Geospatial Analyses for Assessing the Driving Forces of Land Use/Land Cover Dynamics Around the Nile Delta Branches, Egypt

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Abstract

Major driving forces can alter Land use/Land cover (LULC) dynamics and affect landscape sustainability around the Nile Delta of Egypt. The present study aims at evaluating and mapping changes in LULC and assessing the dynamics of LULC and Land Surface Temperature (LST) around the two branches of the Nile Delta, Egypt using Landsat data and GIS. Calibrated Landsat images were acquired on 2000, 2014 and 2019 and processed to produce LULC, environmental indices and LST, respectively, using ENVI 5.3. ArcGIS 10.1 was used to extract a transition map from 2000 to 2019 around the two branches. The results displayed that five classes of LULC were extracted around Damietta and Rosetta branches; water, urban, bare, dense and spare vegetation. A continuous increase in water was recorded around Damietta branch; 13.66 km² (197%), 14.21 km² (2.04%) and 16.54 km² (2.30%) in 2000, 2014 and 2019, respectively. Also, urban area was increased around Damietta and Rosetta branch as follows: 53.6 km² (7.72%), 58.34 (8.37%) and 90.37 km² (13.70%) in 2000, 2014 and 2019, 59.55 km² (6.809%), 104.16 (11.90%) and 149.77 km² (17.11%) in 2000, 2014 and 2019, respectively. Urban achieved the highest gain of 24.807 and 85.70 km² at the expense of dense vegetation around Damietta and Rosetta branch, respectively. The results showed that the decrease in vegetation and the increase in urban density lead to increasing LST of the study area. The changes in LST can be monitored depending on the construction materials such as the presence of green areas and topography. Urban and bare lands have the highest LST while the water bodies and vegetation temperature showed a tendency to decrease. It can be concluded that urban areas increased with annual rate 0.27 and 0.54 km² and vegetation decreased with annual rate −0.57 and −0.55 km² around Damietta and Rosetta branches from 2000 to 2019. Results showed that comprehensive index was 321.14 and 330.03 around Damietta and Rosetta branch, the higher the degree of development and exploitation. There has been a significant land use change which was due to an increase in population. Overall, this research provides valuable data about changes in LU/LC around the Nile Delta branches, it is very important for decision maker and stockholders for proper management.

Keywords Nile delta · Damietta · Rosetta · Driving forces · LULC · LST · Anthropogenic

Introduction

Extensive modification in land-use/land-cover change (LUCC) has been occurred due to development of agriculture (Saunders et al. 1991). These modifications are dynamics which induced by major driving forces as social, political, economic and ecological variables on local, regional and global scales (Hassan et al. 2016)

resulting in climatic change (Peng et al. 2006). Land-use/land-cover change (LUCC) may mainly affect the sustainable development. Nowadays, changes in LULC are resulting from many environmental factors as urbanization, climate change and economic growth that cause major variations in the ecosystem of the environment (Chuanzhe et al. 2011). Around the two branches, many cities and industrial activities through untreated wastewater directly on the water of Nile River. Around the two branches, electric power and some petrochemical affect negatively on the resources of the study area. Industrial activities occupy the majority of change in ecosystem along the two branches. El-Alfy et al. (2019).

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mentioned that residential zones in villages and cities as well as industrial and commercial areas are examples of the activities included in the urbanized areas around Rosetta branch. These zones lie in the eastern and western sides of the River Nile in addition to some parts in the southern side. The pressure on the environmental ecosystem and LULCC has been increased as a result of urbanization and anthropogenic activities. Change detection is the method of detecting alterations in the state of a feature or phenomenon by observing it at different years (Singh 1989). Change detection is very essential in several applications associated with (LULC) changes, such as shifting cultivation and landscape variations (Imbernon 1999). Many studies have studied the relationship between LULC and Land Surface Temperature (LST) using remote-sensing imagery on regional and global climate (Mohan and Kandya 2015; Chen et al. 2017). The relationship between LULC and LST is very important in land management and global climate change studies. In Egypt especially around the Nile Delta branches, population growth has been a main reason of land use and land cover change than other forces. Urbanization, population growth, land scarcity and expansion of agricultural land are among the many drivers of LULCC in the world (Quentin et al. 2006). The indicators of LULCC manifest as the current global environmental concerns such as increasing concentrations of greenhouse gases in the atmosphere, loss of biodiversity and conversion and fragmentation of natural vegetation areas (USA 2001). Change in LULC can conflict with demand and supply of the land that resulting from both natural and man-made activities (El-Hamid et al. 2019). The technology of remote sensing and geographic information system (GIS) can assess and monitor change in LULC and dynamic of the land in addition to driving forces of these changes. It also can provide researchers and decision maker with temporal and spatial resolution data that enables all specialists for appropriate planning in the future for sustainable development (Hong et al. 2011). It is difficult to achieve exact data by relying only on communication and ground transportation (Abd El-Hamid and Hong 2020). Remote sensing and GIS are a precisely accurate and low-cost technique (Abdel Hamid et al. 2020). Remote sensing is an important science in estimating and assessing changes in LULC in different years. Remote sensing has many advantages as safe time and give accurate data about features and phenomena that human cannot explore it easily (Hong and Abd El-Hamid 2020). Modern technology of remote sensing serve many researchers in the world for assessing change in LULC and provide them with accurate temporal and spatial data (Mustafa el at. 2019). According to previous studies, the area around the

two branches of the Nile Delta is subjected to many of the driving forces that cause change in LULC. Due to the environmental importance of the Nile Delta branches, the extensive changes by different driving forces in LULC have been analyzed using remote sensing data and modern GIS techniques.

Materials and Methods

Study Area

In the south of Egypt, the Nile Delta has been formed and distributes its recycle water into the Mediterranean Sea. It was extended from Alexandria in the west to Port Said in the east covering 240 km its one of the largest river deltas in the world. Majority of agriculture sector in Egypt depend mainly on the water drained from the River of the Nile Delta. About 160 km length from north to south, the Delta begins slightly down-river from Cairo. El-Ameir (2017) said that the western branch is called Rosetta branch (about 242 km in length) and the eastern branch is called Damietta Branch (about 239 km in length).

Climatic Data

The coastal area of the Nile Delta is characterized by a mild climate. It is characterized by typical Mediterranean fairly cool rainy winter and warm dry summer with small diurnal temperature variations. Precipitation occurs mostly in winter. The observed amount of average rainfall in the study area is estimated at about 107 mm in Damietta and 175 mm in Rashid. It is observed that rainfall occurs mostly during Dec., Jan. and Feb. It is recorded that the maximum air temperature at Damietta approaches 30 °C in July while the minimum air temperature falls to 8.4 °C in January. In Rashid the maximum air temperature approaches 29.7 °C in July while the minimum air temperature falls to 14.1 °C in January. Relative humidity is generally high due to the proximity to the Mediterranean Sea. In August, relative humidity values approach 76% at Damietta and 72% in January at Rashid. Generally, wind blows from the northwestern direction most of the year throughout the coastal zone of the Nile Delta. However, some other directions such as the southwest and the northeast significantly occur particularly during winter and spring, respectively. Evapotranspiration is usually higher in summer than in winter. The recorded evapotranspiration values at Damietta are 1.7 mm/d in January and rises to 5.8 mm/d during July. On the other hand, evapotranspiration rates at Rashid are 2 mm/d during January and 5.9 during June.

Remote Sensing Analysis

Data Sets

Three images were acquired in 2000, 2014 and 2019 representing the study area; including Damietta branch and Rosetta branch. These images Thematic Mapper (TM), Enhanced Thematic Mapper (ETM) and Operational Land Imagers (OLI) were downloaded from online. These images were geometrically and radiometrically corrected.

LULC Mapping

Firstly, unsupervised classification was chiefly applied to classify the classes according to spectral signature using ENVI 5.3 Software. Some retransformation processes were created for enhancement of Landsat images in the study area. These transformations are normalized difference vegetation index (NDVI), principal component analysis (PCA) and tasseled cap (Klarestaghi et al. 2006). The land use and land cover were classified using supervised classification based on the land cover classification system and field observation as ground truth. Every class was identified and drawn using ArcGIS 10.5. Four classes were identified with area calculation and percentage.

Transition of LULC

Transition matrix of LULC reveals the way of every type conversion to another type in the study area. It is a mathematical and statistical method that studies the changes among types of LULC. A new matrix was applied for assessing the trend of land use type reflection in the study area (Jijun et al. 2003). This method was applied using ArcGIS10.5 and the function of PivotTable in Excel. Data of LULC were extracted from classification images and change detection during 2000 and 2019. Transition simulates the major changes of every class, helping the decision maker for proper development.

$$\begin{pmatrix} p_{11} & \cdots & p_{1n} \\ \vdots & \ddots & \vdots \\ p_{n1} & \cdots & p_{nn} \end{pmatrix}$$

$$0 \leq p_{11} < 1$$

$$\sum_{i=1}^n p_{ij}x = 1, i, j = 1, 2, \dots, n$$

where P_{ij} is the probability of land area in transition from land scape i to j .

Land Use dynamics

Dynamic of LULC reflect the development of the study area in the future. A comprehensive index was proposed to study the dynamics of LULC in the study area from 2000 to 2019. This index is mainly depending on the effect of each land use in the environment showing different degrees as mentioned in Table 1 (Jiyuan 1992). Land use types were classified into five classes from unused to high level depending on its importance in the environment. Unused level includes bare, salt and sand area, where high level include built up and urban area which reflect the human interface in the community. Also, the comprehensive index shows the integration among natural variables of environment and anthropogenic activities (Sisi et al. 2012).

$$L = 100 \times \sum_{i=1}^n A_i C_i$$

$$\begin{aligned} \Delta L_{b-a} &= L_b - L_a \\ &= 100 \times \left[\sum_{i=1}^n (A \times C_{ib}) - \sum_{i=1}^n (A \times C_{ia}) \right] \end{aligned}$$

$$\begin{aligned} R &= \frac{\Delta L_{b-a}}{\sum_{i=1}^n (A \times C_{ia})} \\ &= 100 \times \frac{\sum_{i=1}^n (A \times C_{ib}) - \sum_{i=1}^n (A \times C_{ia})}{\sum_{i=1}^n (A \times C_{ia})} \end{aligned}$$

From three equations, L denotes the comprehensive index of land use degree, L : 100–400, the closer the L is to 400, the higher the degree of development and exploitation; A_i represents the classification index of land use type. C_i characterizes the percentage of land use type area; ΔL_{b-a} denotes the change in the comprehensive index of land use change; L_a and L_b describe the comprehensive land use degree index of a and b time stages; C_{ia} and C_{ib} denote the area percentage of the i -type land type in the two phases a and b ; R represents the rate of change in land use. $R > 0$ is the development stage; $R < 0$ is the decay stage; $R = 0$ is the stabilization or adjustment phase. Based on level standard of land use dynamic, five levels were created. From the first to the fifth were known as follow; bare land, water bodies, cultivated lands, farmland and construction. Construction level is the most important and sensitive level as it contains industry, mining, transportation and residents as shown in Table 1.

Change in Vegetation and Water Cover

For identification of water bodies and vegetation cover of the study area, NDVI and NDWI were applied using ENVI 5.3. NDVI is the difference between the red and near infrared and combination divided by the sum of the red and near infrared band combination as shown in Eqs. 1 and 2.

Table 1 Levels of comprehensive index degree

Intensity level	Land-use type	Value
Unused level	Unused land, bare and intertidal zone	1
Light utilization level	Water	2
Low utilization level	Grass, swamp and vegetation	3
Strong utilization level	Irrigated land	4
High-strength utilization level	Construction land and urban	5

NDWI is the difference between the green and near infrared and combination divided by the sum of the green and near infrared band combination. NDWI images reflect the water bodies present in the study area. The value of this transformation varies from -1 to one, depending on the amount of vegetation. Highly vegetated areas will yield values of NDVI close to one, where poorly vegetated areas will have NDVI values close to zero. Two indices were computed as follows.

$$NDVI = \frac{p \text{ NIR} - p \text{ red}}{p \text{ NIR} + p \text{ red}}$$

$$NDWI = \frac{p \text{ NIR} - p \text{ swir}}{p \text{ NIR} + p \text{ swir}}$$

where $p\text{NIR}$ is the reflectance of the near-infrared wavelength band, $p \text{ red}$ is the reflectance of the red wavelength band and $p \text{ swir}$ band is Short-wave infrared.

Driving Forces of LULC

In the present study, around the Nile Delta branches, driving forces were assessed using temporal and spatial data. Some environmental variables were taken into consideration; climatic change, pollution and population growth. These variables helped stakeholders and decision maker for accurate planning in the study area.

Land Surface Temperature (LST)

Surface temperature is a critical parameter in properly understanding the economic exchange of energy between the earth surface and the local environment. The surface temperatures were extracted from the TIR band radiance values of sensors. The local time of satellite overpass was in the midmorning. The surface temperatures were extracted using the following steps.

Conversion of Digital Number (DN) to Radiance The first necessary step of the LST retrieving is the creative input of Band 10. Spectral radiance of band 10 may be digitized using the top of atmosphere (TOA) via some tools of ArcGIS 10.5 and ENVI (Barsi et al. 2014).

$$L\lambda = M_L * Q_{cal} + AL - O_i$$

where M_L is the band-specific multiplicative rescaling factor, Q_{cal} is the band 10 image, AL is the band-specific additive rescaling factor and O_i is the correction for band 10.

Conversion to Top Brightness Temperature After effective conversion of DN to radiances, the band data should be professionally changed to brightness temperature (BT) using the thermal constants provided in the metadata file. The following equation is applied for successful conversion (Xu and Chen 2004).

$$TB = \frac{k_1}{\ln \left[\left(\frac{k_1}{L_\lambda} \right) + 1 \right]} - 273.15$$

where BT: Satellite brightness temperature in Celsius; K_1 = Band Specific thermal conversion from the metadata; K_2 = Band Specific thermal conversion from the metadata. Brightness temperatures naturally assume that the earth is a blackbody, which it is not, and this can promptly lead to errors in surface temperature. In order to reduce these errors, emissivity correction is important, and this is done to finally retrieve the (LST) from BT.

Land Surface Emissivity (LSE) from NDVI Three equations were proposed to estimate land surface emissivity (LSE (ϵ)). LSE is a proportionality factor that scales blackbody radiance (Planck's law) to predict emitted radiance, and it's the efficiency of transmitting thermal energy across the surface into the atmosphere (Sobrino et al. 2004).

$$\epsilon_\lambda = \epsilon_v P_v + \epsilon_s (1 - P_v) + d\epsilon$$

$$d\epsilon = (1 - \epsilon_s) (1 - P_v) F \epsilon_v$$

$$P_v = (NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})$$

$$NDVI = \frac{\text{Nearinfrared} - \text{Red}}{\text{Nearinfrared} + \text{Red}}$$

where ϵ_v represents the emissivity of vegetation, ϵ_s is the emissivity of soil, P_v is the vegetation proportion, F is a shape factor whose mean value, assuming several geometrical distributions is 0.55.

Calculation of LST (°C) After obtaining the emissivity images, the LST can be derived (Stathopoulou and Cartalis 2007) according to the following Equation.

$$LST = \frac{BT}{1 + \frac{\lambda(BT) * \ln \varepsilon}{\rho}}$$

where LST is in Celsius (°C). BT is the at-sensor brightness temperature in Celsius (°C). λ (11.5 μm) is the wavelength of emitted radiance: $\rho = h * c / \sigma = 1.438 * 10^{-2}$ mK, σ is the Stefan–Boltzmann constant, h is Planck's constant, c is the velocity of light, and ε is the land surface emissivity (LSE).

Results and Discussion

Land Use/Land Cover Change

Five classes of LU/LC were extracted around Damietta branch as shown in Fig. 2. LU/LC were classified as dense vegetation (61.22%), spare vegetation (27.14%), urban (7.72%), bare (1.93%) and water (1.97%) in 2000. In 2014; LU/LC were classified as dense vegetation (62.87%), urban (8.37%), bare (10.50%), water (2.04%) and spare vegetation (16.20%). In 2019; LU/LC were classified as dense vegetation (52.84%), urban (13.70%), spare vegetation (34.71%), bare (1.34%) and water (2.49%) as shown in Table 2. Dense vegetation was the dominant LU/LC in all periods of the study area. Around Rosetta branch, LULC were classified as dense vegetation (83.07%), spare vegetation (5.58%), urban (6.80%),

bare (1.49%) and water (3.03%) in 2000 as shown in Table 3. In 2014; LULC were classified as dense vegetation (78.19%), urban (11.90%), spare vegetation (5.05%), bare (1.45%) and water (3.39%). In 2019; ULC were classified as dense vegetation (72.50%), spare vegetation (6.62%), urban (17.11%), bare (0.44%) and water (3.30%) as shown in Fig. 3. Dense vegetation was the dominant LULC in all periods of the study area. It was shown that urban lands increase from one year to another affecting negatively on vegetation cover of the areas around the Delta. Urban achieved the largest change rate from 2000 to 2019; however water achieved the lowest change rate. About 13.10, 44.78, 1.55, 228.37 and 57.14 km^2 from water, urban, bare, dense vegetation and spare vegetation were constant, respectively. Dense vegetation represented the highest loss (164.86 km^2) of its area from 2000 to 2019; on the other hand, water achieved the lowest loss (0.0038) of its area from 2000 to 2019. Urban achieved the highest gain of its area (79.99 km^2) from 2000 to 2019; on the other hand water achieved the lowest gain of its area (24.807 km^2) from 2000 to 2019 in the expense of dense vegetation as shown in Table 4. The results from the present study proved that aridity and altitude are the two most highly influential in determining the quantity and quality of urban green space. Sometimes, in these cities, it is actually preferable to utilize techniques to reduce Temperature that are not so reliant on scarce water resources) such as light-colored building materials and cool roofs. About 3.82, 581.84, 0.67, 50.85 and 24.22 km^2 from bare, dense, spare, urban and water were constant,

Fig. 1 The Nile Delta branches; Damietta and Rosetta

Fig. 2 LU/LC around Damietta and Rosetta branches in 2000, 2014 and 2019, respectively

Table 2 Land use/ land cover (Km^2) and percentage (%) in Damietta branch from 2000 to 2019

Class	2000		2014		2019		2000–2019 Annual change
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	
Water	13.66	1.97	14.211	2.04	16.43	2.37	0.02
Urban	53.60	7.729	58.34	8.37	90.40	13.0	0.27
Bare	13.41	1.934	73.17	10.50	8.91	1.28	0.034
D. vegetation	424.54	61.22	437.98	62.87	348.5	50.27	− 0.57
S. vegetation	188.23	27.14	112.86	16.20	228.9	33.02	0.308

respectively, as shown in Table 5. Spare vegetation achieved the largest change rate from 2000 to 2019; however urban achieved the lowest change rate as shown

in Fig. 4. Urban lands gained about 85.70 km^2 in the expense of dense vegetation. According to El-Alfy et al. (2019), the agricultural zones occupy the majority around

Table 3 Transition matrix (Km²) of Damietta branch from 2000 to 2019

Class	Water	Urban	Bare	Dense	Spare	Gain
Water	13.10	0.0087	0.0075	3.21	0.220	16.54
Urban	0.082	44.78	3.66	24.807	16.98	90.312
Bare	0.288	1.350	1.55	3.704	2.036	8.929
Dense vegetation	0.0038	3.76	4.96	228.37	111.37	348.48
Spare vegetation	0.20	3.564	3.052	164.86	57.14	228.82
Loss	13.67	53.46	13.24	424.96	187.75	693.10

Rosetta branch showing about 48%, 21% and 12% were high dense vegetation, moderate vegetation and naturally vegetation, respectively. Abd El-Hamid and Hong (2020).

Change in water and vegetation cover

The change in water and vegetation cover were really recognized and mapped using remote sensing and GIS techniques via water and vegetation index, respectively (Figs. 5, 6). The high reflectance of water is due to some organic impurities and suspended matter. It was shown that wet lands concentrated near to open water. The reflectance of no vegetation lands is due to clay minerals. It was shown that wet lands are higher around Damietta branch than Rosetta branch. The higher amount of wet land around Damietta branch was attributed to low lands near to the River that may be exposed to flood in any time. According to vegetation index, non-vegetative lands are concentrated around Damietta branch than Rashid branch. The higher NDVI values were found over the dense vegetation areas. The lowest NDVI values were observed in urban city (Effat and Hassan 2014), agriculture land and water body. Bare land had the second highest average NDVI values over the study period.

Land use dynamic

The comprehensive index of land use in 2000, 2014, and 2019 was 309.62, 293.70 and 321.14, respectively; all data in the range of 100–400, representing that land use has been in a reasonable development stage; the comprehensive land use index from 2000 to 2019 has continued to increase with an increase of 11.52. The land use dynamic of urban areas has been increased from 2000 to 2019. The degree of transformation in land use is larger than zero. R values were -0.051, 0.093 and 0.035 for 2000, 2014 and 2019, respectively as shown in Table 6. The comprehensive index of land use in 2000, 2014, and 2019 was 307.59, 317.52 and 330.03, respectively; all data in the range of 100–400, indicating that land use has been in a reasonable development stage; the comprehensive land use index from 2000 to 2014 has continued to increase with 9.93, 12.51

and 22.44, respectively. R values were 0.032, 0.039 and -0.067 for 2000, 2014 and 2019, respectively as shown in Table 7. In the present study, land use dynamics around the Nile Delta branches (Damietta and Rosetta) were distinguished using a combination of digital and satellite data. Extremely tracking advanced land use benefits likely results in severe ecological degradation. It is a clear from field visits and focus group discussions with local people that the vegetation cover is decreasing due to bad management, cropland expansion, and extensive human activities. Conversion of vegetation to other classes leads to negative impact on the economy (Abd El-Hamid et al. 2020). The irrigation and drainage canals are well scattered around the two branches. The ecological effects of the great loss of vegetation cover are soil erosion, degradation and physicochemical properties alteration, change of climate, biodiversity, effect on hydrologic cycle, and reduction of landscape. From this study, remote sensing and GIS are very important in detection the land use dynamics. In the fact, large deforestation has occurred due to some development in agriculture projects. Conversion of dense vegetation into urban areas also occurred around the two branches due to adequate climatic conditions. The reduction of dense vegetation related to habitats of people in the selected area who use remains of these materials for their activities. According to El-Hamid et al. (2019), due to the development and construction, agricultural lands can mainly increase the value of the environment. In general, urbanization or nature development are mainly responsible for transformations of agricultural land not agriculture sector. The changes in agricultural production are driven by universal improvements on the market for agricultural products, ecological guidelines and scientific innovations. The change towards multi-functional agricultural land use varies per area, and is driven by regulations and subsidies for nature and landscape management, and by the attractiveness of various chances for farmers to raise their incomes. Change in water and vegetation can reflect the dynamic of LULC in the study area. Change in water can serve the stakeholders and government to take aware of low land area and preventing the flood in any climatic change. Also, vegetation index give accurate data about degradation of lands in the study area. The urbanization

Fig. 3 LU/LC around Damietta and Rosetta branches in 2000, 2014 and 2019, respectively

process has led to chaotic growth in city, deteriorated the living conditions and has worsened the environmental scenario having detrimental impacts on human health.

Therefore, it is required to determine the rate and trend of land cover/use conversion for devising a rational land use policy.

Table 4 Land use/ land cover (Km²) and percentage (%) in Rosetta branch from 2000 to 2019

Class	2000		2014		2019		2000–2019
	Area (Km ²)	%	Area (Km ²)	Annual change	Area (Km ²)	%	
Water	26.56	3.03	29.67	3.39	28.92	3.3	0.014
Urban	59.55	6.80	104.16	11.90	149.77	17	0.54
Bare	13.08	1.49	12.70	1.45	3.925	0.4	− 0.05
D. vegetation	726.54	83	683.93	78.19	634.45	72	− 0.55
S. vegetation	48.85	5.5	44.22	5.055	58.014	6.6	0.055

Table 5 Transition matrix (Km²) of Rosetta branch from 2000 to 2019

2000	Bare	Dense	Spare	Urban	Water	Gain
Bare	3.82	0.123	0.0028	9.114	0	13.062
Dense vegetation	0.0014	581.84	56.237	85.70	3.486	727.28
Spare vegetation	0	46.62	0.672	0.579	0.24	48.12
Urban	0.019	7.28	0.41	50.85	0.674	59.24
Water	0.063	0.126	0.022	2.14	24.22	26.57
Loss	3.90	636	57.34	148.39	28.62	874.28

D. vegetation: Dense vegetation, S. vegetation: Spare vegetation

Fig. 4 Transition of LULC in Damietta and Rosetta, respectively from 2000 to 2019

Driving Forces of LULCC

According to the LULCC and land use dynamics, there are some driving factors which are controlling the loss and gain of land use types in the present study. Assessing of driving forces focused on main sectors around the two branches: agriculture, urban, water, nature and

employment. For each sector, some data were collected and then analyzed. Results showed that dynamics of LULC around Damietta branch is more dangerous than Rosetta branch. According to the pressure of migrant people with unplanned management from south Egypt to North Egypt, especially to Damietta, major changes were taken place in LULC causing adverse effect on the community and

Fig. 5 Change in water and vegetation around Damietta branch in 2019

Fig. 6 Change in water and vegetation around Rosetta branch in 2019

national income. All changes from urban to vegetation and from vegetation to urban are related to some driving forces. **Firstly**, Demography is considered as one of the most important driving forces in our community. Many studies mentioned that demography is a main factor in LULC. **Secondly**, demography is one of driving forces containing many constituents that disturb population and homes.

Demographic changes are particularly dominant, because the behaviour is frequently associated with demographic features. Technological changes cause increasing productivity in agriculture, technical opportunities affecting underground storage or desalination of water, or internet allowing online shopping. **Thirdly**, a wide set of economic developments are representing a driving forces that

Table 6 Change of land use dynamic around Damietta branch

LULC	2000	2014	2019
Urban	38.65	41.88	65.21
D.vegetation	183.67	188.63	150.84
Barren	1.93	10.50	1.29
Water	3.94	4.08	4.74
S.vegetation	81.43	48.61	99.07
<i>L</i>	309.62	293.70	321.14
ΔL_{b-a}	2000–2014	2014–2019	2000–2019
	– 15.92	27.44	11.52
<i>R</i>	– 0.051	0.093	0.035

Table 7 Change of land use dynamic around Rosetta branch

LULC	2000	2014	2019
Urban	34.04	59.54	85.58
D.vegetation	249.22	234.58	217.51
Barren	1.50	1.45	0.45
water	6.07	6.78	6.61
S.vegetation	16.76	15.17	19.89
<i>L</i>	307.59	317.52	330.03
ΔL_{b-a}	2000–2014	2014–2019	2000–2019
	9.93	12.51	22.44
<i>R</i>	0.032	0.039	0.067

affecting land use are development in income and trust funds, rise in double-income households, variations in structure of economy, agglomeration forces, global and local market growths (e.g. agricultural crops), and organization of production processes are examples of economic developments. Furthermore, every of these economic constituents are affected by various features; a description of these relations can be found in the supporting notes, per area. **Fourthly**, land use may be affected negatively by social values. Change in lifestyles of people can affect directly or indirectly on the transformation of land use from one type to another. So, change in LULC can cause alteration on food production and economy of the cities around the two branches.

Population Growth

All problems caused in LULC change resulted mainly from population growth. Even today, the population of the area around two branches of the Nile Delta is increasing and concentrated mainly around the agriculture lands, but a bare land occupies about 96% from all land surfaces. On

the other hand, population has been increased from 4 to 70 million. Due to the major conversion from agriculture land to bare lands around the Nile Delta, the government lake great efforts to solve these problems. LULC around the Nile Delta branches may be affected by construction, transportation and others. This growth in population had an equitable consequence of rise in stress on the restricted resource-base and led to the expansion of urban land by deforestation and infilling of low-lying areas as shown in Table 8. Urbanization may have positive or destructive effects on the environment but unplanned growth of urban zones always has adverse effects (El-Hamid et al. 2019). There was a remarkable negative relationship between cropland change and population growth. In addition, population growth has little effect on land dynamics around the Nile Delta branches. The Population of Egypt will continue to grow for most of the twenty-first century as shown in Table 9. This can mainly be attributed to the high demand of the comparatively high quality health services available in Cairo and Alexandria, thus most travel to these metropolitan areas to seek health treatment. When deaths occur, they are registered in these metropolitan areas which results in the higher death rate.

Impact of LULC Change on LST

Climatic change is one of the most significant variables that controlled on the conversion of LULC around the Nile Delta branches. LULC significantly affects LST. Temperature, rainfall and precipitation of the study area affect negatively on the environment causing major conversion from one class to another. According to monthly, seasonally and yearly, data were recorded in some major cities around the Nile Delta branches; Cairo, Port Said and Alexandria. Results showed that mean values of temperature was high in August (26.52 °C and 27.17 °C) in Alexandria and Port Said, respectively, while it was during July 28.02 °C in Cairo (Hussein and Mohamed 2016). LST was achieved the high values near to urban and bare lands around the two branches as shown in Fig. 7. Rainfall is the most substantial aspect in continuous degradation of agriculture lands especially around the two branches. Therefore, high amount of precipitation could lead to high amount of rainfall. It is noticed that, change in climate factors can cause adverse effect on LULC especially vegetation. Climatic change as temperature and precipitation is the main factors that affecting on the water cycle in any study area (Yufeng and Chunxiang 2013). LULC of area around Damietta and Rosetta branches are controlled by contribution of environmental, geographical and socio-economic factors. It is known that urbanization has been caused mainly by population growth. The rapid population growth in the study area was mainly resulted from

Table 8 Urban growth in Egypt from 1955 to 2020

Year	Population	Y. Change (%)	Yearly change	Migrants (net)	Median age	Fertility rate	Density (P/ Km ²)	Urban pop (%)	Urban population
2020	102,334,404	1.94	1,946,331	– 38,033	24.6	3.33	103	43.0	44,041,052
2019	100,388,073	2.00	1,964,475	– 38,033	24.3	3.43	101	43.1	43,229,498
2018	98,423,598	2.05	1,981,007	– 38,033	24.3	3.43	99	43.1	42,437,529
2017	96,442,591	2.11	1,995,518	– 38,033	24.3	3.43	97	43.2	41,659,745
2016	94,447,073	2.17	2,004,526	– 38,033	24.3	3.43	95	43.3	40,889,370
2015	92,442,547	2.24	1,936,262	– 56,189	24.3	3.45	93	43.4	40,123,329
2010	82,761,235	1.85	1,447,533	– 56,715	23.7	3.02	83	43.7	36,182,597
2005	75,523,569	1.87	1,338,402	– 14,893	22.5	3.15	76	43.7	33,035,354
2000	68,831,561	2.00	1,299,505	– 42,180	21.1	3.60	69	43.5	29,917,321
1995	62,334,034	2.12	1,239,912	– 92,081	20.2	4.15	63	43.8	27,278,501
1990	56,134,475	2.65	1,375,149	– 42,437	19.7	5.00	56	44.5	24,961,581
1985	49,258,732	2.61	1,189,934	– 78,586	19.5	5.49	49	44.8	22,059,000
1980	43,309,063	2.36	951,984	– 119,059	19.4	5.70	44	44.7	19,340,901
1975	38,549,142	2.24	807,058	– 111,836	19.2	6.00	39	44.0	16,964,582
1970	34,513,850	2.55	816,166	– 47,940	19.1	6.45	35	42.1	14,536,071
1965	30,433,022	2.70	760,026	– 10,020	19.0	6.65	31	40.3	12,253,382
1960	26,632,894	2.78	681,954	– 10,020	19.9	6.75	27	38.4	10,221,871
1955	23,223,124	2.57	554,229	– 10,020	20.7	6.75	23	35.3	8194,766

Table 9 Egypt Population Forecast from 2020 to 2050

Year	Population	Y. change (%)	Yearly change	Migrants (net)	Median Age	Fertility Rate	Density (P/ Km ²)	Urban pop (%)	Urban population
2020	102,334,404	2.05	1,978,371	– 38,033	24.6	3.33	103	43.0	44,041,052
2025	111,727,822	1.77	1,878,684	– 40,000	25.1	3.33	112	43.3	48,427,431
2030	120,831,557	1.58	1,820,747	– 40,000	25.6	3.33	121	44.4	53,613,464
2035	130,340,364	1.53	1,901,761	– 30,000	26.2	3.33	131	46.0	59,988,198
2040	140,350,381	1.49	2,002,003	– 30,000	27.3	3.33	141	48.3	67,730,752
2045	150,355,053	1.39	2,000,934	– 30,000	28.5	3.33	151	50.8	76,439,477
2050	159,956,808	1.25	1,920,351	–	29.7	3.33	161	53.3	85,320,777

Source Worldometer (www.Worldometers.info). Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2019 Revision. (Medium-fertility variant)

migration of rural to urban area. This increase in population has a severe pressure on land resources causing major conversion from one class to another. Results of the present study agreed with (El-Zeiny and Effat 2017); desert bare lands exhibited the highest mean LST ($> 42^{\circ}\text{C}$) followed by urban, vegetation and finally water bodies for the four studied years. Studies done by Pu et al. (2006) and Zareie et al. (2016) have shown that the LST values of bare land are higher than the LST values of urban areas. Similar results were obtained in our study. The high LST values in these areas can vary depending on the type of the soil. The LST values on the dates of satellite images are not

dependent on the spatial values of the land use classes, but may depend on the average daily air temperature on the satellite images taken.

Conclusion

The study results show that there was a significant change in land use. Monitoring of land use dynamic via LULC is very important for stockholders, policy maker and researchers to take aware of areas which sensitive to change and degradation. To overcome this degradation and

Fig. 7 Variation in LST around the two branches Damietta and Rosetta, respectively

preserve biodiversity of these areas, effective measures should be taken into consideration for sustainable development. In the present study, some driving forces were explained showing the change in LULC along two branches of the Nile Delta in Egypt. Dynamics of LULC around Damietta branch is more dangerous than Rosetta branch. According to the pressure of migrant people with unplanned management from south Egypt to North Egypt, especially to Damietta, major changes were taken place in LULC causing adverse effect on the community and national income. All changes from urban to vegetation and from vegetation to urban are related to some driving forces. The comprehensive index of land use around Damietta and Rosetta branches has been increased as a result of human activities and climatic change. The development around the two branches affects negatively on the total yield of agriculture crops. So, awareness from the government should be spreading to all specialists for appropriate management of environmental resources. Change detection of LU/LC can be useful for managers and policy makers to know vulnerable areas which in the possibility of deforestation and degradation are more than the other areas. Also, suitable strategies can be considered to prevent deforestation and to perform sustainable yield and management in these areas. Therefore, this study shows that there is an increase of urban and decrease in vegetation lands which needs due attention towards soil conservation for the enhancement of the useful life of the Nile Delta.

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