivation of olive in Siwa loses annually 248.23 Million LE versus 127.17 Million LE of date palm, which amounts 375.40 Million LE annual result of the environmental problems, hence there is need to improve the environmental situation, Solving the Environmental of Siwa problem to achieve sustainable development: Put restrictions on the arbitrary digging of wells. Redeveloping the agricultural drains and irrigation. Pumping part of the excess water outside the Oasis to the Tabaghbagh Depression which cost about 13.29 US$. The organizational situation should be resolved as quickly as possible.

Key words: *Sustainable agriculture development, environmental problems, land use, water use.*

INTRODUCTION

Siwa oasis is a natural depression of about 23m below sea level. The total number of inhabitants in Siwa was about 23,745 residents in 2010(SIC, 2010). The main activity of Siwa oasis is agriculture which depends upon the groundwater that outflows from about 1435 wells and springs, giving a total annual discharge of the order 275 million m^3. Out of which, about 240 million m^3 are used as in different activities, while the remainder goes to the natural lakes. Thus, the annual surplus groundwater estimated reaches 35 million m^3 which causes significant water logging (*Ministry of irrigation, 2006*).

Siwa depression covers some 250,000 feddans, of which about 23095 feddans are currently cultivated in 2010. Agriculture represents the main source of the Siwan economy, essentially focused on cultivation of dates and olives which cover about 93.4% from the cultivated area, with limited cultivation of other crops for home consumption, and small numbers of

domestic animals for home use. The animals are an integral part of the agricultural system (IUCN, 2000).

The article aims to contribute to the social, economic and environmental development of Siwa through a conservation of natural resources and the sustainable development of agricultural production so as to increase the household income of the rural population. Sustainable agricultural together with the diversification of economy pursued by the Siwan community and controlled by them is a crucial element for the strengthening and defence of the local society which would, in turn, help it in taking care of environmental conditions, their impact on agriculture to identify priorities for developmental beginning with areas of high potential and less vulnerable to environmental problems.

The Research Problems

Siwa Oasis suffers many environmental problems, the most important of which can be classified as follows:

1. Rising groundwater table levels in the soil zone during summer and winter especially when the profile is thin, which causes water logging for cultivated land (Parsons, 1963). This leads to salinization and consequently soil deterioration which in turn results in lowering crop productivity by more than 60%. (Abo Ragab, 2010).
2. Random and constant drilling of shallow water wells and improper water management, in additional to the inefficiency of disposed drainage water (Misak, 1988), have contributed to an increase in the deteriorated lands that reached 475 km^2 representing about45.24% of the overall area in the oasis in 2010.
3. The distribution of irrigation and drainage systems affects the rate of evaporation during the summer (25 mm/day) leading to the development of a thick salty layer that hampers agricultural activities (El Hossary, 1999)
4. The groundwater affects the foundations of buildings or the development of cracks in the walls due to water fluctuation (Eman, 2005).

All these reason's collectively contribute to; (a) water logging, (b) soil salinization, (c) increase of the surface area of the water ponds from 49.9 Km^2 in 1988 to 89 Km^2 in 2010, (d) the rise of the water level in the soil deposits by 4.5 cm/year, (e) deterioration of land productivity and, (f) reduce the household income of the rural population.

Objectives

The article aims to contribute to the conservation of natural resources and the sustainable development of agricultural production so as to increase the household income of the rural population of Siwa Oasis with full involvement of the community focusing on:

- better use of natural resources (soil and water) and contributing to the conservation of the environment with improving the living conditions of the rural people;
- developing the knowledge and consciousness of the Siwan population concerning natural resources management and micro-planning;
- a viable development strategy for local institutions.

The major issues around agricultural sustainability are increasing land productivity through water quality and use, soil, biodiversity, income risks, food safety and rural development.

Methodology

In order to achieve the sustainable agriculture development through conservation soil and water management objectives, the principal research components and activities are:

1- The production of different layers for a Land Use / Land Cover Map for the

period 1990 to 2010 through tracking human activities and the development of environmental problems in Siwa Oasis in order to evaluate trends (positive or negative) over the past a few years, so as focusing on raising the people's consciousness regarding the conservation of the natural resources and their better use through the implementation of sustainable agricultural activities(su, 2000).

2- Conducting a questionnaire survey with villagers; experts and local authorities to provide information to decision makers concerning:
   1 Estimating the amount of production loss due to decreasing productivity as a result of land deterioration;
   2 Increasing household income and ensuring a more even spread income and food sufficiency throughout sustainable agriculture development for land and water resources.

3- The study has adopted the future of sustainable agriculture development using the method of the standard functions of the regression trend for the time-series forecasting models. Using Maximum Likelihood Estimation (MLE) which maximize logs probabilities of the Autoregressive Integrated Moving Average (ARIMA) (Nour, 2008), where the model contains an autoregressive [AR (p)], a moving average [MA (q)], and the degree of difference (d), (Adel, 2008). Then integrated forecasting data in geographical information systems (GIS) models have projected the forecast data in the real world coordinate systems via applying GIS layers (previous Land Use, elevation, slope, DEM, and prospect development agriculture development). Producing expected potential land use layers in 2030 to evaluate trends (positive or negative) in case of getting rid of the environment problems or the environment problems being unchanged.

RESULTS AND DISCUSSION

Land use/Land Cover form 1990 to 2010: In order to evaluate trends (positive or negative) over the past few years, the following approaches are carried out.

1 Land Use Maps: (Comparison of 1990 and 2010): A comparison between the different lakes, marshes, cultivated land, and urban during the period 1990 to 2010 bounded by the zero contour line, as indicated on different satellite image, topographic maps and other available data (for the years 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008 and 2010).

The total area of the different lakes in Siwa Oasis (1990 to 2010):

i. Data in Fig. (1) Show 6 lakes inside the concerned area. The lakes areas were estimated to be about 60.40, 61.28, 62.80, 54.20, 54.60, 58.10, 60.20, 65.50, 69.70, 75.54 and 89 km^2 in 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008 and 2010, respectively. Siwa Lake is the largest one, whereas the Aghormi and Ma'asser &Timera pools are the smallest lakes.

ii. The increase in surface area is more pronounced with respect to the western lakes while there is, more or less, a natural balance for the Timera and El Ma'asser lakes.

iii. The decrease in Lakes surface area from about 62.80 to 58.10 km^2 during the period 1994 to 2000 was due to the improvement of irrigation and drainage systems, and the closure of the well which contributed to a decrease surface area for Siwa Lake (the Ministry of Irrigation, 1996). Increasing the area to about 89 km^2 by 2010 was due to the increase of land reclamation, Fig. (1) and Table (1).

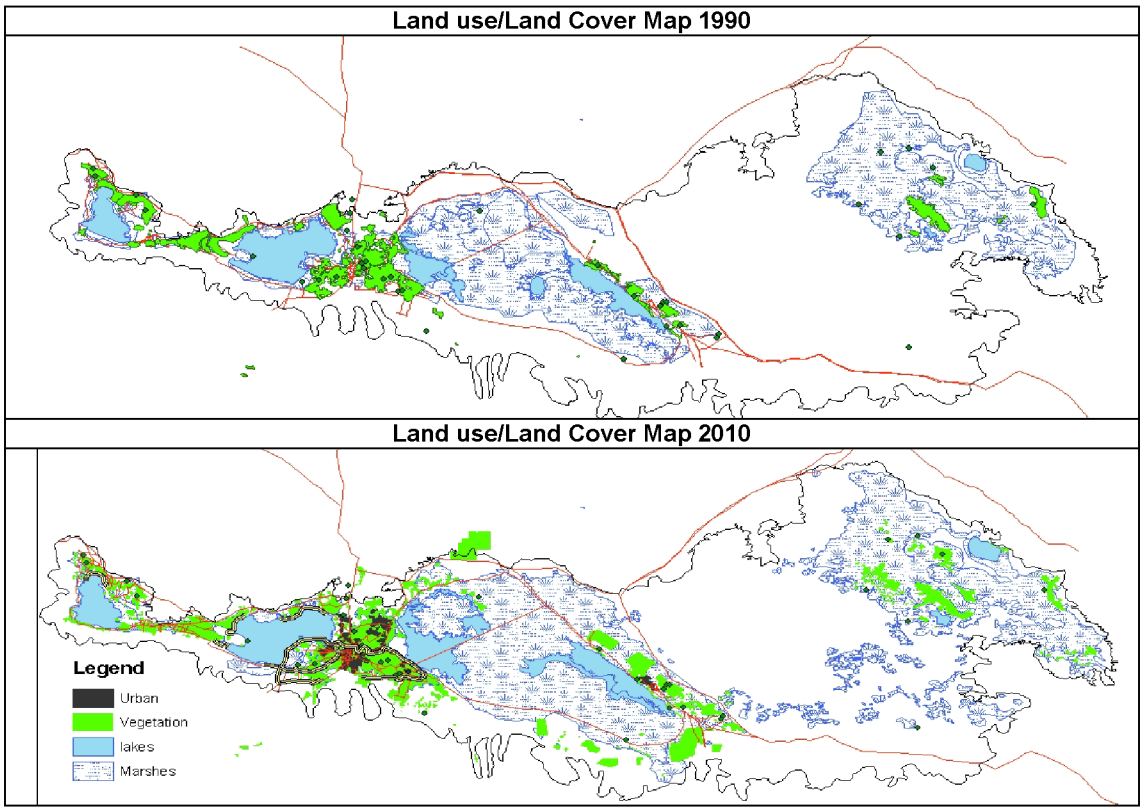

Fig. (1): Land Use / Land Cover Map 1990 and 2010.

Source of data: The construction of the Land Use/ Land Covers from 1990 to 2010 results from a three-step process: a baseline Topographic maps with administrative boundaries Reference topic over zero contour, using satellite image (TM, ETM, Spot and Quickbird) for each year to digitizing Land Use/Land cover maps for Siwa , the legend for both layout are similar, with the aid of GIS Software (ARC/GIS 10 and Imagine 10)

Table (1): Areas of different land use types in Siwa Oasis, (Km^2) from 1990 to 2010.

Year	Total area	Lake	Marshes	Cultivated area	Urban	Other
1990	1050	60	335	53	6	596
1992	1050	61	356	56	6	571
1994	1050	63	374	58	7	548
1996	1050	54	390	62	7	537
1998	1050	55	401	68	7	519
2000	1050	58	516	70	8	398
2002	1050	60	436	72	8	474
2004	1050	66	447	77	8	452
2006	1050	70	454	82	9	435
2008	1050	76	470	88	10	410
2010	1050	89	475	97	11	378

Source: from Imagine 10 and Arc/GIS 10 software using Different Land Use/ Land Covers Maps Fig.1.

The total Area of the different marshes in Siwa oasis (1990 to 2010): The area of the largest marshes was estimated, about 475 km^2, in 2010; while the smallest marshes estimated, about 335 km^2, in1990. Based on these available data, the largest marshes surround the El Zaitoon pool (207.5 km^2 in surface area) while the smallest one (0.5 km^2) is located SW of Naqab Abdel Hady, Fig.1 and Table1.

The total area of agricultural activities in Siwa oasis (1990 to 2010): The maximum cultivated area reached 97 km^2 in 2010; while being at minimum, about 53.00 km^2, in 1990, Fig. (1) and Table (1).

The total area of the different urban in Siwa Oasis (1990 to 2010): The maximum urban area was about 11.16 km^2 in 2010; while being at minimum, about 6 km^2, in1990, Fig. (1) and Table (1).

2. Sustainable Agriculture Development for Land and Water.

The article has adopted the strategy of addressing environmental issues beginning from areas of daily life which are closer to the Siwan population. Environmental issues related to water, soil and agricultural productions are easily understood. Thus the article's is focusing on raising the people's consciousness regarding the conservation of the natural resources and their better use through the implementation of sustainable agricultural activities.

Sustainable Agriculture Development of Water.

In order to attain a sustainable agricultural development of water; which leads to increase productivity, and thus increase the income of farmers and social indicators, the following steps must be implemented:

Solution of Water Environmental Problems.

Overcoming the environmental problems, (groundwater and natural resources) and conserving and protecting the natural environmental in Siwa oasis, these are outlined in the following:

A. Organizational Solutions

- Installing greater environmental awareness in Siwan population, based on a participatory approach, with the involvement of the local people (through the tribe/village committees) beside the authorities and concerned institutions at different levels.
- Greater involvement of the local authorities of villages and Siwa town in decision-making for the management of local water resources.
- Introducing new legislation for land reclamation projects, which may negatively affect the Oasis environment.
- The development of Siwa Oasis should not be attempted as one large project, but rather in phases. The result of each phase should guide the design and the implementation of the following phase.
- Introducing tight controls for the well drilling process, with a license being issued for each well.
- Shutting down of the producing wells and springs, to minimize water consumption.
- Alleviate pressure inside the depression of the Nubian Sandstone aquifer.
- Introducing restrictions for using the fresh water of the Nubian Sandstone aquifer for irrigation.
- Improving the efficiency of irrigation and the drainage network.

B. Biological Solutions

In order to control the water level in the oasis, different biological solutions are recommended. These solutions depend on minimizing the amount of the discharged water into the lakes and accordingly, preventing of land deterioration. These are outlined in the following:

- Reclaiming of 7,000 feddans aimed to consume 22 Mm^3/year of water at the footslope of the northern plateau at Um El Huse and Um El Huamel areas and the southern elevated plain.
- Transferring drain water to cultivate and fix sand dunes in south Siwa area by water loving trees as (Acacia Saligna,

Tamarix Spp., Prosopis Pallida, Agave Sisalana, Ficus Carica and Eucolyptus) (Diraz and Misak, 1992).

- Growing high-water consuming plants on the drainage area (DRC, 1988, 1996).

C. Mechanical Solutions

The study proposed two scenarios. The first scenario proposed the transfer of lake water from the Oasis to the Tabaghbagh Depression; while the second one would ensure the transfer of part of the surplus water from the most degraded lakes (Siwa and Zitoone) to the Tabaghbagh Depression (Hammad *et al.,* 2000):

A line is proposed to transfer water, based on the elevation contour, GCP and slope map, to Tabaghbagh depression, located 25 km to the east of Siwa and has a ground elevation from 20m to -80 m below sea level. The study takes into consideration the difference in relief between the lowest point in the depression (-80 m) and the highest point along the pipeline (20 m). A station for electricity generation can be constructed to produce electric power for the development of the oasis and operating the pumping station (Fig, 2).

A drainage pipeline was proposed to transfer water under gravity from Siwa to Tabaghbagh depression. The Tabaghbagh depression extends NE to a distance about150 km and has a width about 8 km.

The study estimated the cost of transporting water from Siwa to Tabaghbagh depression under two scenarios as follows:

A. The first scenario's objective is to lower the excess water surface to reduce the lakes' total surpluses (about 35 Mm^3/year) in order to expose new lands that can be reclaimed.
   1. Total Cost of Pipe Line Drainage: 9541125 US$
   2. Total Cost of Lift and Power Units: 5245000 US$
   3. Collection Units: 0817000 US$
   4. Receiving Units: 0335000 US$
   5. Relief Level: 2850000 US$
   6. 25% Other: 4697031.3 US$
   7. **Total Budget is: 23485156 US$**

B. The second scenario's objective is to transfer part of the surplus water from the most degraded lakes (Siwa and Zitoone) to the Tabaghbagh Depression.
   1. Total Cost of Drainage Pipe Line: 6190500 US$
   2. Total Cost of Lift and Power Units: 2385000 US$
   3. Collection Units: 0210000 US$
   4. Receiving Units: 0150000 US$
   5. Relief Level: 1700000 US$
   6. 25% Other: 2658875 US$
   7. **Total Budget is: 13294375 US$**

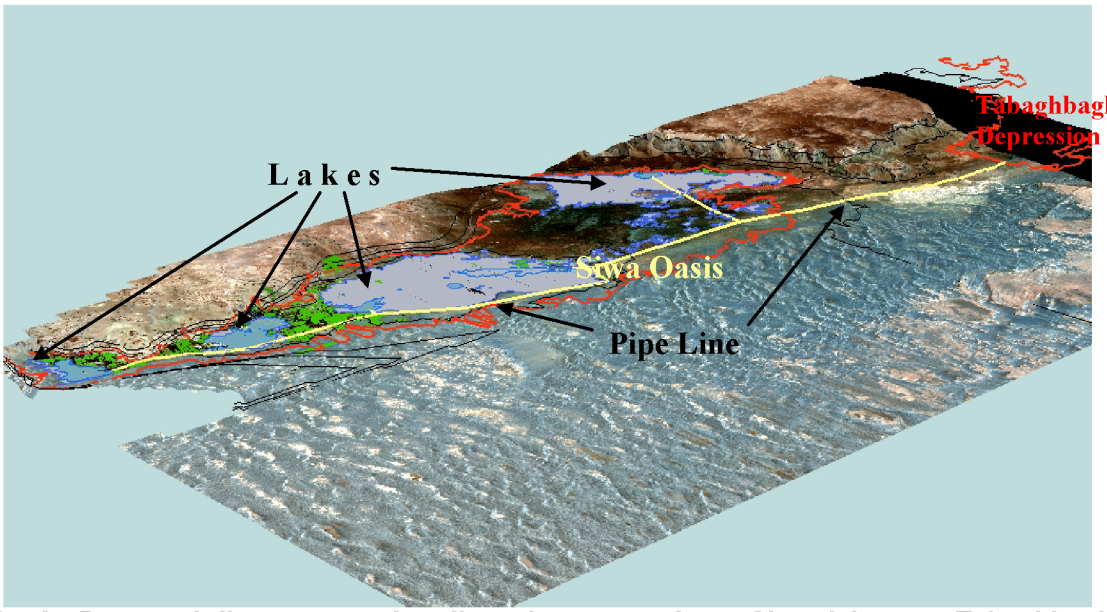

Fig 2: Proposed line to transfer disposing water from Siwa lakes to Tabaghbagh Depression over 3D Image, Siwa Oasis, Tabaghbagh, 2010.

Source of data: The construction of the Fig. results from a three-step process: a baseline Land Use/ Land Covers 2010, Satellite image(Spot) and Land Use draping over DEM, pipeline drawing from sloping layer created base on gravity using hydrology modeling processing (slop) with helping from GIS Software (ARC/GIS 10 and Imagine 10)

Sustainable agricultural development of soil.

In order to attain a sustainable agricultural development of sand sheet soil and salty soil (karchif) which cover most of Siwa land, to diversify agricultural production with better suited cropping patterns (Mohamed, 2000), economically feasible in a saline environment. Improve productivity; to provide viable methods for increasing household income with suitable crop pattern and water management to make a better use of resource (water and soil) As already addressed in the previous paragraph, the article directly supports the implementation of the main productive components to satisfy human food needs, where data indicate self-sufficiency of food in Siwa Oasis by about 5%, as calculated depending on database of FAO (2012) as follow: Per capita food supply, commodities availability for consumption (2009), food group shares in total food supply [%] 2009 (FAO, 2009) , also the average number of inhabitants in Siwa and per capita amount of food production for human consumption during the period from 2007 to 2009 (SIC, 2009).

To achieve the goal of sustainable development some recommendations can be followed:

- Empower rural people to participate in activities with the output of small income-generating projects; and to create new employment in the natural resources sector by encouraging the establishment of environmental-related, sustainable small-scale processing activities.
- Facilitate a better involvement of traditional authorities and the population in general to contribute to the enhancement of villagers' self-reliance and cooperation with local administrative and technical structures at village/town and oasis levels of decision-making for: Local micro-planning; Management of local resources.
- Spread environmental awareness in the community of Siwa and raise the consciousness of the Siwan population concerning sustainable natural resource management and the conservation of natural and cultural heritage.

3. Forecasting Environmental changes and its impact on the Sustainable agriculture development (Land Use/Land covers) from 2012 to 2030 according to two scenarios.

The First scenario, in case of continuing deterioration of the environmental problems in Siwa Oasis. **The Second scenario**, in case of overcoming the environmental problems in Siwa Oasis.

The First scenario, in the event of continued deterioration of the environmental problems in Siwa Oasis.

The study projected future environmental changes using ARIMA, ARIMA model integration with GIS and RS for dynamic forecasting of Siwa problems. The study depends on forecasting the impact of dynamic environmental problems on the available resources and activities in Siwa oasis, forecasting the lakes area, cultivated area, marshes area, urban area, and productivity of olives, date palm, crops in Siwa Oasis. ARIMA fits a Box-Jenkins ARIMA model to a time series (Nour, 2008). ARIMA stands can be used to model patterns that may not be visible in plotted data. Estimation [ARIMA (p, d, q)] model through the four stages (Mulles, 1993), the forecasting data are presented as follows:

Forecasting lakes dimensions, The location of lakes areas is shown between -16.3 and -23 m under sea level, The lakes areas were estimated to be 94.46, 101.54, 109.09, 117.09, 125.56, 134.50, 143.90, 153.76, 162.54 and 171.43 km^2 of the total Siwa area in 2012, 2014, 2016, 2018, 2020, 2022, 2024, 2026, 2028 and 2030, respectively (Table 2 and Fig. 3).

Forecasting marches area, The marshes areas were estimated to be about 575.68 to 898.43 km^2 during the period 2012 to 2030. The altitudes of lakes were about -16.3 and -0.06 m under sea level (Table 2 and Fig. 3).

Forecasting cultivated area, The cultivated areas were estimated to be about 99.06 and 139.22 km^2 during 2012 to 2030 (Table 2 and Fig. 3).

Forecasting Urban area, the predicted urban area for the next twenty years. It was expected to be about 24.56 km^2 (Table 2 and Fig. 3).

Forecasting productivity of olive and date palm for the next twenty years. It was expected to be about 4.15 and 4.18 Tonnes/Feddan in 2030, respectively (Table 3).

So if the environmental problems still unchanged, Siwa will turn into a connected lake within a period of 15 years. The local peoples will lose all life on Siwa Oasis and they will migrate.

The second scenario as an alternative, in the event that the responsible authorities are partnership with the local community by following the previous steps to get rid of the environmental problems of Siwa Oasis.

The study projected future environmental changes and their impact on sustainable agriculture development using GIS Layers (previous Land Use, the elevation, slope, DEM, contours, and prospect development agriculture development) to produce potential land use layers in 2030 to evaluate trends (positive or negative) in case of overcoming the environmental problems.

Forecasting lakes dimensions, the altitudes of lakes were shown between about -17.2 and -23 m under sea level, The lakes areas would decrease from about 94.46 to 50.56 km^2 of the total Siwa area during the period 2012 to 2030 (Tables 4, 5).

Forecasting marches area: The marshes area would decrease from about 575.68 to 33 km^2 during the period 2012 to 2030. The location of these marshes areas were shown between about -17.2 and -15.03 m under sea level (Tables 4, 5).

Forecasting cultivated area: The cultivated areas were estimated between about 99.06 and 250 km^2 during 2012 to 2030. The arable land would increase by 110 km^2 reaching to 250 km^2, which contribute to cover the food shortage (Tables 4, 5).

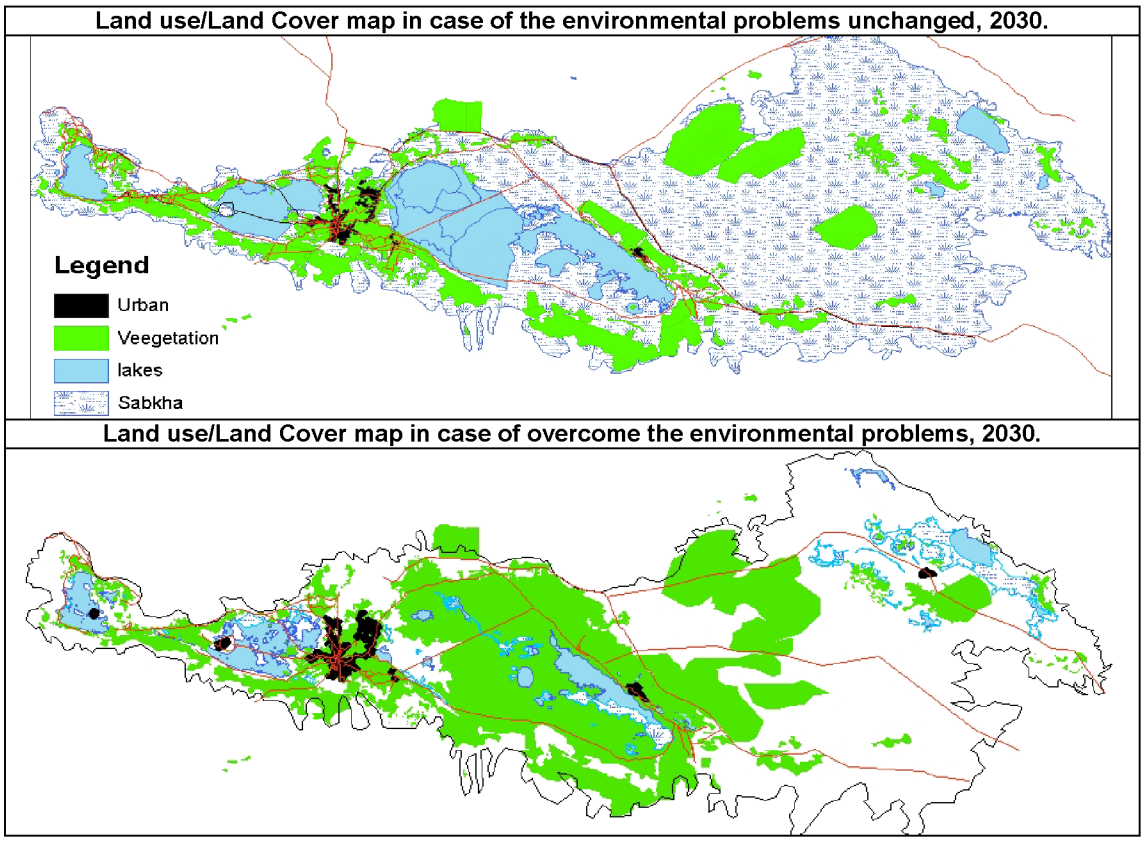

Fig. (3): Projected Land use/Land Cover map in 2030

Source of data: The construction of the Land Use/ Land Covers 2030 results from a three-step process: a baseline Land Use/ Land Covers 2010, using forecasting data from Minitab 15.1.1, agriculture plan for Siwa and converted to digital layout, using contour layer and DEM Model, integrate all data to project the forecasting data in the real world coordinate systems, legend for both layout are similar, with the helping from GIS Software (ARC/GIS 10 and Imagine 10)

Table (2). First scenario, forecasting of the future prospective of Land use, from 2012 to 2030.

Year	Total area (Km^2)	Lake (km^2)	Marshes (Km^2)	Cultivated area (km^2)	Urban (Km^2)	Other (Km^2)
2012	1050	94.46	575.68	99.06	13.69	356.93
2014	1050	101.54	623.85	104.09	14.96	210.59
2016	1050	109.09	680.01	109.11	16.23	140.58
2018	1050	117.09	717.17	114.14	17.49	89.14
2020	1050	125.56	749.34	119.17	18.76	42.2
2022	1050	134.50	781.50	124.20	20.02	-5.19
2024	1050	143.90	813.67	129.23	21.30	-53.07
2026	1050	153.76	845.83	134.25	22.56	-101.38
2028	1050	162.54	868.72	136.14	23.74	-139.25
2030	1050	171.43	898.43	139.22	24.56	-180.56

Sources: The calculated using Minitab software 15.1.1 and are displayed next to the corresponding periods GIS integration to project the forecasting data in the real world coordinates (Fig. 3)

Table (3). The Impact of the Environmental problems on Agriculture productivity of the olive and date Palm.

Statement	Status of Environmental Impact, 2010			Status of Environment Impact, 2030		
Items	PAEP	PUEP	Change %	PAEP	PUEP	Change %
Olive(T/F)	4.28	7.03	39.12	4.15	7.39	43.84
Date (T/F)	4.67	6.97	33.00	4.18	6.87	39.16
PAEP	Productivity Affected by Environment Problems					
PUEP	Productivity Unaffected by Environment Problems					

Sources: Calculated from field survey, 2010, while , 2030 using ARIMA Model.

Table (4). Second scenario, forecasting of the future prospective of sustainable agriculture development (Land Use) in case of get ride form environmental problems, from 2012 to 2030,

Year	Total area (Km^2)	Lake (km^2)	Marshes (Km^2)	Cultivated area (km^2)	Urban (Km^2)	Other (Km^2)
2012	1050	94.46	575.68	99.06	13.69	356.93
2030	1050	50.56	33	250	23.26	692.7

Sources: The calculated using GIS.10, imagine 10 using DEM and Contour Line to project the forecasting data in the real world coordinated (Fig. 3).

Table (5). The Impact of the environmental problems on sustainable agriculture development (Land Use area) in Siwa Oasis from 2010 to 2030

Statment	Status of EP, 2010					Status of EP, 2030				ROEP,2030	
Items	Total	UEP	%	AEP	%	AEP	%	UEP	%	ROEP	%
lake(Km^2)	89	-	-	89	100	171.43	16.33	50.56	04.82	120.87	70.51
Marshes(Km^2)	475	-	-	475	100	898.43	85.56	33.00	03.14	865.43	96.33
Cultivated(Km^2)	97	25.43	26.22	71.57	73.78	139.22	12.97	250.0	23.81	110.78	79.57
Urban(Km^2)	11	6	54.55	5	45.45	24.56	2.34	23.74	02.26	0.82	3.34
Other(Km^2)	378	378	100			-180.56	-17.20	692.7	65.97	873.26	483.64
AEP	Affected by Environmental problems										
UEP	Unaffected by Environmental problems										
ROEP	Return Environmental due to overcome the Environmental problems(ROEP) 2030 = (AEP – UEP)										

Sources: Calculated from Tables (1,2,4).

Forecasting urban: the predicted urban area for the next twenty years, is expected to be about 23.26 km^2 (Tables 4, 5).

Forecasting productivity: the predicted productivities for olive and date palm in the next twenty years are expected to be about 6.86 and 7.38 Tonnes/feddan respectively, in 2030, (Table 3).

4. The economic impact of environmental problems on agriculture, 2010:

The data show the variables of productivity and economic situation of samples surveyed that have been classified into two areas (cultivated with olive and date palm) totaled about 21575 feddan

representing about 93.40% of the cultivated area in Siwa oasis, 2010.

The first category, cultivated area affected by environmental problems, a cultivated area of olive and date palm is about 15918 feddans representing about 73.77%, namely about 9213 and 6705 feddans representing about 57.88%, 42.12%, of olive and date palm, respectively. Table (3) shows that productivity is about 4.28 and 4.67 Tonnes/feddan of olive and date palm, respectively.

The Second category, **cultivated area unaffected by environmental problems**, the total area of olive and palm around is about 5657 feddans, representing about 26.22%, which the area of olive and palm reached 3645, 2012 feddans, representing about 64.43% and 35.57% of olive and palm, respectively. Table (3) shows that productivity is about 7.03 and 6.97 Tonnes/feddan of olive and date palm, respectively.

The data shows that the total sample was about 120 holders, covering about10 % of the total area of olive and date palm in Siwa. The study sample was selected for the farmers by the purposive sample method that is consistent with the nature of the community study.

Data in Table (6) show that in the first category (cultivated area affected by environmental problems) net revenues were about 68.42 and 35.46 million L.E for olive and date palm, respectively and the total net revenue was about 103.88 Million LE. In the second category (Cultivated area unaffected by environmental problems) net revenues were about 47.40 and 23.18 million LE for olive and Date palm, respectively, 70.58 Million LE in aggregate.

The data in Table (7) show that the cultivation of olive in Siwa Oasis loses annually about 64.83 Million LE against 40.67 Million LE of date palm, which amounts to 105.50 Million LE annual result of environmental degradation, hence an essential need to improve the environmental situation is quite apparent.

5. The economic impact of environmental problems on agriculture, 2030:

The first model, cultivated area affected by environmental problems, Table (3), shows expected productivity to be about 4.15 and 4.18 tonnes of olives and date palm, respectively. Table (5) shows that the agricultural area is expected to be about 33174.62 feddans.

Table (6). Averaging net revenue estimates of first category and the second category for olive and date palm, 2010 – million LE.

Statement	Net revenue of First category	Net revenue of second category	Total
Olives	68.42	47.40	105.82
Date Palm	35.46	23.18	58.64
Totals	103.88	70.58	174.46

Source: collected and calculated from field research and tables (3, 5).

Table (7). Estimating the average profits achieved as a result of environmental degradation in 2010 – million LE.

Statement	Unrealized profits
Olives	64.83
Date Palm	40.67
Totals	105.50

Source: collected and calculated from field research and Tables (3, 6).

The second model, cultivated area unaffected by environmental problems, productivity is expected to be about 6.86 and 7.38 tonnes of olives and date palm, respectively. Table (5) shows that the agricultural area is expected to be about 59523.81 feddans.

It was assumed that cultivated area of olive and dates palm is the same proportion as the base year (2010), with an area of olive and palm around 93.40% of the cultivated area.

Two models were applied to measure the economic impact of desertification on agricultural production of olive and date palm in 2030.

The first model: Studying the economic net revenues for olive and date palm if environmental problems continued in Siwa Oasis in 2030.

Data in Table (8) show that the cultivation of olives in Siwa oasis achieved annual net revenue about115.7 Million LE. while 83.00 Million LE of date palm, which amount 198.7 Million LE in aggregate.

Second model: Studying the economic net revenues for olive and date palm if environmental problems get resolved in Siwa Oasis in 2030.

Data in Table (8) reveal that the cultivation of olive in Siwa oasis achieved annual net revenue of 363.93 Million LE. For 210.17 Million LE of date palm, which amount 574.23 Million LE in aggregate.

The cultivation of olive in Siwa loses annually 248.23 Million LE versus 127.17 Million LE of date palm, which amounts 375.40 Million LE annual result of the environmental problems, hence there is need to improve the environmental situation. This can be done through intervention by the state, but must be contributed by farms Sawy.

6. Economical impact in case of overcoming the environmental problems.

Table (5) shows that the lakes area was decreased about 120.87km^2,representing to about 70.51% and marshes to about 865.43 km^2, representing to about 96.33%, while the cultivated and other areas were increased about 110.78 and 873.26 km^2, respectively.

The income of cultivated olive is expected to increase annually to 248.23 Million LE against 127.17 Million LE Of date palm, which totally amounts 375.40 Million LE annually, resulting from overcoming environmental problems.

7. Social Impact in case of overcoming the environmental problems.

1- Improve health of inhabitants.
2- Minimize the number of harmful insects.
3- Enhance the quality of life of farmers and society as a whole
4- Satisfy human food needs
5- Enhance environmental quality and natural resources
6- Employ natural and biological controls for pests and disease

Table (8). Estimating the average earnings achieved as a result of environmental degradation, 2030, Million LE.

Statement	Profit for first model Cultivated affected by Environmental problems	Profit for second model Cultivated unaffected by Environmental problems	Unrealized profits Desertification
Olives	115.7	363.93	248.23
Date Palm	83	210.17	127.17
Totals	198.7	574.23	375.40

Source: collected and calculated by field research and tables (3, 5, 6, 7).

Conclusions

Social and economic impact is a consequence of what had been achieved environmentally; hence the environmental impact has a socioeconomic return. To improve environmental conditions in Siwa Oasis, it is conducive to improve water and soil characteristics, which lead to increased productivity, and thus increase the income of farmers and social environment. The rate of change depends on the extent of progress in reducing the problem of groundwater and natural resources to reach the normal rates.

If the environmental problems are unchanged, Siwa will turn into a connected lake within a period of 15 years. The local inhabitant will lose all opportunities for life in Siwa Oasis and therefore will be migrating.

The previous solutions are based on Siwa oasis data but many other countries suffer from the same problems so this model can be applied on many other parts of the world.

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التنمية الزراعية المستدامة بواحة سيوة، الصحراء الغربية، مصر

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الملخص العربى

تقع واحة سيوة فى الصحراء الغربية والواحة عبارة عن منخفض تحت سطح البحر بحوالى 23م. تبلغ المساحة الإجمالية للواحة حوالى 1050 كم2 ، يمثل الإنتاج الزراعى النشاط الرئيسى لسكان الواحة حيث تبلغ مساحة الأراضى الزراعية حوالي 23095 فدان عام 2010، ويشغل االزيتون والنخيل حوالي 93.4 من مساحة الزرعات بالواحة، ويبلغ عدد سكان سيوة حوالى 23745 نسمة عام 2010، المشاكل البيئية بالواحة من أهمها إهدار الموارد المائية نظرا لسوء إدارتها واستغلالها وارتفاع مستوي الماء الاراضي وملوحة التربة وتدهور الغطاء النباتى وانخفاض الانتاج الزراعى ومن ثم انخفاض الدخل الزراعي حيث يمثل الدخل الرئيس لسكان الواحة .

يهدف البحث الي تحسين الاوضاع الاجتماعية والاقتصادية لواحة سيوة، من خلال تحسين الظروف البيئية للموارد الطبيعية من التربة والمياه الجوفية، مما يؤدي إلى زيادة الإنتاجية، وبالتالي زيادة دخل المزارعين والمؤشرات الاجتماعية ومن ثم تحقيق التنمية المستدامة بالواحة.

استخدم البحث الاستشعار عن بعد ونظم المعلومات الجغرافية في انتاج خرائط استخدام الاراضي للفترة من 1990 الي 2010 لدراسة الاثار السالبية والايجابية لتطور المشاكل البيئية بالواحة. حيث بلغت الخسائر الاقتصادية سنويا الناتجة عن الاستخدام الجائر للموارد الطبيعية بالواحة عام (2010) حوالي 105.50 مليون جنيه ، منها 64.83 مليون من الزيتون في حين يبلغ حوالي 40.67 مليون لمحصول البلح ، استخدام نموذج (ARIMA) بالتكامل مع نظم المعلومات الجغرافية لتقدير الاثار الاقتصادي والاجتماعية الناتجة عن المشاكل البيئية بسيوة في المستقبل عام (2030) في حالة استمرار المشاكل البيئية حيث قدر الفاقد في الانتاج الزراعي سنوياً نحو 375.40 مليون جنيه منها نحو 248.23 مليون جنية من الزيتون بينما يفقد البلح نحو 127.17 مليون جنية، بالاضافة الي تفاقم المشاكل الاجتماعية.

تم اقتراح مجموعة من الحلول العلمية للتغلب علي المشكلات البيئية للواحة لتحقيق التنمية المستدامة من خلال الخطوات التالية: وضع قيود على الحفر العشوائي للآبار؛ إعادة تطوير منظومة الري والصرف ؛ ضخ جزء من المياه الزائدة خارج واحة سيوة بتكلفة تبلغ حوالي 13.29 مليون دولار.