CATRINA (2015), 12 (1): 1-6

Geologic Factors Controlling Urban Planning of Ismailia City, Suez Canal Province, Egypt

Naema M. Moheb[1], Ahmed E. El Rayes[1], Mohamed H. Geriesh[1], Mona F. Kaiser[1] and Hisham M. Gadou[2]

[1] Geology Department, Faculty of Science, Suez Canal University, Ismailia 41522, Egypt.
[2] Urban Planning Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt

ABSTRACT

The present research aims to assess the geologic determinants influencing sustainable urban planning of Ismailia City at the Suez Canal Province. GIS data integration was utilized to specify geologic factors influencing the 2010 strategic urban plan. Field observations, chemical properties of shallow groundwater and remote sensing data were integrated using Geographic Information Systems. The acquired satellite images in this research were selected to be within 1990-2014 time span. It is noticed that some environmental problems which are originated following the development of urban and industrial projects in Ismailia City in addition to the extension of informal unmanaged settlement areas. These include waterlogging, salinization and land subsidence. The results of chemical analyses of water indicate exceedance of sulphate content which causes salt crust problem and severely affects the foundation resistance. Also, unexpected urban sprawl produces unplanned urban extensions which are strongly suffered by waterlogging and land subsidence. Change detection emphasized that the newly cultivated land, salt crust and informal settlement areas increased during 1990-2014 period. However, waterlogged areas decreased within the same time period. Consequently, this study recommends considering the geological determinants and environmental factors in any future planning.

Key word: Geologic factors, GIS, Groundwater chemistry, Ismailia, Remote sensing, Urban planning, Waterlogging, Soil salinization.

INTRODUCTION

Ismailia Governorate consists of an area of approximately 5066Km^2 at the northeastern part of Egypt, representing 0.46% of the total area of Egypt. Ismailia Governorate is the capital of the Suez Canal province where the Suez Canal Authority has its headquarters, where the Suez Canal University is established. Suez Canal province consists of six Governorates including, El Sharkiya to the west, Port Said to the north, Suez to the south, North and South Sinai to the east. Ismailia governorate is located directly on Timsah Lake along the coast of the Suez Canal, half –way between Port Said and Suez. Ismailia City (the study area) is the capital of Ismailia Governorate, it is approximately bounded by latitudes 30º 33` & 30º 38` N and longitudes 32º 12` & 32º 20` E (Fig. 1). It covers an area of about 210 km².

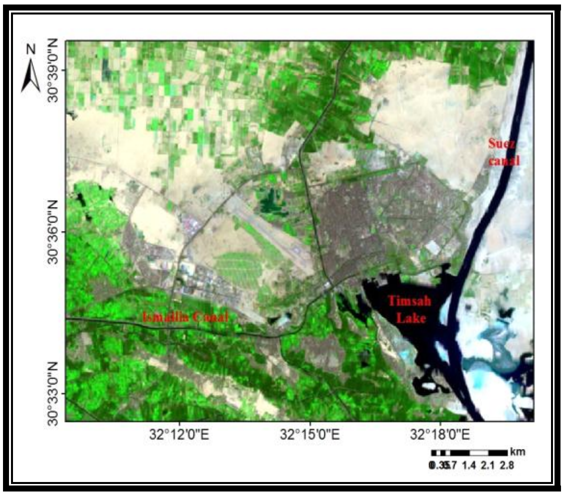

Figure (1): Location map of Ismailia city area showing location of the N-S hydrogeoogic profile.

* *Corresponding author:* nana_moheb@hotmail.com

Population of Ismailia Governorate is 1424616 inhabitants in 2014. The rate of population growth is 2.54 % per year (Ministry of housing, infrastructure and urban development, 2010). Population of Ismailia City was 567621 inhabitants in 2014 (Information and Decision Support Department, Ismailia Governorate, 2014). Ismailia climate is characterized by three forms (cold winter for a long time, intermediate with light rains and warm summer with some humidity). Generally it has a moderate climate all-over the year. Rain falls in winter; totally it doesn't exceed 50 mm / year (Environmental action plan of Ismailia, 2008).

Suez Canal zone is dominated by low land relief and much water bodies. The mountainous area is relatively limited and extends from the southern part of the Suez Canal zone via the north up to west of Faied town. The low land areas are generally covered by gravels, eolian sands and sand sheets, clays, marshes with some scattered low hills of sandstone and limestone especially at the eastern side of the Bitter Lakes (El-Shazly et al., 1975a). The main geomorphic landforms of the area southwest of Ismailia governorate are Gabal Shabraweet and Gabal Um Ragam structural belt, which forms a mountainous border to the south of the area. The Suez Canal, El-Timsah Lake and the Great Bitter Lake form the main water bodies occupying the eastern low lands (El-Shazly et al., 1975b). The narrow depression of wadi El-Tumilat of E-W trend forms the main western limit of the area. Generally, the area is covered by Quaternary sands, gravels and occasional clay lenses (El-Fawal, 1992). Ismailia City is located on a topographically low site varying between few centimeters up to 30 meters above sea level. Topographical features are carefully incorporated within the designed plan of Ismailia urban area and are used to give the city a varied landscape with harmonious interspacing of low-lying green areas and the built-up districts. The surrounding desert with its small dunes and scattered palm trees are considered positive scenery, which enhances land- scape and improves the appearance of the city entrance.

The role of geological determinants in urban planning of Ismailia city was completely ignored during planning processes. This led to arise of many environmental hazards threating the city and its recent extensions. The present article aimed to assess the geological determinants affecting urban planning of Ismailia city. Water logging and soil salinity are the most serious environmental threats that affects Ismailia city (Fig. 2).

Figure (2): Land drowning due to water logging (A) at El-Mostaqbal district, western sector of Ismailia city and (B) near Canal TV Station, eastern sector of Ismailia City.

MATERIALS AND METHODS

A considerable data-base and previous works were obtained from different governmental agencies, universities, web sites and personal researchers. These data include census data, urban planning studies, environmental studies and different geological and hydrogeological researches. In addition, several maps, including topographic, hydrogeological, geological and land-use maps are constructed based on processed images using remote sensing techniques. Physical and environmental data of the studied area have been derived from office, field and laboratory works done through the present study as described below.

Remote sensing and digital image processing involving the manipulation and interpretation of digital images with the aid of a computer were used to detect outline and monitor water logging and salt crust problems at the studied area. Satellite images are used to monitor current land cover changes due to their rapid up-date capability. Urban change detection mapping and analysis are facilitated through the interpretation of multi-date satellite images (Lillesand et al., 2004). Remote sensing image processing techniques are applied in the present study using band combination, band ratios, image classification, Principal component analyses and change detection techniques. Hydrochemical and water level data are represented on contour maps using SURFER program (Surface mapping system, 2002) and used, in conjunction with field observations, to decipher the source of recharge and history of groundwater flow along Ismailia city.

Field survey was done to check the interpreted satellite images and to find out the causes for the land degradation by water logging and salinity. During the field investigation of the present study, water samples for a number of 8 surface water points were collected through digging a number of a network of 8 auger holes all over the investigated area.Hydrogeological field works, including groundwater level monitoring, well data collections, groundwater and surface water sampling and in situ measurements of physico-chemical parameters {pH-value, Electric Conductivity (Ec), Oxidation-Reduction potentials (Eh) & Temperature (T)}, are done along several field trips to different sectors of Ismailia city (Table 1).

Table (1): Physico-chemical parameters of the studied water samples.

Sample No.	Ground level (m)	DW (m)	WT (m+msl)	EC (µS/cm)	pH	TDS (mg/l	Ca (mg/l)	Cl (mg/l)	HCO_3 (mg/l)	SO_4 (mg/l)
1	4.5	0	4.5	1112	7.2	712	56	150	6.1	720
2	5	1.15	3.85	4210	7.4	2695	132	710	6.1	720
3	4.5	0	4.5	2020	7.3	1293	40	400	12.2	320
4	10.8	0	10.8	108240	8.2	69274	1040	38350	6.1	600
5	9.4	0.5	8.9	51400	8.0	32896	160	1350	12.2	390
6	14.8	2.4	12.4	5000	7.6	5000	24	1400	10.0	300
7	13	0.3	12.7	10240	7.9	5664	180	2640	12.2	360
8	4.8	0	4.8	4210	7.4	8880	132	710	6.1	720

DW: Depth to water, WT: Water table level, EC: Electric conductivity, TDS: Total dissolved salts

In addition, historical data of water level and water chemistry for a number of 16 water points within the study area (Moheb, 2004) were used as reference wells for measuring groundwater level and salinity. This helps us to correlate the water level and salinity variation during the last two decades and to recognize the environmental changes developed along Ismailia city.

Water chemical analyses was done in the hydrogeological laboratory of Geology Department, Suez Canal University for the major ion constituents following the standard methods of APHA (1971).

RESULTS AND DISCUSSION

1. Remote Sensing

(a) Band combination

The most appropriate band combination giving high contrast among land covers were selected; band combination 742, RGB was used for TM images for year 1990 and 653, RGB was used for Landsat 8 for year 2014 (Fig. 3).

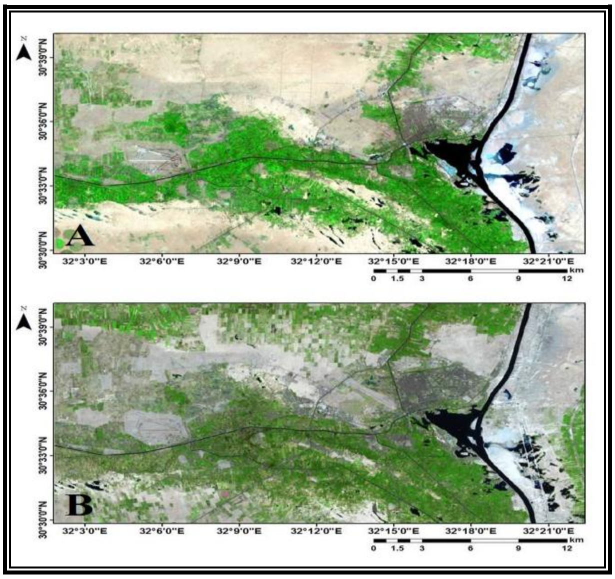

Figure.(3): (A): Band combination 742, RGB for TM in 1990, (B): 653, RGB for Landsat 8 in 2014

(b) Band ratioing

Band ratioing 7/4, 4/2, 7/2 was used in band combination R, G, B for the TM satellite image for year 1990. Band combination ratios 6/5, 5/3, 6/3 were used as RGB for Landsat 8 image data in 2014 (Fig. 4).

(c)Principal Component Analyses

Colour composites made from images representing individual components often show information not evident in other enhancement products (Sonka et al., 1993). Principal Component Analyses PC1, PC2, PC3 for the TM satellite image for year 1990 and Landsat 8 image data for year 2014 are used as band combination R, G, B to get the most appropriate enhancement showing the distribution of water logged and salt crust, land subsidence and extension of informal settlement areas (Fig. 5).

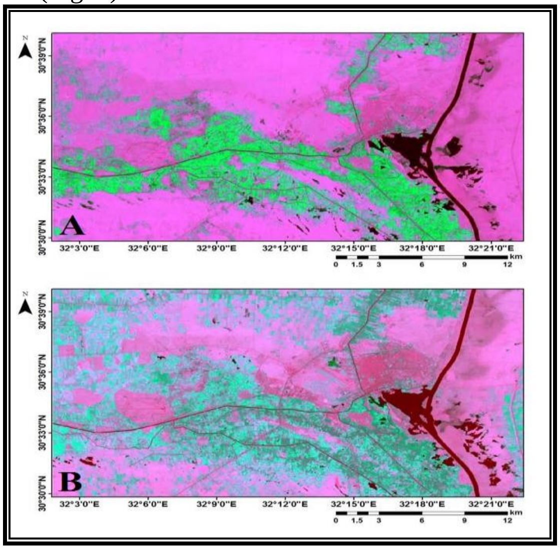

Figure (4): (A): Band ratio combination 7/4, 4/2, 7/2, RGB for TM in 1990, (B): 6/5, 5/3, 6/3, RGB for Landsat 8 in 2014.

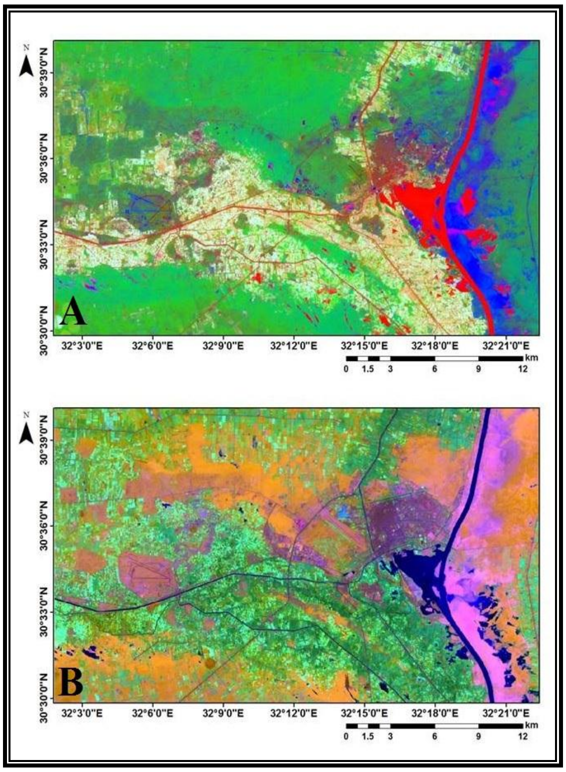

Figure (5): (A): Principal Component Analyses PC1, PC2, PC3, RGB for TM in 1990, (B): PC1, PC2, PC3, and RGB for Landsat 8 in 2014.

(d) Image classification

The intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes, or "themes". This categorized data may then be used to produce thematic maps of the land cover present in an image. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization (Lillesand and Kiefer, 1994). Image classification is the most important part of digital image analysis. In unsupervised classification, clustering software is used to uncover the commonly occurring landcover types, with the analyst providing interpretations of those cover types at a later stage (Sonka et al., 1993). Unsupervised classification was carried out on two data sets of separate images using a histogram peak cluster technique to identify dense areas or frequently occurring pixels (Lillesand & Kiefer, 1994; Eastman, 1997; Mather, 1999). To undertake supervised classification, it is necessary to collect training samples that relate ground cover to spectral signatures for a given geographic location. All spectral classes in the scene were represented in the various subareas. These areas were then clustered independently and the spectral classes from the various areas were analyzed to determine their identity. Clusters representing land cover types that are similar were combined together (Lillesand et al., 2004).

Unsupervised classification was performed to classify the land covers at the studied sites and changes were mentioned during the last 25 years during 1990- 2014. Twenty-five ground control points were checked. The number of classes was determined by hierarchical clustering. Supervised classification using the maximum likelihood approach has been performed. Image accuracy was assessed, it was 86%. Five classes were observed at the study sites (Fig. 4) including, surface water (waterlogged areas) with red colour, Quaternary playa deposits (sand) with yellow colour, urbanized land with blue colour, fluviatile and lacustrine deposits (salt-affected soils) with pale blue colour and Nile deposits & cultivated areas with green colour (Fig. 6).

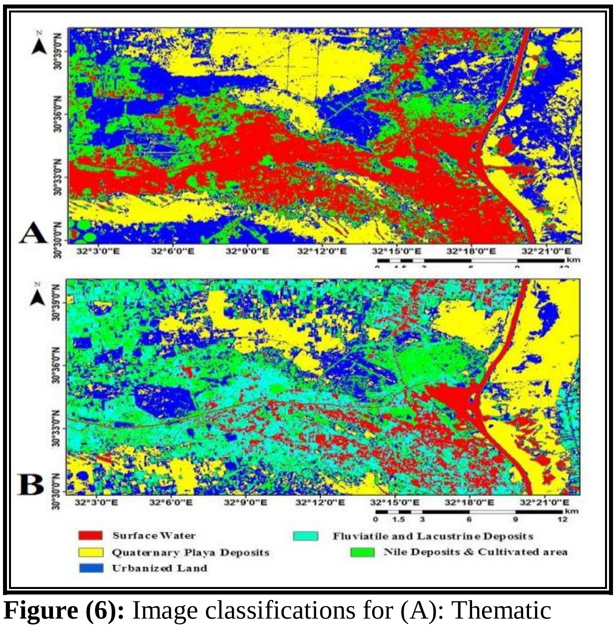

Figure (6): Image classifications for (A): Thematic mapper image (TM) in 1990 and (B): for Landsat-8 image data in 2014.

In conclusion, water logging is the most serious and extensive environmental problem that forms soil salinization and land degradation in Ismailia governorate area. The underflow and agricultural drainage water drain upward towards low wetlands and surface water. During field visits, it was noticed that geologic factors including topography, lithology and soil types, level of water table, underground water flow are not considered in account during future urban and development plans.

Image classifications and change detection techniques were applied to determine changes between the available images. Unsupervised/ supervised classification was employed to obtain a detailed land classification data. The classes in the unsupervised classification scheme were very similar to those produced in the supervised classification. Maximum

Likelihood supervised classification was applied to Landsat images acquired in 1990 and 2014 for the assessment of land cover classes. Five land use categories were identified, including surface water, sand cover, urbanized land, salt-affected soils and Nile deposits & cultivated areas. Each class was verified in the field using a Garmin 38 GPS unit; more than 25 ground data sites were visited and checked. The results confirmed a decrease in the rate of water logged areas during 1990-2014. The surface water areas decreased from 166 km^2 in 1990 to 31.5 km^2 in 2014. On the other hand, salt crust area increased from 3 km^2 in 1990 to 54.5 km^2 in 2014.

2. Groundwater flow regime

Water-bearing formations of east Nile delta consist mainly of Quaternary fluvial and local fluvio-marine sand deposits. Their lithologic characteristics and thickness are highly controlled by the prevailing geological and environmental conditions. There are two types of water-bearing formations; the main fluvial Pleistocene aquifer and the local fluvio-marine Holocene semi-permeable aquifer. The Quaternary Sediments are underlined by Miocene and Pliocene successions of limestone and shale respectively, which act as an impervious base for the main Quaternary aquifer in most areas (Fig. 7).

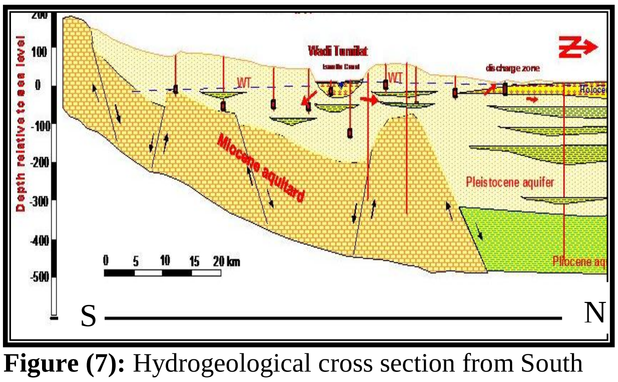

Figure (7): Hydrogeological cross section from South to North along the Eastern Nile Delta area (after Geriesh, 1995) (See Fig. 1 for location).

The Pliocene shale, according to Geriesh (1995), shows foreshore to relatively deep quiet marine character deposited under transgressive sea, whereas the Quaternary, sandstones at the top seem to have been deposited under rather regressive sea.

Groundwater recharge to the Quaternary aquifer of Ismailia area could take place through seepage from canal water distributaries and through excess irrigation return flow in traditionally cultivated lands all over the study area and the newly reclaimed desert fringes to the east. Water table map in 2004 shows existence of water mound (water level maxima) at the central part of the mapped area which reaches up to 5 m above sea level (Fig. 8). This mound radiates groundwater flow in several directions around the mound. The main source of this mound is the irrigation returned water flow that arises from reclaiming a local new land at El-Salhya plain. Ten years later, water table map in 2014 shows that there is a regional increase in water level that reaches 13m above sea level. The regional flow of groundwater is mainly directed from west to east via Ismailia city (Fig 8). The source of water table increment is attributed to the access irrigation practice to wider reclamation lands along El-Salhya plain and eastern Nile Delta region. The hydraulic gradient around urban area of Ismailia city highly increased resulting in the appearance of many water logged sites within the urban area of Ismailia. It is recommended that dewatering system should be designed before construction of building foundations in order to decline the groundwater level.

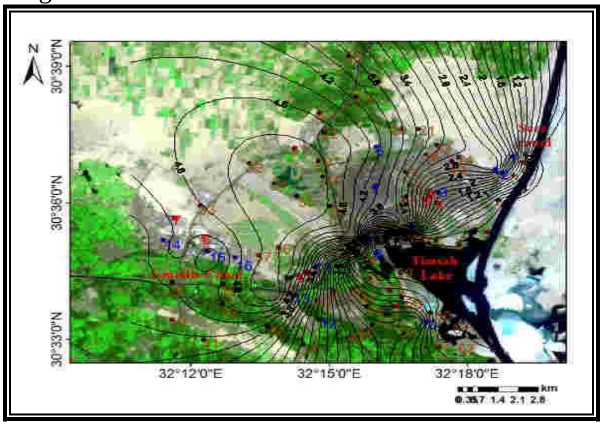

Figure (8): Water table map of Ismailia area in 2004 (data after Moheb, 2004).

3 Threats of sulphate content in groundwater

Sulphate content in groundwater in 2004 (Fig. 9) ranged between 64 and 530 ppm. Two separate SO4 maxima are observed along the northern part of Ismailia city urban area and the middle part of Wadi El-Tumilat. The SO_4 distribution pattern confirms the interaction between groundwater and soil-rich gypsum as a source of sulphate in ground water. In 2014, sulphate content in groundwater progressively increased and varied between 300 and 720 ppm (Fig.10). Sulphate distribution map exhibits a regional increasing trend from southwest to northeast which referred to leaching trend of gypsum salts along the flow path. The excessive leaching of sulphate led to the connect the above mentioned two

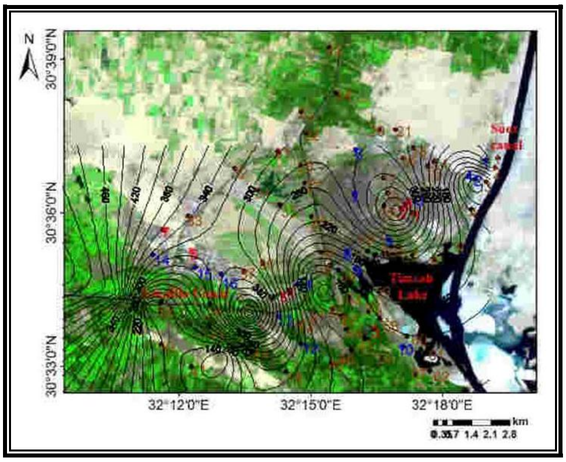

Figure (9): Sulphate content of groundwater in Ismailia area in 2004 (Data from Moheb, 2004).

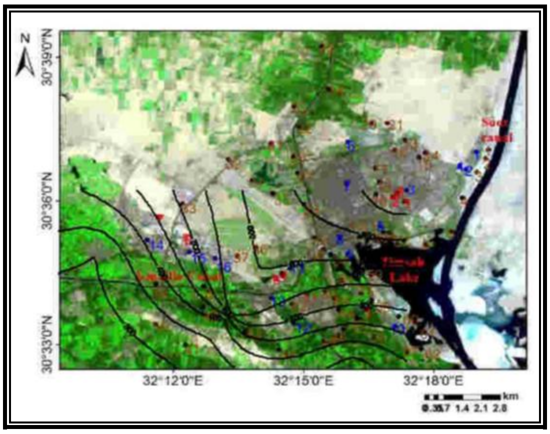

Figure (10): Sulphate content of groundwater in Ismailia area in 2014.

CONCLUSION AND RECOMMENDATIONS

Remote sensing and hydro chemical approach has successfully used in the present study to obtain geological factors controlling future strategic urban plan of Ismailia City. The following broad conclusions can be drawn as:

1- Proper urban planning should consider the impacts of geological and environmental features.

2- At the northern parts of Ismailia city, it is noticed that sulphate content is very high; so sulphate resistance precautions should be taken into account to avoid corrosion of building foundations.

3- At the eastern and northern parts of Ismailia city, it is noticed that water level is very high; so water drainage management should be performed to lower the water level and to avoid waterlogging risk.

REFRENCES

APHA, 1971. Standard methods for the examination of water and waste water. American public health association, Washington, DC. 874p.

EASTMAN, J. R., 1997. Supervised classification in IDRISI for windows version 2, tutorial exercises. Worcester, Massachusetts: Clark University. pp. 86–94

EL-FAWAL, F.M. 1992. Sedimentology of the quaternary southwest of Ismailia and its chronostratigraphy west of the Suez Canal; pro.3rd conf. Geol. Sinai develop. Ismailia, pp.141-152.

EL-SHAZLY E., M. ABDEL HADY, A. SALMAN, W. MESHERF, M. MORSY, M. EL RAKAIBY, I. EL_AASSY, A. KAMEL, A. AMMAR, AND M. MELEIK. 1975a. Geological and geophysical investigations of the Suez Canal zone, Remote sensing research project academy of scientific research and technology, Cairo, Egypt.

EL-SHAZLY E., M. ABDEL HADY, M.M. EL_SHAZLY, M. EL_GHAWABY, I. EL_KHASSAS, A. SALMAN, AND M. MORSY. 1975b. Geological and ground water potential studies of Ismailia master plan study area, remote sensing research project, Academy of scientific research and technology, Cairo, Egypt.

ENVIRONMENTAL ACTION PLAN oF ISMAILIA. 2008. Egyptian Environmental Affairs Agency Cairo

ENVIRONMENTAL PROFILE oF ISMAILIA. 2008. Egyptian Environmental Affairs Agency, Cairo.

GERIESH, M.H. 1995. Hydrogeological and hydrogeochemical evaluation of groundwater resources at Suez Canal Province, Egypt. Ph.D. Thesis, Suez Canal University, Ismailia, Egypt.

INFORMATION AND DECISION SUPPORT DEPARTMENT, ISMAILIA GOVERNORATE. 2014. Monthly report, Ismailia, Egypt.

LILLESAND T.M., R.W. KIEFER, AND J.W. CHIPMAN. 2004. Remote sensing and image interpretation. John Wiley & Sons, Inc. 763pp.

LILLESAND, T.M. AND R.W. KIEFER. 1994. Remote Sensing and Image Interpretation, Jon Wiley & Sons, New York, 750pp

MATHER, P.M. 1999. Computer processing of remotely-sensing images, an introduction (2nd ed.). Chichester: John Wiley and Sons. pp. 1–75.

MINISTRY OF HOUSING, INFRASTRUCTURE AND URBAN PLANNING ORGANIZATION, 2010. Infrastructure and urban development, Strategic plan of Ismailia City, Cairo, Egypt.

MOHEB, N.M. 2004. Land use planning of Ismailia City and surroundings using GIS techniques . M.Sc. thesis, Faculty of Science .Suez Canal University, Ismailia, Egypt.

SONKA M., V. HLAVAC, R. BOYLE. 1993. Image processing, analysis and machine vision, Chapman & Hall, London, 555pp.

SURFACE MAPPING SYSTEM. 2002. Surfer program, version 8.00, Golden Software, Inc. Colorado.

العوامل الجيولوجية المتحكمة فى التخطيط العمرانى لمدينة الإسماعيلية ، إقليم قناة السويس ، مصر

نعيمة محمد محب[١] ، أحمد السيد الريس[١] ، محمد حلمي جريش[١] ، منى فؤاد قيصر[١] ، هشام محمود جادو[٢]

[١] قسم الجيولوجيا، كلية العلوم، جامعة قناة السويس، الإسماعيلية، مصر

[٢] قسم التخطيط العمرانى، كلية الهندسة، جامعة عين شمس، القاهرة، مصر

يهدف البحث إلى تقييم المحددات الجيولوجية المؤثرة فى التخطيط العمرانى المستدام لمدينة الإسماعيلية بإقليم قناة السويس. وقد أستخدمت تقنية نظم المعلومات الجغرافية فى تكامل البيانات الحقلية والخصائص الكيميائية للمياه الجوفية وقياسات مناسيب سطح الأرض وسطح المياه الجوفية لتحديد العوامل الجيولوجية المؤثرة فى الخطة الإستراتيجية لمدينة الإسماعيلية لعام ٢٠١٠. وأظهرت الصور الفضائية المأخوذة لمدينة الإسماعيلية خلال الفترة من ١٩٩٠ إلى ٢٠١٤ أن المدينة قد تعرضت لبعض المشاكل البيئية (مثل غدق الأراضى وتملح التربة والإنهيارات الأرضية) عقب إنشاء المشروعات العمرانية والصناعية والزراعية الجديدة بها. بالإضافة إلى ظهور الإمتدادات العشوائية حولها وهى مناطق غير مخططة عمرانيا. وأظهرت نتائج التحاليل الكيميائية للمياه الجوفية إزدياد محتوى الكبريتات فيها، والتى تتسبب فى تكوين القشرة الملحية على سطح التربة. كما أظهرت النتائج أيضا أن المناطق العشوائية تعانى من مشكلة إرتفاع منسوب المياه الجوفية فيها مما يتسبب فى إغراق مساحات واسعة من أراضيها. وبينت خرائط التغير فى إستخدامات الأرض أن هناك زيادة فى مساحات الأراضى المستصلحة للزراعة ومساحات القشرة الملحية ومساحات المناطق العشوائية خلال الفترة من ١٩٩٠ إلى ٢٠١٤ فى حين أن مساحات المناطق التى تعرضت للإغراق قد قلت خلال نفس الفترة وذلك لتطبيق نظم الصرف لخفض منسوب المياه فى بعض المناطق حول المدينة. وتوصى الدراسة بأخذ المحددات الجيولوجية والبيئية فى الإعتبار عند وضع الخطط العمرانية المستقبلية.