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The challenges of urban sprawl and its impacts on the fragmented agricultural lands: A case study of Tersa, Giza

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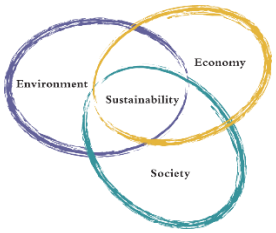

THE CHALLENGES OF URBAN SPRAWL AND ITS IMPACTS ON THE FRAGMENTED AGRICULTRAL LANDS: A CASE STUDY OF TERSA, GIZA

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Abstract

Parallel to the fast growing population, the whole world in general and the developing countries in particular are experiencing an unusual rapid rate of urbanization. Unmanaged urban sprawl is one of the major challenges in the urbanization process. Urban sprawl occurs as an expansion over the limited fertile land and therefore adds more stress to agricultural resources, food security as well as stressing the available infrastructure.

This research aims to study and highlight the influences of urban sprawl on the agricultural lands in Egypt with particular emphasis on the fragmented agricultural lands produced by it. The study sheds light on a case study in Giza governorate (Tersa district).

The research affirms that urban sprawl has direct and indirect impacts on the various dimensions of the agricultural process in Tersa and in turn influences crop production and food security. Urban sprawl led to losing about 19 percent of Tersa's fertile agricultural lands between 2007 and 2017. Farmers of the remaining agricultural lands face many challenges in traditional farming practices. Crop type has totally changed as a result of polluted irrigation water and other practices of the surrounding urban residents. Accordingly, the remaining agricultural lands are losing its soil fertility.

The study is investigating the impact of the urban sprawl in Tersa district on agricultural resources over a ten years period between 2007 and 2017. It attempts to answer the research questions through integrating remote sensing data and primary data obtained from conducted social study in four areas within Tersa. In addition, irrigation water samples were collected and analyzed to evaluate irrigation water quality which is considered a major dimension influencing the changes of crop production.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CAPMAS	Central Agency for Public Mobilization And Statistics
CSD	Center of Sustainable Development
EEAA	Egyptian Environmental Affairs Agency
FAO	Food and Agriculture Organization
GCMR	Greater Cairo Metropolitan Region
MENA	Middle East & North Africa
SWERI	Soil, Water & Environment Research Institute
UNDESA	United Nations Department of Economic and Social Affairs

Chapter 1. Introduction

The world faces an unprecedented rate of urbanization nowadays. More than 50 percent of the world's population lives in high densely populated areas with different urbanization levels (UNDESA, 2014). Though urbanization occurs in both developed and developing countries, urbanization rate occurs at rapid pace in developing countries and causes significant pressure on the available limited resources in these countries (UN-WWAP, 2015).

The problems of urbanization are exaggerated if not managed properly. Unplanned urbanization is usually associated with negative short and long term consequences that has direct impacts on natural resources. Natural resources have clearly declined over the past period as a result of urbanization activities. Madlener & Sunak (2011) stated that although cities only cover about 2 percent of the Earth's surface, but they are incharge of consuming nearly 75 percent of the world's resources. It is also responsible for depletion of ecological communities, worsening air and water quality and loss of many species. Furthermore, urban areas in general contribute to release of greenhouse gases with 60 to 80 percent globally.

Anderson (2000) summarized the environmental impacts of rapid urbanization as follows:

- Over exploitation and misuse of natural resources (water, energy, .. etc.) as a result of high consumption in condensed urban areas
- Air pollution due to extra anthropogenic activities releasing pollutants such as hydrocarbons, heavy metals, carbon and sulfer oxides; this leads to many health problems beside the environmental impacts
- Urban heat island effect and contribution to climate change where urban areas show unusual rise in temperature compared to the surrounding nonurbanized areas
- Increase of generated solid waste in return to insufficient available solid waste disposal services leading to many environmental and health problems
- Spreading of slum areas and informal settlments within cities due to shortage of housing facilities for immigrants from rural areas; so they construct their own dwellings informally

Land insecurity, noise pollution, and waste disposal problems are also consequences of uncontrolled urbanization. It further puts heavy preasure on transportation, electricity, sanitation and other provided services (Uttara, Bhuvandas, & Aggarwal, 2012).

Unplanned urbanization is considered one of the main causes of environmental degradation manifested in encroachments over arable lands. According to the results mentioned in Bren d'Amour et al.'s study in 2016, nearly 1.8 to 2.4 percent of the global agricultural lands will be lost under urban sprawl by 2030. These lands were responsible to produce 3 to 4 percent of the global crop production in 2000. In addition, they are 1.77 times more productive than the global agricultural lands' productivity averages. Moreover, 80 percent of these land losses are concentrated in Asia and Africa and considered to be more than 2 times productive compared to their national averages. (Arunpandiyan, Aarthi, Vidyalakshmi, Rj, & Devi, 2015; Kharel, 2010; Uttara et al., 2012). Figure 1 presents expected cropland losses under urban expansion globally and regionally.

Region or country	Expected cropland loss, Mha	Relative cropland loss, % of cropland	Production loss, Pcal·y^{-1}	Production loss, % of total crop production	Productivity compared to domestic/regional average
World	30 (27–35)	2.0 (1.8–2.4)	333 (308–378)	3.7 (3.4–4.2)	1.77
Asia	18 (16–21)	3.2 (2.9–3.7)	231 (214–264)	5.6 (5.1–6.3)	1.59
Africa	6 (5–6)	2.6 (2.4–3)	49 (45–52)	8.9 (8.3–9.4)	3.32
Europe	2 (2–3)	0.5 (0.5–0.9)	17 (16–23)	1.2 (1.1–1.5)	2.18
Americas	5 (4–5)	1.2 (1.1–1.4)	35 (32–40)	1.3 (1.2–1.5)	1.09
Australasia	0.1 (0–0.1)	0.2 (0.1–0.3)	0.3 (0.1–0.3)	0.2 (0.1–0.3)	0.94
China	7.6 (7.1–8.6)	5.4 (5–6.1)	137 (128–153)	8.7 (8.2–9.8)	1.53
India	3.4 (3.3–3.7)	2.0 (1.9–2.2)	34 (32–38)	3.9 (3.7–4.3)	1.61
Nigeria	2.1 (1.8–2.5)	5.7 (5–6.9)	16 (15–17)	11.7 (10.7–12.6)	1.82
Pakistan	1.8 (1.7–2)	7.6 (7.2–8.6)	9 (9–10)	8.8 (8.4–9.9)	1.22
United States	1.5 (1.4–1.6)	0.8 (0.8–0.9)	11 (11–12)	0.7 (0.7–0.8)	0.90
Brazil	1.0 (0.9–1.2)	2.0 (1.7–2.4)	10 (9–12)	2.4 (2.1–2.8)	1.22
Egypt	0.8 (0.7–0.8)	34.1 (31.6–35.8)	25 (23–26)	36.5 (34–38)	1.07
Vietnam	0.8 (0.7–0.8)	10.3 (9.3–11.2)	15 (15–17)	15.9 (15.2–17.2)	1.41
Mexico	0.7 (0.6–0.8)	1.9 (1.7–2.3)	4 (4–5)	3.7 (3.2–4.4)	1.91
Indonesia	0.6 (0.5–0.7)	1.1 (0.9–1.3)	10 (8–11)	2.3 (2–2.7)	2.03

Figure 1: Regional and national implications of urban area expansion on croplands and crop production (Bren d'Amour et al., 2016)

Sprawling over the agricultural lands usually threatens livelihood and is usually accompanied other sustainability risks (Bren d'Amour et al., 2016). Urban sprawl is accompanied with the wide spread of informal settlements that lack accessibility to basic needs and services and whose dwellers commonly use the available resources inefficiently. According to UN-Habitat (2015), about 25 percent of urban population live in informal settlements around the worlds. Unfortunatly, most of traditional authorities and developers frequently ignore the negative consequences of this unplanned development (Cobbinah, Gaisie, & Owusu-Amponsah, 2015).

1.1. Research problem

Egypt is one of the most populated countries in Africa with 2.0 percent population growth rate (World Bank, 2018). Egypt's fertile arable lands are limited representing about 3.9 percent of the national territory. About 43.2 percent of Egypt's population live in urban areas with 2.4 percent urbanization growth rate ("Egypt-Urban Issues – UN-Habitat," n.d.). Over the last five decades, Egypt faced rapid informal urbanization despite all attempts from the government side to decelerate its pace (Osman, Arima, & Divigalpitiya, 2016).

According to the Egyptian Environmental Affairs Agency (2006), unplanned urbanization led to loss of many arable lands in Egypt, and formation of informal settlements. Although this phenomenon is spreading all over Egypt, but it is dominating in the peripheral areas of Greater Cairo. Recent data show that 80 percent of the formed informal settlements are built on privately owned agriculture lands where 62 percent of Greater Cairo and 87 percent of Giza is informal settlements resulted from urban sprawl (Osman, Arima, et al., 2016; Osman, Divigalpitiya, & Arima, 2016).

This rapid urbanization process results in deteriorating the available resources, threatening the fertile arable lands in Egypt's Nile Delta and causing major changes in the agricultural ecosystem (Shalaby, Ali, & Gad, 2012). This research explores the impact of urban sprawl on the dimensions of the agricultural system including: crop type, irrigation, land ownership, labor force, fertilizers, machinery, livestock and the productivity. It also describes the status of resource use in the informal communities that are formed by this urban sprawl throughout the case study of Tersa in markaz Al-Jizah in Giza governorate.

1.2. Research questions

1. What is the impact of urban sprawl on the dimensions of agricultural process?

2. What is the state of available resources and provided services at each stage of urban sprawl?

1.3. Study objectives

The general main objective of this study is to determine the impact of urban sprawl on the fragmented agricultural lands; involving the following specific objectives:

- To describe the stages through which urban sprawl occurs and compare between them

- To identify the consequences of urban sprawl on the inputs and outputs of the agricultural process
- To examine the resource use conditions in the built area due to urban sprawl

1.4. Thesis structure

This research study is comprised of seven chapters which elaborates a detailed investigation about urban sprawl over agricultural lands. **Chapter one** is an introduction chapter reviewing the urbanization pace worldwide and its impact and a general overview about the situation of urban sprawl in Egypt followed by the problem statement and the research questions. **Chapter two** focuses on the background overview and literature on urban sprawl; the chapter starts with defining different terminologies in the area of urban sprawl, followed by detailed discussion of the impacts of urban sprawl on agricultural lands and the status of resources in the informal settlements formed as a result of urban sprawl. **Chapter three** is devoted to the methodology of the research study. **Chapter four** comprehensively describes the study area and presents the status of available resources based on the field study. **Chapter five** explains the changes occurred to the agricultural sector in Tersa that are mainly caused by urban sprawl. **Chapter six** presents the conclusion and recommendations of this research study.

Chapter 2. Literature Review

This chapter presents a background review of the urbanization, urban sprawl and its impacts. The chapter starts with the basic definitions of urbanization related concepts, namely urban growth, urbanization, urban sprawl and other related terms (section 2.1) followed by global urbanization trends (section 2.2) and a brief explanation on how urbanization takes place physically through land use change (section 2.3). The impact of urban sprawl on agriculture including loss of agricultural lands and the impact on the remaining agricultural land pockets is presented (Section 2.4). The final section (2.5) presents the resource use characteristics in the informal peri-urban communities formed because of urban sprawl (section 2.5).

2.1. Terminologies

Due to multidisciplinary dimensions involved in the topic of urbanization and urban sprawl, and other related terms are usually used synonymously to each other.

Urbanization is a wide multidimensional definition. It is a basic transformational path which low-income rural communities go through to modernize and combine with the upper income communities (Various, 2006). Urbanization is a non-spatial complex change in life style; it is a social process that refers to behavioral changes due to the impact of cities on societies. Li Keqiang (2012) defined urbanization as: *"Urbanization is not about simply increasing the number of urban residents or expanding the area of cities. More importantly, it's about a complete change from rural to urban style in terms of industry structure, employment, living environment and social security".* Yet, the term urbanization is currently used in broader direction. Urbanization is indicated as to the physical growth of urban communities involving people movement from rural areas to urban areas. Accordingly, urbanization does not only refer to simple increase of population in urban areas but it also including economic, political structure and social changes of the community.

Urban growth describes the increased population concentration within certain society and economy through spatial demographic process (Balram, Dragicevic, & Bhatta, 2010). Urban growth occurs due to the natural population increase or immigration of rural dwellers into urban areas. Natural population increase rates in urban communities is usually lower than rural communities in addition to the unemployment problems and the lack of facilities in the rural

communities; accordingly the major reason for urban growth is the rural-urban migration (Cohen, 2006).

Urbanization and urban growth terms are used synonymously to each other (Balram et al., 2010).

Urban agglomeration is a densely populated region encompassing city inhabitants, suburbs, and any high density populated adjoining territory (Pirozzi, Kamber, & Nesbitt, 2012).

Urban sprawl is conceptualized as a poorly controlled physical expansion form of urbanization. It is an undesirable pattern of development (Adaku, 2014). EEA and Eadaku (2014) defined urban sprawl as a low density expansion model of urban regions which usually occurs over agricultural lands. Urban sprawl is a dispersed form of urbanization where horizontal uncontrolled spreading takes place from urban area over the surrounding rural area forming peri-urban areas. Urban sprawl is prevalent in high income countries and low income countries with different rates and forms. Through different definitions of urban sprawl, there are two common dimensions among all of them; inefficient land use and low density (Soares, Ramos, & Fonseca, 2011). Urban sprawl usually leads to formation of separate poorly planned and served residential areas with scattered population (Pirozzi et al., 2012).

Peri-urban area is the urban fringe at the geographical edge of a city. Peri-urban area describes the grey area lies between urban and rural communities with a mix of both communities (urbanized rural region). It is considered as an interaction region between urban and rural boundaries. As a conclusion, peri-urban areas definition goes beyond the idea of a place; however, it is a transitional dynamic process from rural context to urban context. The morphology of peri-urban areas is heterogeneous less complex urban area, which includes both formal and unplanned informal settlements mix (Maryati & Humaira, 2015; McConville & Wittgren, 2014).

Land cover is the physical and biological state of the land surface that includes both natural resources and man-made built structures (Sajjad & Iqbal, 2012), while **land use** describes how human beings make use of land and manage its resources in terms of various activities; it is the way of employment of land cover for different uses (Kharel, 2010).

Land use change is the transformation of land cover by conversion and/or modification to fulfill human needs. Land use change takes place either through A) total conversion of the classification

of land cover from one type of land cover to another, or B) through simple change (modification) in some characters of land cover without total conversion (Daniel & Thuo, 2013; Kumar, Mukherjee, Sharma, & Raghubanshi, 2010; Mundhe & Jaybhaye, 2014).

2.2. Trends of urbanization

2.2.1. Global trends

Globally, residents of urban areas exceed those of rural areas. Year 2007 is considered the keystone when it was the first time that urban population exceeded rural population worldwide and continued on the same pace. In 1800, only 2 percent of global population lived in cities and towns, this percent was elevated in 1900 to reach 15 percent. The pace of urbanization noticeably increased in the 20th century after 1950, where less than 30 percent of the world population lived in urban areas. By 2050, it is expected that nearly 70 percent of the world population will be living in urban areas (Sun & Caldwell, 2012; UNDESA, 2014; X. Q. Zhang, 2016). Before 1950, the majority of urbanization occurred in the developed countries due to industrialization revolution in Europe and North America.

In the meantime, the slow pace of urbanization in developed countries may has come to an end (Gouda, Hosseini, & Masoumi, 2016; X. Q. Zhang, 2016). In the contrary, rapid urbanization is currently concentrated in developing countries and is stressing the available resources (UNWWAP, 2015). The proportion of people who live in urban settlements increased from 17.8 percent in 1950 to reach over 40 percent in the following 50 years according to the data presented by the United Nations Department of Economic and Social Affairs (UNDESA, 2014). Presently, the most urbanized communities are concentrated in North America, Latin America and the Caribbean and Europe where urban areas represent 82 percent, 80 percent and 73 percent respectively in 2014. In contrast, rural areas are still dominating Africa and Asia, where 40 percent and 48 percent of their population live in urban areas, respectively.

Rapid urbanization is expected to continue with faster rate in the coming decades especially in Africa and Asia where urban areas are expected to cover 56 percent and 64 percent of their area respectively by 2050 (UNDESA, 2014). Nigeria, China and India are estimated alone to add 900 million urban inhabitants to their mega cities by 2050 (Gumma, Mohammad, Nedumaran, Whitbread, & Lagerkvist, 2017). Besides, the proportion of urban population in MENA region has

almost doubled from 1960 to 2017; where the urban population share was 34.96, 48 and 64.90 percent in 1960, 1980 and 2017 respectively according to the data presented by the WorldBank in 2018. Urbanization occurs in every region with different pattern, speed and rate. In addition, urban environments vary in their characteristics (UNDESA, 2014). Accordingly, effective policies and successful management plans in particular region many not be effective in another region (Soares et al., 2011).

Figure 2 shows the number of the population residing in urban and rural areas worldwide and the expected population projections for these two regions through 2050. It clearly shows that the population in urban areas exceeded that for rural areas by the year 2007. It also shows that urban population will continue to increase until it almost double the size of the rural population in 2050.

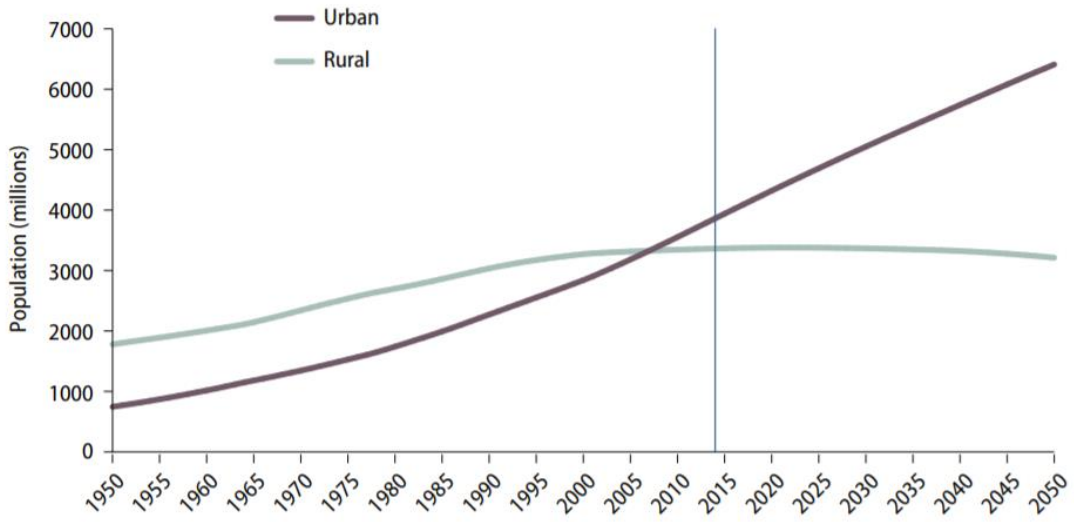

Figure 2: Projections of global population in urban and rural areas (UNDESA, 2014)

2.2.2. Sprawl in Egypt

Egypt's population inhabits only 5 percent of its land area so that about 95 percent of the population is concentrated in the Nile Delta ("The World Factbook — Central Intelligence Agency," n.d.). This unbalanced allocation of population leads to critical socio-economic impacts represented in prevalence of informal settlements and poverty (Shalaby et al., 2012).

Figure 3 and figure 4 show Egypt's urban and rural population distributions according to the FAO projections. Urban areas were doubled between 1968 and 1982, 43 percent of Egypt's population lived in urban areas in 2014; where Egypt was in the 10th rank of global urban agglomerations.

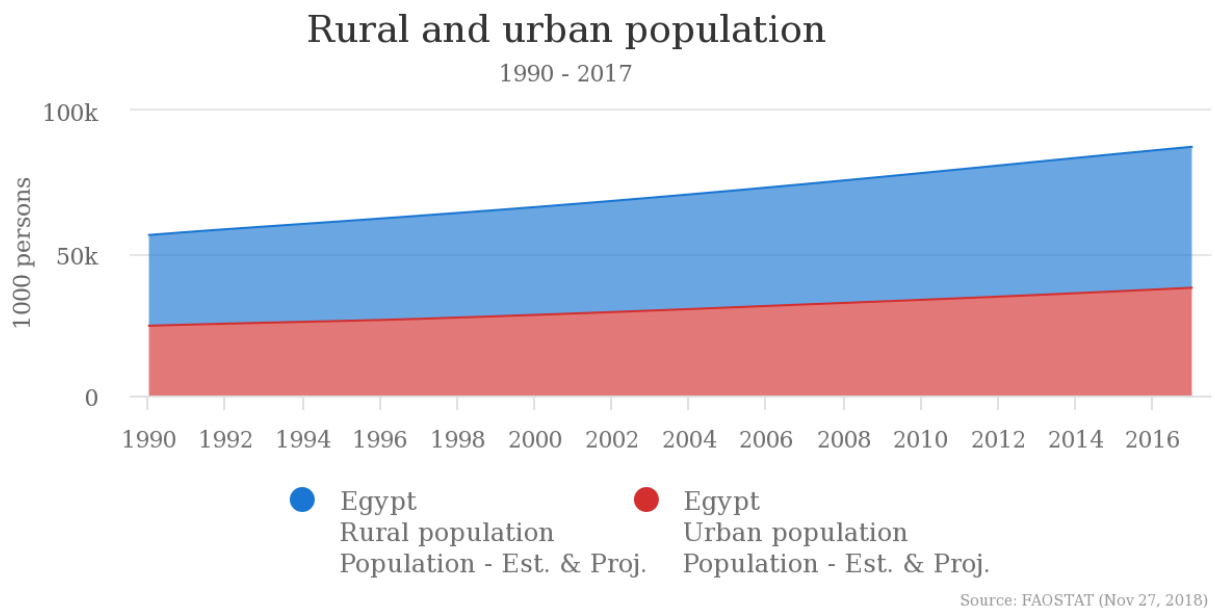

Figure 3: Egypt's rural and urban population projections (FAO, 2018)

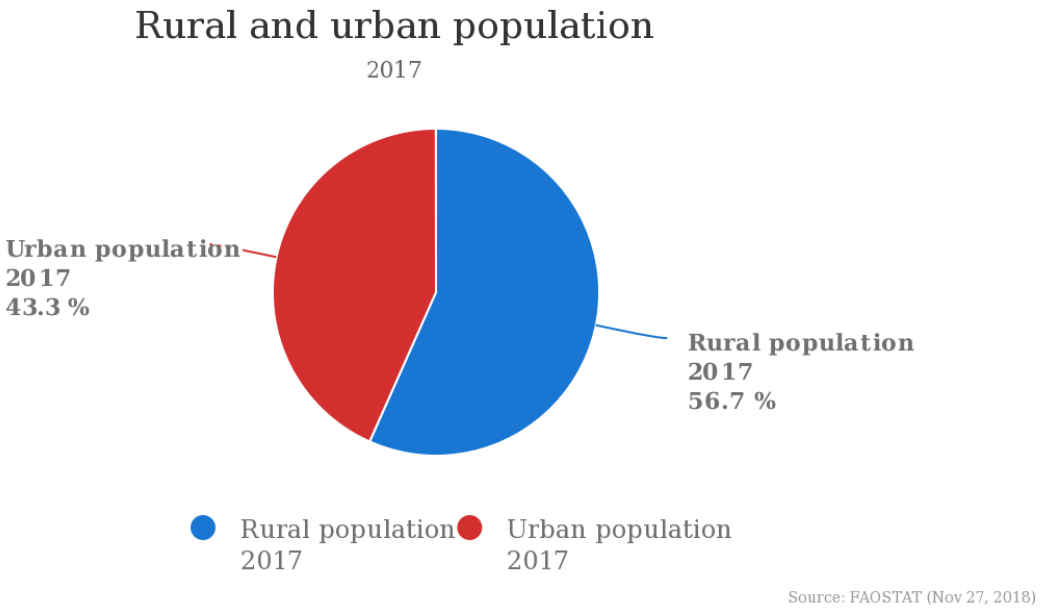

Figure 4: Percentage of Egypt's rural and urban population in 2017 (FAO, 2018)

Although Greater Cairo Metropolitan Region (GCMR) is the elementary engine for economic growth and one of the largest metropolitan cities in Africa (18th largest metropolitan area globally), it witnessed unmatched urban sprawl rate concentrated over the fertile agriculture lands ("Egypt-Urban Issues – UN-Habitat," n.d.). Khamis, Ali, & Hahn (2015) highlighted in their study that nearly all of Cairo's urban expansion took place on fertile and rich agricultural lands.

Many drivers led to encroachments over agriculture lands in GCMR; these drivers include: the rapid population growth that Egypt witnessed since 1950s, the need for more houses, low profitability of agricultural lands compared to prices of lands devoted for urban uses -the market value of agriculture lands increases up to 8 times if converted into urban uses -, and the lack of powerful legislations that proscribe agriculture infringements (Gouda, Hosseini, & Masoumi, 2016).

The majority of urban sprawl invaded GCMR from the communities living in the outskirt area (peripheral villages). As a result, informal peri-urban communities formed and swallowed most of the available agriculture lands on its way.

Egypt's total agricultural lands was estimated to be 37,503 km^2 (8.92x 10^6 feddans) in 2012, representing about 3.7 percent of Egypt's total land area (Hereher, 2013). Between 1952 and 2002, Egypt has lost about 2940 Km^2 of agricultural lands due to urbanization (Alfiky, Kaule, & Salheen, 2012). Satellite images of the Nile Delta were captured in 1972, 1984 and 1990 and compared showing occupation of urban areas over 3.6, 4.7 and 5.7 percent of the Nile Delta respectively (Sultan et al., 2015). Hereher (2013) indicated in his study based on world bank's reports that the annual loss of agricultural lands due to urbanization in Egypt is estimated to be 20,000– 100,000 acres. Moreover, the political situation during the three years succeeding January 25th, 2011 led to dramatically encroachments upon agricultural lands. The highest rate of these encroachments were concentrated in Greater Cairo and the Nile Delta. Sims, D. (2012) asserted that the rate of unlicensed informal buildings activities after January 25th, 2011 has raised by 2.5 times than the rate before January's revolution. The infringements over the agriculture lands in the Nile Delta were estimated to be about 215 Km^2 up to 630 Km^2 (Gouda et al., 2016).

2.3. Land use change

Land is a limited resource that should be managed effectively. With population increase, the need for more housing units, new roads, infrastructure and other related human services increases. Even though, in most of the world parts, land use changes (urban expansion processes) are occurring faster than the increase of urban population. Whereas, between 2000 and 2030, urban areas are expected to triple while urban population growth is expected to double from 2.6 to 5 billion (Bren

d'Amour et al., 2016). In the meanwhile, the available land resources are usually fixed. Urban areas lies at the focal point of complicated dynamic forms of land use change, with their developing structured framework based on human and economic activities. The significantly continuous increase of population pushes urban zones to encroaches over the available surrounding lands (Doygun, 2009). As a result, losing and destroying valuable natural resources such as agriculture lands, forests and surface water bodies take place (Kharel, 2010). Urban sprawl invades water ways or agriculture lands to build more houses (Madallah & Tarawneh, 2014).

Building over agricultural lands causes huge losses and multi-dimensional impacts. Many rural communities are changing or completely lost due to urban sprawl over arable lands (Wu, 2008). Other than agricultural land losses, water quality and quantity are severely affected when covered with impervious building layer, which affects the percolation of rains into groundwater aquifers. Consequently, the rate of floods increase and the whole hydrologic cycle is directly disturbed (Madallah & Tarawneh, 2014).

2.4. Impacts of urban sprawl on agricultural lands

2.4.1. Direct impacts: loss of agricultural lands

Agricultural lands at the outskirts of urban communities play an important vital role as being an ecosystem services providers, for example, clean air, water, soil, and food to the urban regions, and as buffer areas to lessen negative impacts of the urban systems on the environment. They are considered a transitional regions between natural habitats of rural areas and urban landscapes. (Doygun, 2009).

Most of the previous studies present an extensive variety of negative impacts relating to the human-environment framework in sprawled urban regions (Du, Shi, & Rompaey, 2013). Urban sprawl is linked to the shrinkage of the near surrounding agricultural lands (Shalaby et al., 2012). Encroachments over agricultural lands is a profit oriented process accompanied with ineffectiveness land use (Du et al., 2013).

Thus, urban sprawl is a major threat for agricultural lands. This also affects agricultural products, market and influences the long-run ability of producing food and fibers leading to food security problems. The more population increases, the more agricultural lands are converted into urban areas leading to agricultural land losses (Heimlich & Anderson, 2001) and changes in the

agricultural activities of the remaining lands (Eko, 2012). The low revenues of farming compared to the high profits gained from building activities in addition to increasing population are the main drivers of urban sprawl over the agricultural lands (Khamis et al., 2015; Soares et al., 2011).

Urban sprawl over the agriculture lands takes place through successive stages. Farmers (land owner) first divide their land into smaller parts, then they constructs their own houses followed by a chain of buildings as much as possible on both sides spread over the remaining area; consequently the agricultural land is turned into residential area over a small period of time (Madallah & Tarawneh, 2014).

Figure 5 and 6 show the global projections of urban expansion leading to loss of agricultural lands. The red highlighted areas represent hot spot areas with high probability (>75 percent, medium scenario) of being converted into urban areas by 2030. Egypt, in particular GCMR is among the threatened areas.

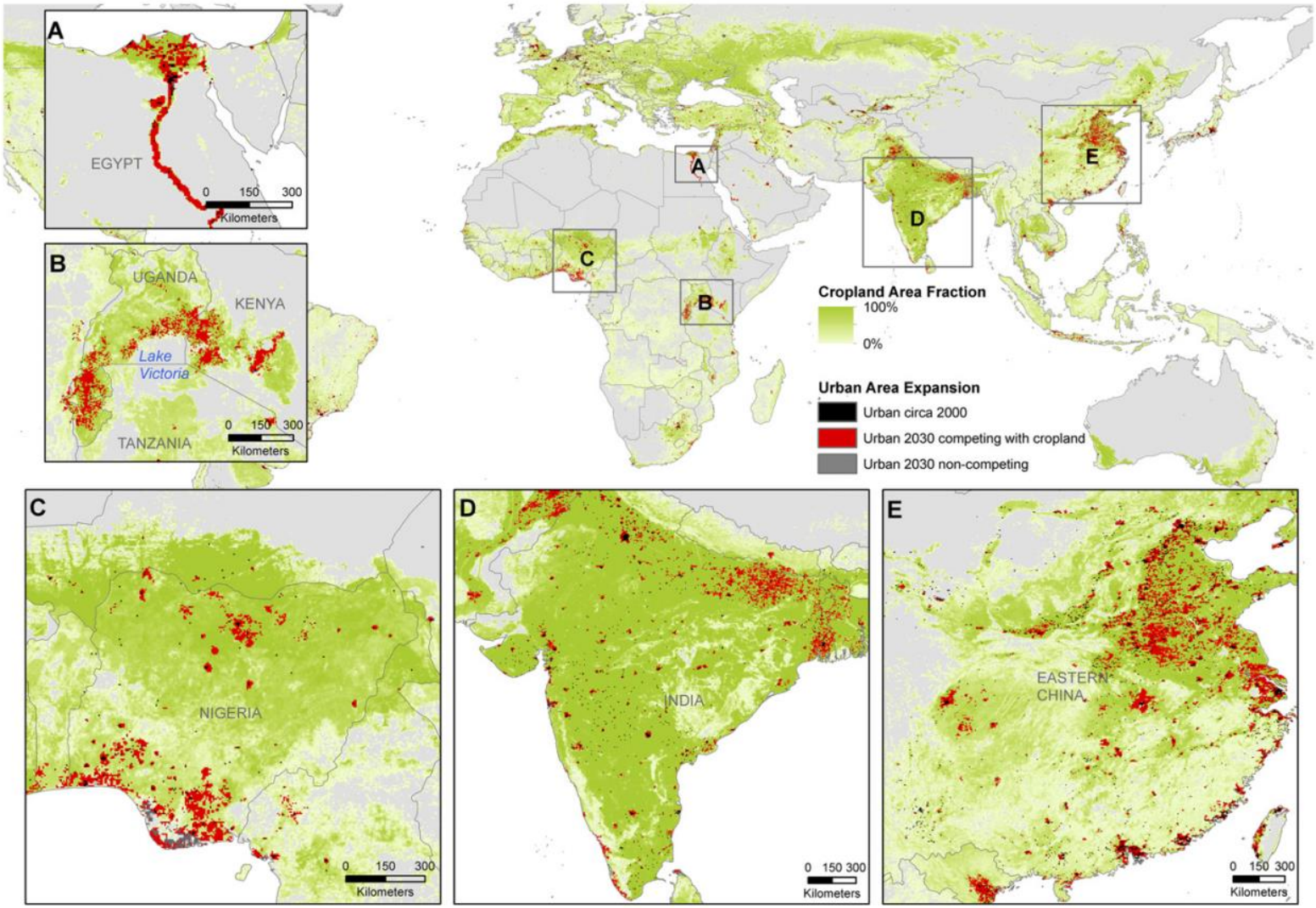

Figure 5: Projections of urban expansions by 2030 (Bren d'Amour et al., 2016)

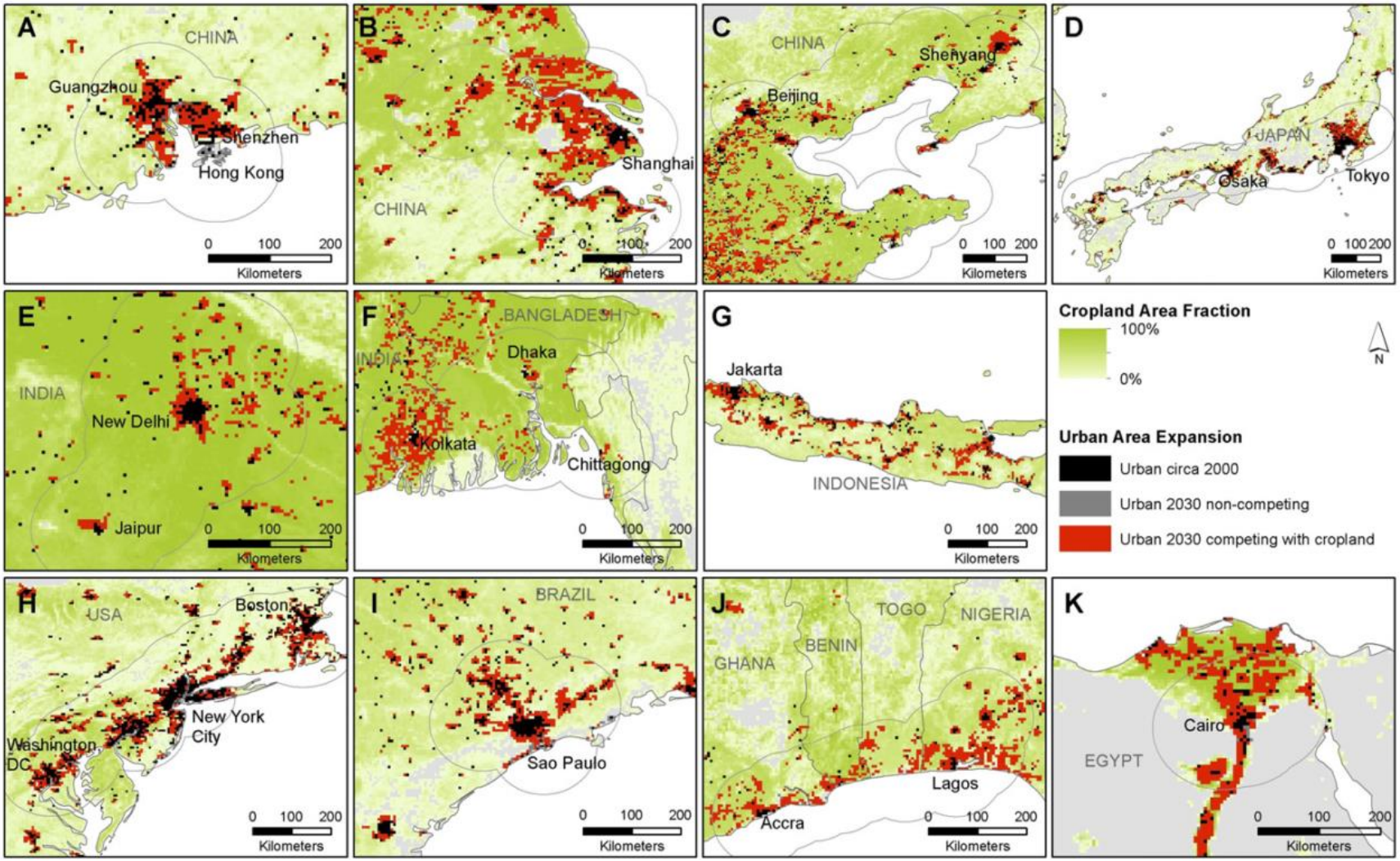

Figure 6: Projections of urban expansion over agricultural lands in 2030 (Bren d'Amour et al., 2016)

According to Kharel (2010), Madallah and Tarawneh (2014), macro- level impacts of encroachments over agriculture lands can be classified in three broad categories, namely economic, environmental and social. The following is a listing of these impacts for each category:

Economic impacts:

- Depleting the main resource that is responsible of food production, consequently food production decreases and affects national food security
- Losing job opportunities afforded by agriculture industry
- Increase of food prices and taxes

Environmental impacts:

- Degradation of soil quality due to change of soil characteristics (physical, chemical and biological), soil erosion is more frequent, land becomes less fertile and productivity decreases. This increases the chance of desertification
- Increase of heat island effect, cities which faces high levels of informal urbanization are more exposed to extreme heat days and high temperature (twice) than cities with green cover
- Change of air quality and increase of greenhouse gases due to the increased consumption of fossil fuels and losing the natural carbon sink (vegetation and trees)
- Landslides (slopes failure) is more frequent

Social impacts

- Spread of informal settlements with very poor services and poor quality housing units is the most common problem that is related to urban sprawl
- Ruralization of urban areas due to migration of farmers and villagers to the city

2.4.2. Indirect impacts: fragmented agricultural pockets

While many peripheral agricultural lands are transformed for sprawl development, the remaining agricultural lands work intensively to produce food and sustain the needs of the large urban residents (Eko, 2012). Population growth and rapid urbanization, especially in developing countries, are expected to increase the stress on agricultural lands' productivity as well as

increasing the difficulties that farmers face in agricultural practices (Gumma et al., 2017). According to Larson, Findeis & Smith (2001), there are indirect influences on the remaining agricultural lands and agricultural activities beside the direct impact of sprawl over agricultural lands –loss of fertile lands-. Urban sprawl makes it more expensive and hard to cultivate in the traditional ways.

Farmers face many problems such as increased pressure on available water resources, unbearable spillover from urban area and crop yields deterioration. In some regions, they may suffer from lack of support of machinery dealers and agricultural inputs suppliers. Adding to this, the increased taxation accompanied with urban lifestyle. The major indirect effect that farmers meet is the increase of costs and thereby their profitability to stay in agricultural production decreases (Larson, Findeis, & Smith, 2001).

2.4.2.1. Loss of critical mass

Residential development increase the value of agricultural lands so farmers sell their land for urban uses. According to Larson et al. (2001), farmers' proportion as a fraction of the community decreases and becomes less significant; consequently their political and economic power decreases. The vital support provided to farmers decreases, public or private markets for fertilizers, seeds, pesticides, providing machines, machinery spare parts and repairing shops reduce their support and become less frequent; farmers find themselves have to go for far distances to get their simple tasks done. Moreover, they are required to accommodate regulations for the new situation of having urban neighbors. Sometimes they are obliged to change agricultural practices for being a small portion of non-farmers predominant community.

2.4.2.2. Surrounding Neighborhood

Conflicts and vandalism

The increased tension between farmers and their new urban neighbors is an important driver leading to adjusting or changing agricultural practices (Heimlich & Anderson, 2001). Urban neighbors complain about nuisance generated from farming activities, machinery noise, livestock waste or odor and spraying pesticides. On the other hand, neighbors and children form nuisance source to farmers. Farmers complain about vandalism from the residents' side such as: stealing

crops or animals, destruction of crops or machinery. Increased pollution resulted from different urban activities leads to reduction of the crop yield and affects crop growth (Berry, 1978).

Neighborhood influences on water quality

Aichele (2005) showed in his study that neighborhood practices influence the water quality of the investigated watersheds in addition to affecting the water flow in underground water. Tu, Xia, Clarke & Frei (2007) had the same conclusion indicating the presence of a significant correlation between urban sprawl indicators and water quality. One of the important conclusions presented in the case study of Arequipa, Peru carried out by Carpio & Fath(2011) is the exponential increase of fecal and total coliform bacteria with increase of population. Qin, Su, Khu, & Tang (2014) discussed the major causes that deteriorates water quality during the early stage of rapid urbanization. The study identified domestic discharges of the surrounding neighborhood - inadequate sanitation and septic tanks poor designs- as the major contributor to deteriorating water quality. Water is a primary component in agricultural process, deteriorating water quality consequently affects agricultural production. Accordingly, international organization set general guidelines and standards for evaluating the water quality used for agriculture. In addition, each country regulates these standards according to its environmental conditions.

2.4.2.3. Market effect

Among the indirect impacts of sprawl on the remaining agricultural lands is the dual market effect. On one hand, sprawl brings farmers closer to market channel. This contributes to increasing access to urban market, facilitates and expands direct marketing of agrarian products rather than wholesale prices and consequently reduces crop transportation expenses. On the other hand, market effect accompanied with urbanization increases the off-farm employment opportunities in addition to increasing the land value for further urban development. Accordingly, many farmers opt out of farming activities and sell their farmlands. The overall situation puts farmland owners of the remaining lands in a confusion state and makes them disinclined to invest in their farmlands.

Accordingly, farmers make agricultural adaptations and adjustments due to pressure caused by sprawl. These adaptations include changing the crop types or other agricultural management practices, for example, changing the location or source of irrigation, they may be forced to shift into more intensive agricultural practices or into higher value agricultural enterprises. (Eko, 2012). At the end, farmers may feel it is difficult to proceed in agricultural activity and sell his land, Berry

& Plaut (1978) summarized the important factors resulting from urban pressure and push farmers to sell their lands as follows:

- Unbearable overflow impacts from urbanization
- Low productivity of the agricultural land and prices fluctuations leading to low net income for the farmer
- High taxes which may result with urban transformations or which may be high in respect to low net income
- Tempting prices offered from developers in return of the farmer's land

2.5. Characteristics of the informal peri-urban areas

Urban growth if not managed properly and well planned leads to formation of informal settlements with poor services. This section presents the characteristics of settlement that are usually formed because of unplanned urban sprawl.

2.5.1 Land ownership

Major problem in the informal peri-urban areas is land ownership security. Illegal subdivision of agricultural lands is considered an unconformity to the law. It is also the main reason behind the insecurity of land tenure. Furthermore, residents of these areas may also include squatters with illegal land acquisition or immigrants who bought the land from land agents claiming to be the owner of the land. Officials are not ready to invest in providing or improving services in peri-urban areas due to the issue of the legality land ownership (Cobbinah et al., 2015; McConville & Wittgren, 2014; Webster & Muller, 2009).

Housing in peri-urban region also faces other problems. Although housing rents in peri-urban areas is low, which attracts low-income urban dwellers, most of buildings are unimproved and temporary with poor quality for easy dismantling due to the probability of future displacement or lawful eviction. They do not comply with building regulations. Durability of housing in informal peri-urban areas is limited. Formalizing the tenure in peri- urban areas can lead to higher rental costs which many disenfranchised families cannot afford so they are pushed away from accessibility to urban livelihood (McConville & Wittgren, 2014).

Insecurity of land tenure set difficulties to authorities to proper plan and zone the area. Investors are afraid of having land confiscated if land ownership is not guaranteed and they lose their investments. On the other hand, dwellers of informal peri-urban areas prefer to access services such as illegally sharing electricity and pay for this informal service. This shows that people themselves do not invest to improve what they do not legally own.

According to AKROFI (2011), peri-urban areas lack regulated pattern of land use leading to difficulty in accessibility. These areas lack formal subdivisions and functioning guidelines and this is left to the buyer's requirements and needs. Roads of these areas are mainly gravel and most spreading way of transportation is through auto-rickshaw or microbuses. Other infrastructures and services such as connection to water and sanitation amenities, and electricity networks are limited and in poor conditions. Market and workshops availability in these settlements are another dimension which attract low-income dwellers live there. Goods are affordable so dwellers can fulfill their daily needs with suitable prices.

2.5.2. Water resources and sanitation

According to UN-Habitat, nearly 1.1 billion people lack access to clean safe water and more than 2.6 billion people lack adequate sanitation services ("Water & Sanitation – UN-Habitat," n.d.). However, in many peri-urban areas, water and sanitation problem is not a resource scarcity problem as much as being a problem of accessibility and control of resources. Poor governance, widespread poverty and lack of infrastructure especially in developing countries lead to absence of public water provisions and sanitation facilities. Consequently, many poor people meet their water needs (dinking and domestic needs) depending on individual or communal systems. In some cases, vended water obtained from private water vendors may cost higher prices than house connections.

Lack of water and sanitation facilities is the main cause of water-borne diseases and environmental pollution; many peri-urban households develop their own plots or in-house facilities even though in some cases people still defecate in open space (Webster & Muller, 2009). Water and sanitation challenges are expected to increase due to the rapid increase of population who need to share already limited inadequate poorly managed resources (Maryati & Humaira, 2015; McConville & Wittgren, 2014).

According to Shawkat (2013) informal peri-urban areas in Egypt that are formed due to sprawl lack safe drinking water. People use unhealthy pumps to get water from ground water; in Menya Governorate, 20 percent of households lack access to drinking water. Furthermore, only few areas are connected to poor sewage. He added that, most of these informal areas dispose wastes in unlined septic tanks, trenches, deep discharges to groundwater aquifers or collect wastewater in trucks that are disposed in waterways or in vacant open areas. This leads to formation of pools and swamps of wastewater within the area causing sever environmental problems affecting both water and soil quality (Egyptian Environmental Affairs Agency, 2006).

2.5.3. Energy use

Urbanization generally increases the energy use demand. Rapid urbanization puts stress on both energy supply and the environment. However, the impact of urbanization on energy consumptions may differ according to the degree of development as well as the individuals' income. Urbanization in most of the developing countries like China contributes to raising the demand of energy use, while the highly urbanized regions such as Canada shows low energy consumption per capita. Generally; coal, natural gas, crude oil and electricity are the most forms of energy that are used in urban areas (Xiao-dong, Jing-hua, & Shuai, 2015; Zhang & Li, 2015).

There is an increased gap between use of energy in rural and urban areas. Most of urban dwellers rely on energy intensive products in their daily activities; households' residents use more electrical appliances and people use more transportation than in rural areas (R Elliott Puyang Sun Tong Zhu, R Elliott, Sun, & Zhu, n.d.). Moreover, urbanization induces heavy industries that totally depend on intensive energy consumption such as cement and steel industries to support more buildings and infrastructure serving this growth.

Provision and security of energy resources in communities is as important as other essential resources. Energy contributes to improving the quality and living conditions of societies. Access to secure energy is a fundamental step towards achieving sustainable development goals. Unfortunately, most of informal peri-urban areas lack accessibility to safe energy services. Dwellers in informal settlement of peri-urban areas use biomass as primary source of fuel of cooking while kerosene is used as a secondary fuel source used for lighting beside candles(Initiative & Putti, 2011).

Shifting from rural communities to urban communities increases energy consumption; as for an example, stressing usage of transportation sector within production processes; transporting raw materials that are usually originated in rural areas to production centers and transporting the final products to consumption centers in urban areas and other daily inner transportation within the city and peri-urban areas

The barriers that prevent provision of electricity beside the initial connection fees include illegality of land tenure and the inability of dwellers to pay bills regularly. Neighbors share electricity through illegal connections that cause utilities damages. Voltage breaks (voltage outages) often happens due to wastage of use, electricity thefts and irregular loads. Regardless the fact of poor provision of electricity in informal settlements, some of dwellers pay for informal energy services with higher prices which is an evidence for the desire of poor dwellers to benefit from electricity services illegally rather than entering the formal market (Butera, Caputo, Adhikari, & Facchini, 2016).

Chapter 3. Research Method

This chapter presents the implemented methodology used in the research study. The research method included three different phases. Each phase responds to one dimension of the study research questions as shown in Figure 7 and 8 representing the detailed framework followed throughout the research study in order to reach the study objectives.

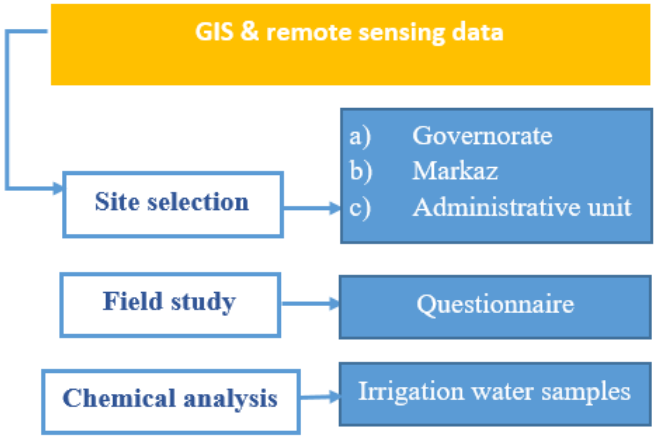

Figure 7: Methodology framework

Phase 1: Secondary data collection:

Collecting GIS and high resolution remote sensing data was an essential first step to determine the percentage of the lost arable lands across GCMR which represents the primary direct impact of urban sprawl on agricultural lands. Furthermore, these data were used to select the proper study area in order to conduct the field study for the research and identify other indirect impacts of urban sprawl. GIS and high resolution remote sensing data were outsourced and calculated by the team of the center of sustainable development (CSD) in the American University in Cairo. In parallel, population growth data, areas and maps were collected from official national and international websites such as CAPMAS, Giza governorate and Ministry of Housing, Utilities, & Urban Communities' official website, Google Earth and World Bank.

Phase 2: Field study

Conducting social study in the selected study area to investigate how urban sprawl occurs on the agricultural lands, study the different stages of urban sprawl and determine the impacts of the urban sprawl on households' livelihood and farming practices as part of the agricultural process.

Phase 3: Chemical water analysis

Analyzing water samples used in irrigation to confirm the results of the conducted social study and to highlight the impact of urban sprawl on water quality which is a main contributor to the changes occurred in the agricultural process.

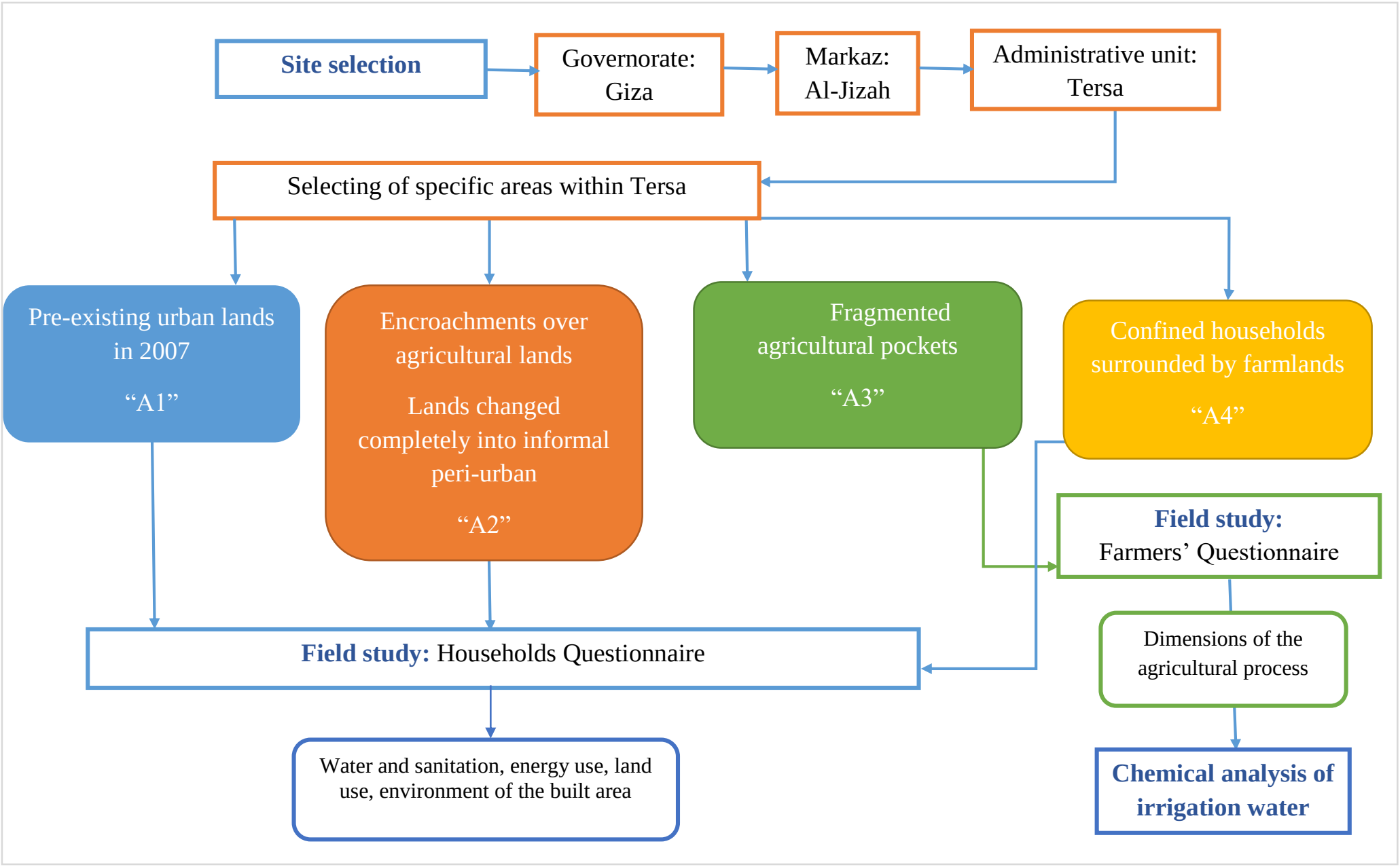

Figure 8: Framework of the research methodology

3.1. Site selection

Recently, GIS and remote sensing have been most common techniques used to map and analyze land use, urban growth and urban sprawl (Bhatta, 2012). High-resolution remote sensing images were used to select the appropriate study area across GCMR. The current study uses the selected areas identified by the Center of Sustainable Development (CSD) team in the American University in Cairo using percent of agricultural lands lost due to urban sprawl between 2007 and 2017 in the three governorates comprising GCMR; namely Cairo, Giza, and Qalyubeya. Accordingly, the area with the largest proportion of lost agricultural lands was identified. The following is a review of the process of selecting the study site carried out by CSD team.

1. **Selection of governorate**

   Based on the previous reviewed studies and the calculated remote sensing data, Giza governorate was selected due to its critical area in GCMR, rapid population growth and the consequent urban sprawl. Population in Giza governorate almost tripled over the past 10 years. It increased from 3123176 to 8777847 over the last 10 years between 2007 and 2017 (CAPMAS, 2018). As a result, Giza faced serious corrosion of agricultural lands and environmental problems resulted from urban sprawl (Osman, Divigalpitiya, et al., 2016). Giza governorate is subdivided into administrative mrakez and aksam.

2. **Selection of markaz/ district**

   Markaz Al-Jizah lies in the middle of Giza governorate (Appendix 3: Giza governorate). Total surface area of markaz Al-Jizah is 136.52 Km^2. It represents the largest percent of agricultural land lost because of urban sprawl compared to other mrakez in Giza governorate as shown in Table 1, where nearly 11.84 percent of its agricultural land is lost between 2007 and 2017. Accordingly, markaz Al-Jizah was selected for the research study. Markz Al-Jizah is subdivided into small cities, mother villages, villages and administrative units that were also reviewed to select a specific area for the field study.

Table 1: Percent of lost areas in Giza governorate due to urban sprawl from 2007 to 2017 (CSD, 2018)

Markaz	Area of Markaz (Km^2)	Area lost due to encroachment (Km^2)	Percentage of land lost (2007-2017)
Al-Jizah	136.52	16.17	11.84
Al-Badrashin	133.18	12.47	9.36
Imbabah	360.89	33.75	9.35
Awsim	57.13	4.96	8.68

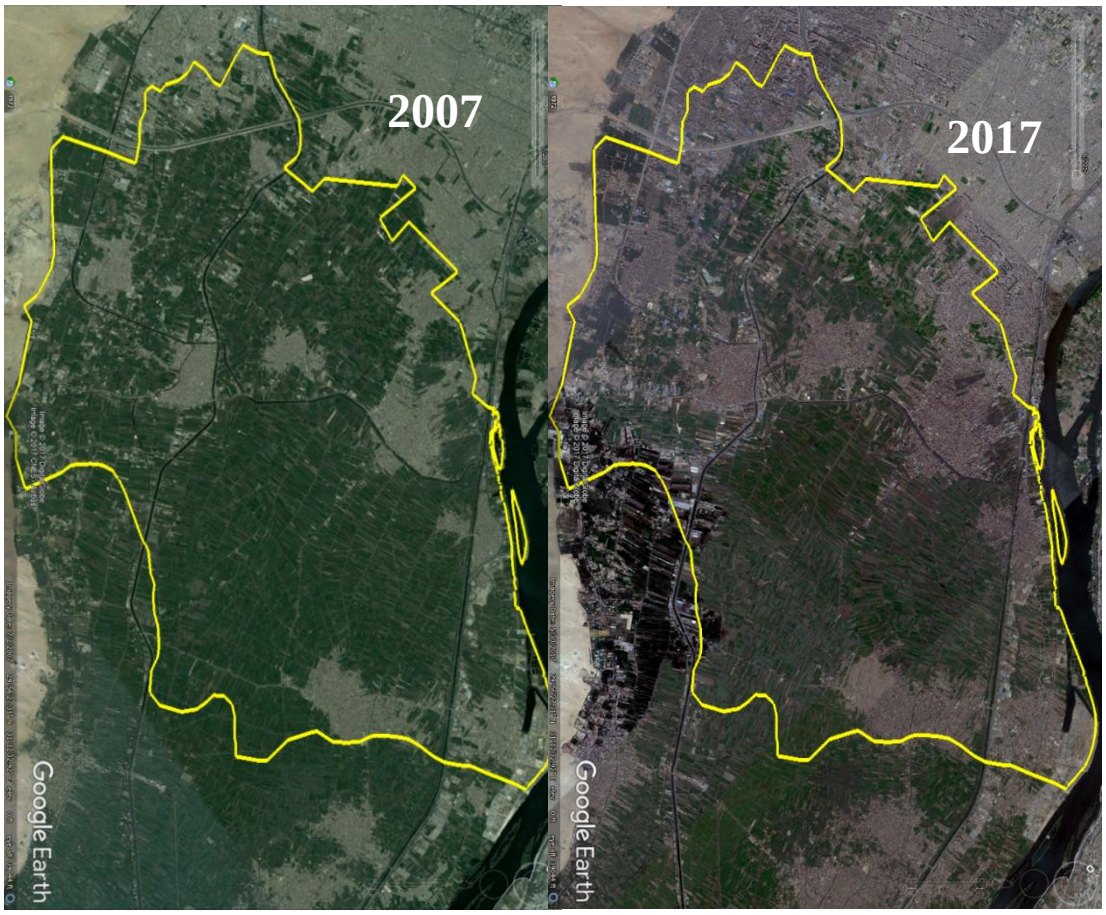

Figure 9: Markaz Al-Jizah in 2007 and 2017 (Google Earth, 2018)

3. Selection of administrative unit

The process of selecting a specific administrative unit (district) based on choosing a district with highest agricultural land loss compared to the total area in addition to the secondary research. Figure 10 shows the districts and administrative units within Markaz Al-Jizah. All of these districts lost agricultural lands with different percentages due to urban sprawl (Table 2). Although Tamouh,

Bany Youssef, Shabramant, and Mitshamas has high percentage of agricultural land losses, they were excluded from selection for the research study due to their small total surface area. Other districts were excluded based on the secondary data collected. Secondary research showed social and political preferences in these area. For example, some parliament members live in Abou Al-Nomros, accordingly this district undergoes special treatment in terms of the provided services. Tersa, a relatively small administrative unit within markaz Al-Jizaha, was selected for the research study due to the relative large percent of fertile agricultural land lost under urban sprawl compared to its total surface area. These lost arable lands were mainly contributing to the local food production. In addition to the presence of clear four categories representing the different stages of urban sprawl required for the study. Tersa is geographically located at the north of markaz Al-Jizah (Appendix 3) between latitude 29°58'50"N & 29°57'00"N and longitude 31°10'50"E & 31°13'10"E. It is affiliated with markaz Abu Al-Nomros. Tersa's total surface area is 6.51 Km^2, its population increased from 21324 in 2007 to 23644 in 2015 (CAPMAS, 2018). Tersa lost about 1.27 Km^2 of its agricultural land area under urban sprawl (Table 2). Despite of the rapid pace transformation in the land cover, Tersa is still predominately a rural village.

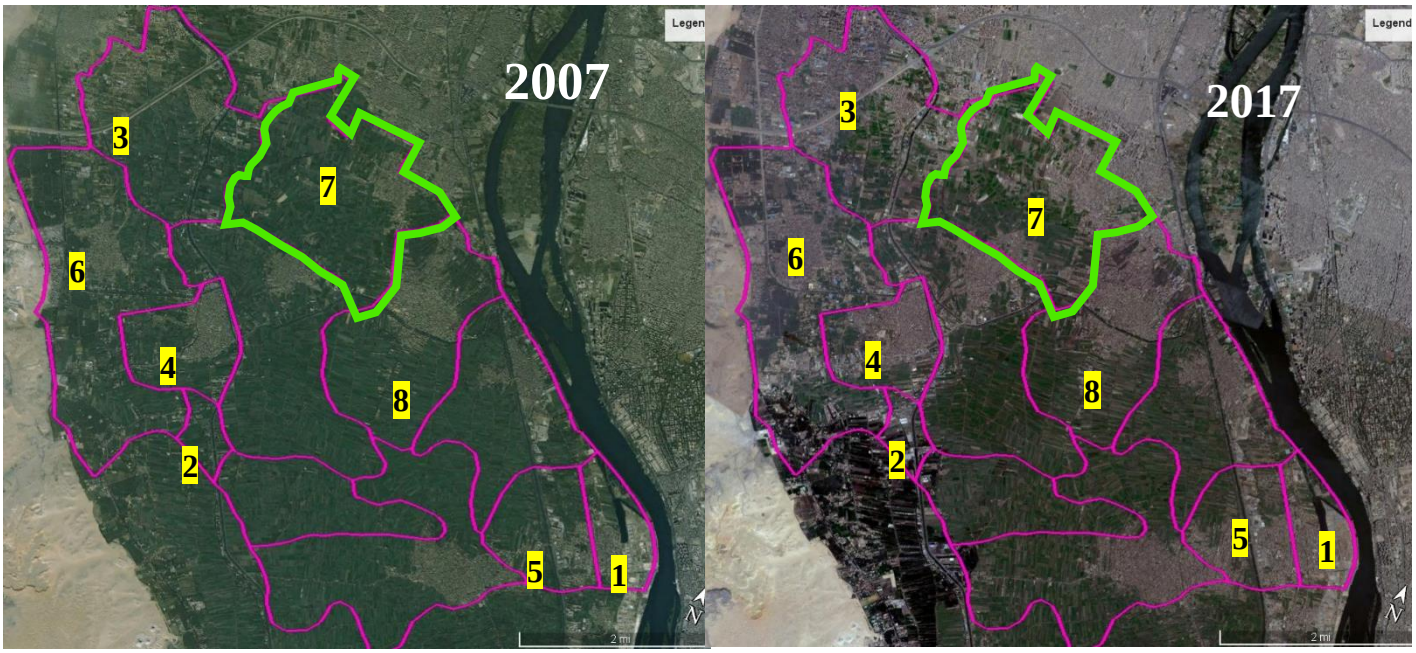

Figure 10: Districts of markaz Al-Jizah in 2007 and 2017 (Google Earth, 2018)

Table 2: Districts in Markaz Al-Jizah with the highest percentages of lands lost under urban sprawl between 2007 to 2017 (CSD, 20183)

#	City/village	District area (Km^2)	Area lost due to encroachment (Km^2)	Percentage of land lost
1	Tamouh	1.65	0.58	35.01
2	Bany Youssef	0.68	0.18	26.16
3	Al-Harraniya	6.37	1.58	24.76
4	Shabramnt	2.43	0.59	24.42
5	Mit Shamas	2.65	0.63	23.73
6	Zwyet Abou Mosalem	8.29	1.67	20.11
7	Tersa	6.51	1.27	19.43
8	Abou Al-Nomros	5.71	0.78	13.71

4. Selection of specific study areas representing different stages of urban sprawl

Spatial selection of specific study areas through high resolution remote sensing images included four categorized areas in North and East of Tersa (Figure 11 & 12). These areas were selected to study different stages of urban sprawl, the status of available resources and residents adaptations with each stage through the last 10 years.

The study areas in Tersa are categorized as follows:

a) Area 1 (A1): Previously existing peri-urban area before 2007

b) Area 2 (A2): Agriculture land in 2007 totally converted into urban use

c) Area 3 (A3): Fragmented agriculture land (agricultural pockets)

d) Area 4 (A4): Confined new built houses surrounded by open agriculture lands

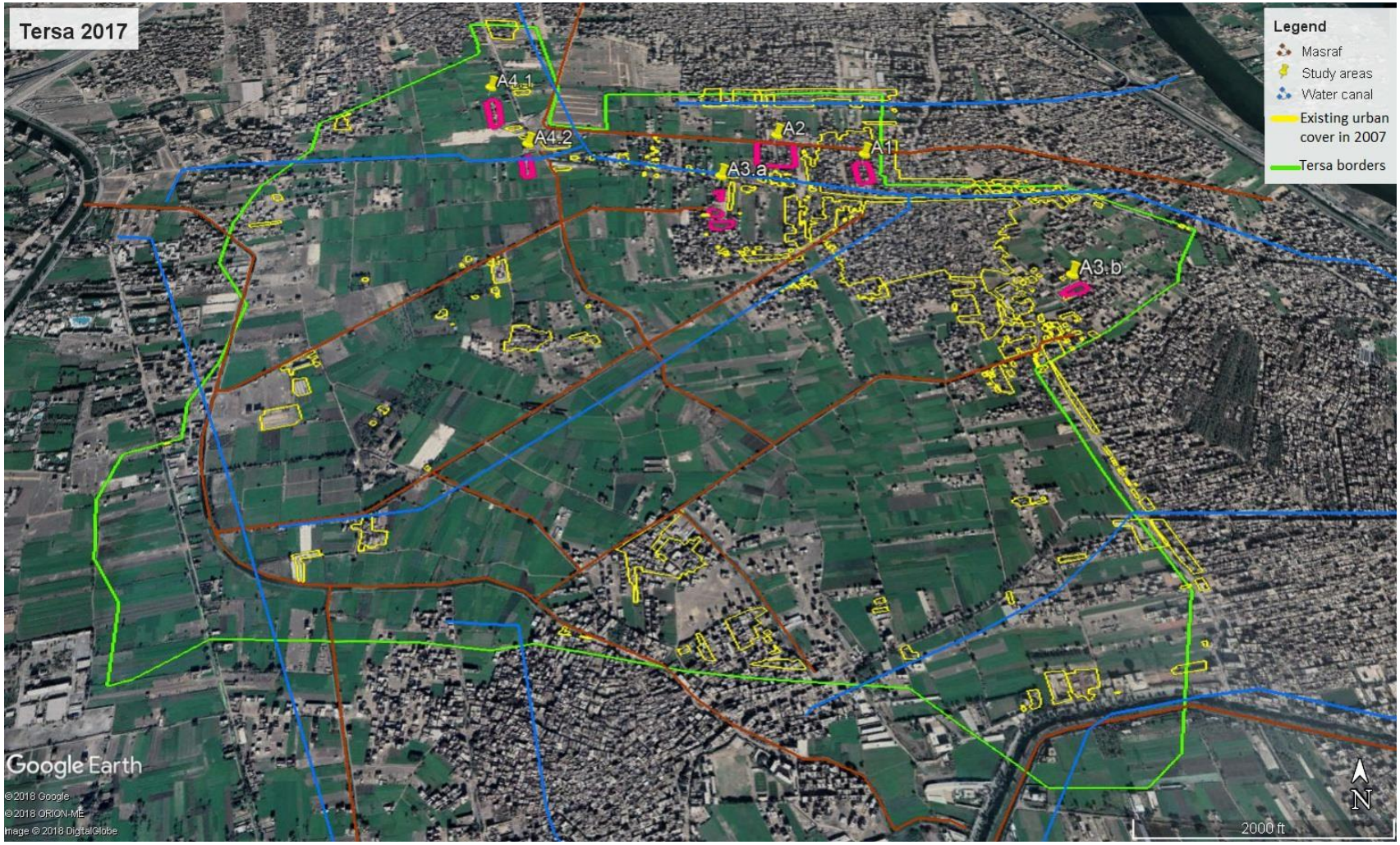

Figure 11: Tersa land cover in 2017, existing urban cover before 2007 is enclosed in yellow borders (Google Earth, 2018)

This figure is a Google Earth image for Tersa in 2017 bounded in green perimeter. The previously existing urban regions in 2007 are bounded in yellow, while the current remaining unbounded urban cover represents regions that were previously agricultural lands. The magenta-bordered squares at the north and north east represent the study areas that were visited for the field study.

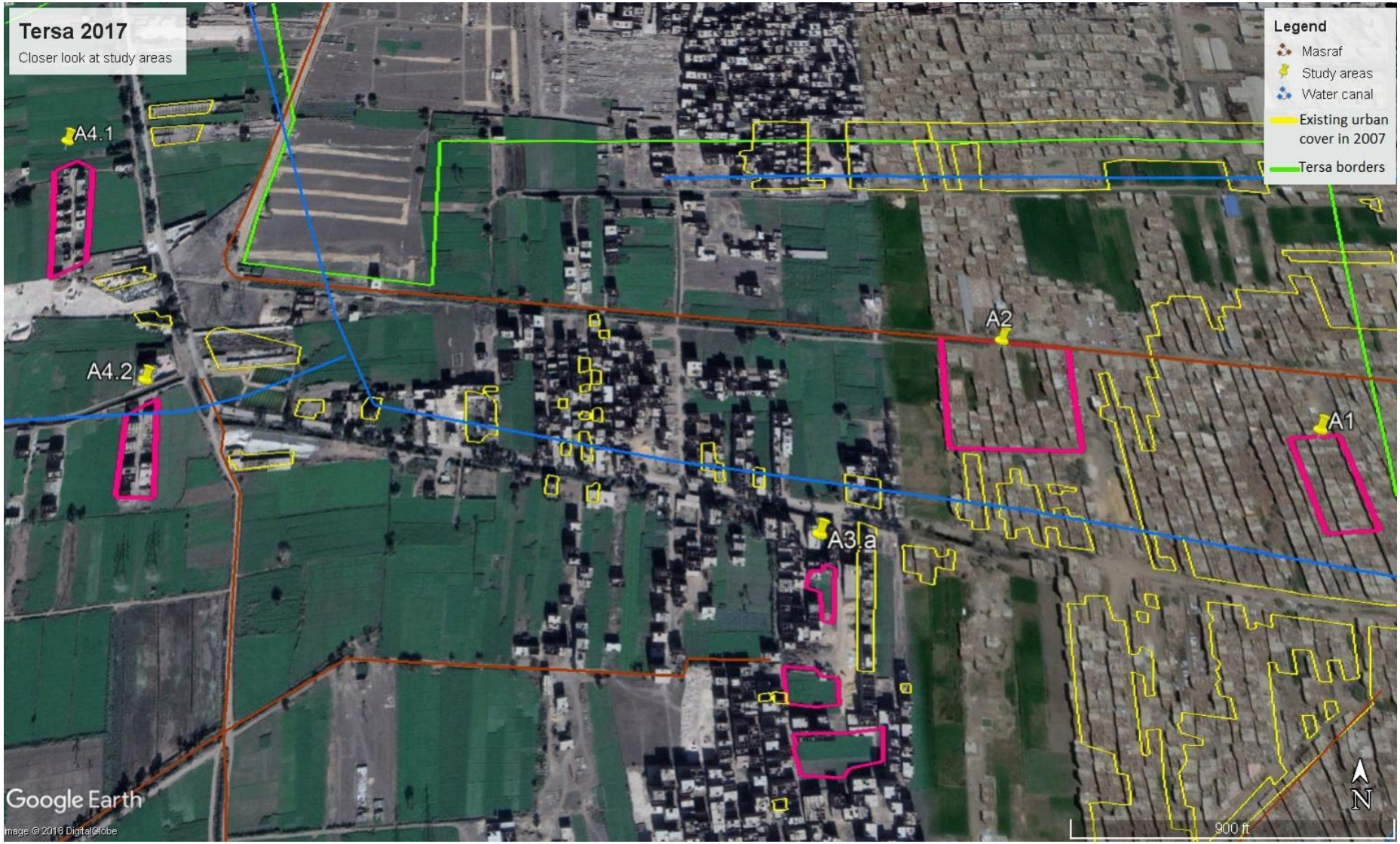

Figure 12: Closer look for the four study areas in north and north east of Tersa bounded in magenta borders (Google Earth, 2018)

3.2. Field study

In keeping with the study objectives, in-field social study was conducted through qualitative and quantitative face-to-face interviews, surveying households and farmers and through direct observations of the study area. The general objective of conducting in-field social study is to obtain summaries of quantified data through quantitative analysis method in addition to getting a deeper detailed insight through qualitative analysis method.

The main objective of this study to my research was to provide a comprehensive explanation of urban sprawl and its impacts on the community in Tersa through integrating community reports of the changes that happened over time to remote sensing data. The field study attempted to define the causes of urban sprawl, the conditions of settlements formed due to urban sprawl, identify the changes in built areas surrounding the remaining agricultural lands and the influences of the sprawled urban community on the environment and the surrounding fragmented agricultural lands.

3.2.1. Questionnaire

The questionnaire is composed of two main sections: households' section and farmers sections (Appendix 8); in order to collect data about the causes and the influences of urban sprawl. Design of the questionnaire took place through identifying assessment indicators linking urban sprawl to each section according to the reviewed literature. Questions were developed to assess each identified indicator.

The process of designing the questionnaire also included reviewing question banks in literature and going through questionnaires of previous development projects that were carried out by Social Research Center of the American University in Cairo and international organizations such as World Bank Group. The questionnaire included quantitative questions provided with coded specific answers and open ended questions to give a wide range of information. All questions that measure the changes caused by urban sprawl are placed in a comparative form of comparing between 2007 and 2017.

a) Households Section

The objective of this section is to define the causes of urban sprawl, the conditions the settlements built as a result of urban sprawl, the current condition of the available resources and the provided services compared to the situation before and at the first stage urban sprawl and how the region has developed between 2007 and 2017. Households' section is categorized as following:

Households General Characteristics

Socio-demographic data	Age
	Education
	Employment
	Marital status
	Reasons of moving to Tersa
General environmental characterstics	Transportation (mobility)
	Environment (Waste disposal, noise, pollution)
	Development projects

Households Resource Use

Housing	Tenure security
	Characteristics of housing unit
Water and sanitation	Source of water use for drinking and domestic use
	Security of this source*
	Sewage disposal system
Energy Use	Type and source of energy used for cooking and lighting
	Security of this source*

*Security of each resource describes the availability, accessibility, affordability and continuity of the resource.

b) Farmers Section

The importance of this section is to determine how urban sprawl influenced the near fragmented agricultural lands and farmers' livelihood, capture the influences of urban sprawl on each dimension of the agricultural process, and how farmers has adapted to proceed in farming activity. Figure 13 shows the main dimensions of the farming activity. These dimensions include cultivated land area, ownership of the land, water used for irrigation, labor force, machinery, livestock, crop products and productivity. Figure 14 shows the main dimensions and detailed sub-dimensions that were addressed in the farmers' section. The term security refers to availability, accessibility, affordability and continuity.

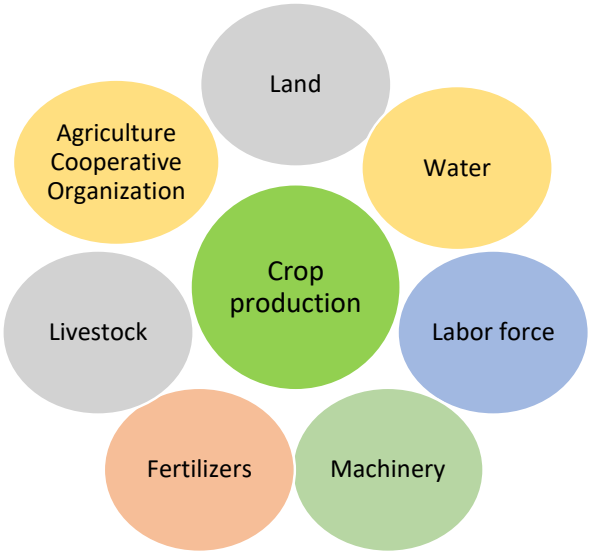

Figure 14: Dimensions of the farming activity

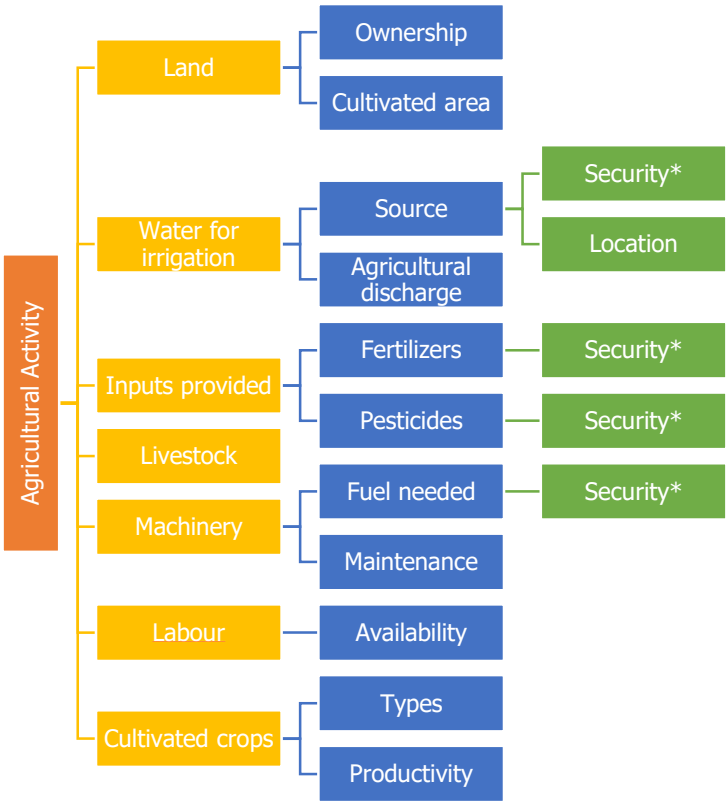

Figure 13: Sub-dimensions of the farming activity (Author)

3.2.2. Navigation to the selected study areas

A navigation tool was essential to assist the researcher in reaching the correct areas. As shown in figure 15, Google maps application (walking mode) was the main way to reach each study area especially the inner areas. It was nearly impossible to reach the selected inner areas without navigation due to the informality of building, some streets were blocked, streets lack numbering or labels and most of the residents do not know the names of the streets.

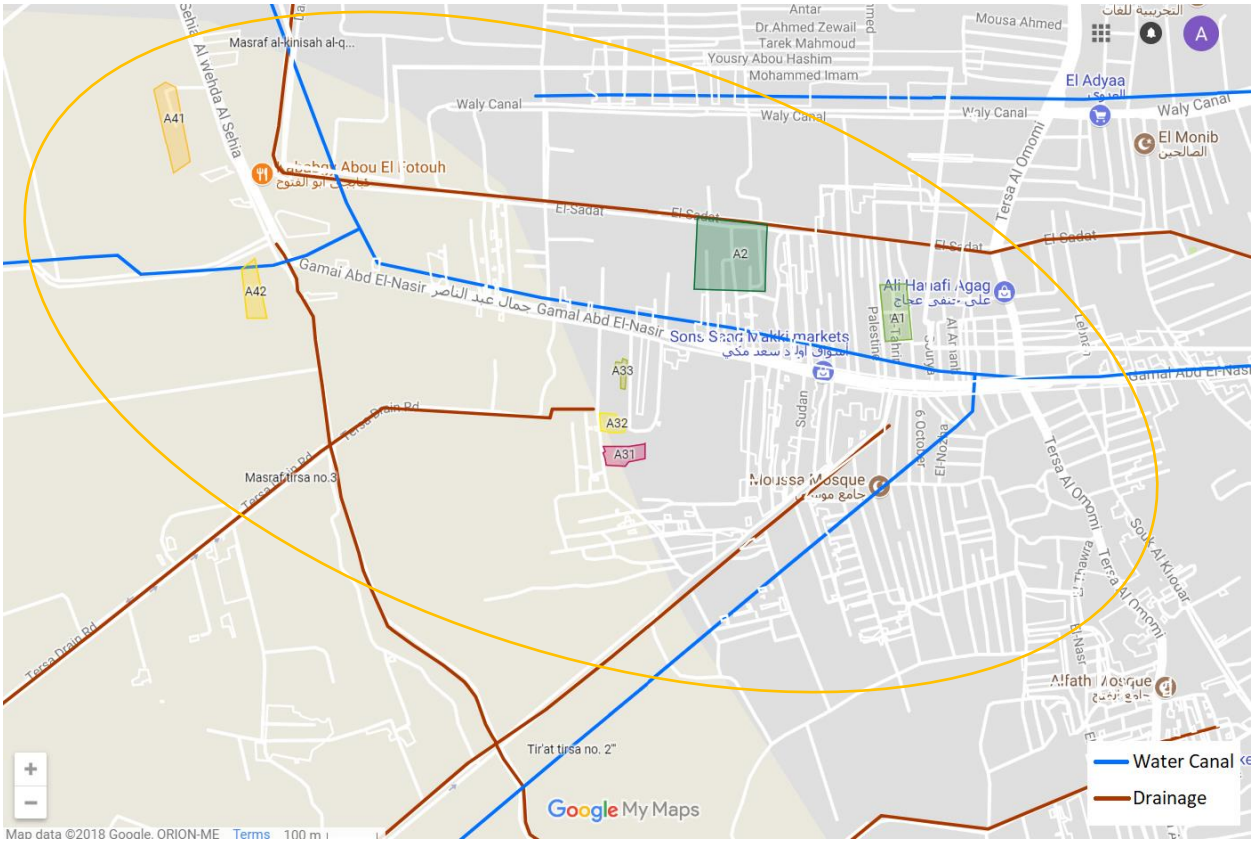

Figure 15: Navigation map to study areas (Google maps, 2018)

3.2.3. Sampling and sample size

Total number of participants in the social study was 50 households distributed between the four study-areas as shown in Table 3. Seven participants did not have reports for 2007 since they recently moved to Tersa. In addition, a total of 30 farmers were interviewed about the changes in the agricultural process. The variation of sample size between the four areas based on the availability of dwellings in each area. For example, very few houses (less than 10) were in area 4 (A4) because this is a recently constructed area representing the starting stage of urban sprawl.

Systematic sampling was followed to choose the participants in the study. Systematic sampling included choosing a random start point in each area and proceeding with fixed interval. However, all available dwellings in area 4 were included due to limited number of houses.

Table 3: Sample size selected to participate in the field study

	Total Households	Area 1	Area 2	Area 3	Area 4	Farmers
2017	50	15	10	19	6	30
2007	43	15	10	14	4	30

3.3. Water analysis

Water samples were collected from the water canal and three different underground water pumps for analysis to evaluate the water quality based on the results of the social study. Water samples were collected from underground water pumps (average 17 meter depth) available in study area A3 that is used for agriculture and livestock.

3.3.1. Sampling

Water was sampled according to standards and methodologies instructed in EPA (Decker, 2013).

- Samples were directly collected from the stream water surface and the underground pump
- Samples were collected in 2 liters clean dry plastic bottles labelled with name, date, and source point
- Sample bottles that undergo chemical analysis were rinsed twice with the sample before filling and after closing it, they were fully filled with the sample to prevent presence of air (oxygen) which promotes sample degradation
- All repetitive samples were collected from the same point
- Samples were sent to the lab analysis in the same day of collection; accordingly preservation and storing procedures were not required

3.3.2. Analysis

Samples were sent to Soil, Water & Environment Research Institute (SWERI) in the Agricultural Research Centre for chemical analysis according to APHA standard methods and Walkley-Black1986 method whereas the bacteriological analysis was done according to Difco manual 1985. Each sample was analyzed twice to ensure repeatability and reproducibility. Results consequently are compared with the FAO, WHO irrigation guidelines and the Egyptian law for protecting Nile River and water surfaces (Law 48/82).

CHAPTER 4. Description of the four study areas

This chapter presents a descriptive overview of the study areas based on the conducted field study. As previously mentioned, the selected areas represent different stages (forms) of urban sprawl.

The starting stage represented in A4, is the case of open arable lands where farmers still follow traditional farming practices. Few constrictions and dwellings scattered on the agricultural lands and some of these houses are owned by those farmers. The second stage starts with the farmers leaving their land uncultivated until the soil loses its fertility, buildings increases gradually. The third stage represented in A3 incorporates a slow start of sprawl with low density building on the arable land leading to formation of fragmented pockets of agricultural lands. These building are built illegally for the owner own uses with primitive resources and poor services. The fourth stage as shown in A2 is characterized with increased population density, residents settling their situation and upgrading their resources connections and services are provided.

4.1. Study areas in Tersa

4.1.1. Study area A1 (5503 m^2)

Area 1 is the nearest study area to the main road "Tersa Al-Omomi". It is located between Tersa's water canal "Teraat Tersa" and masraf Al-konaiesa Al-qibli based on Google maps. However, the water canal that should have been there turned into semi-paved road. According to Google Earth high- resolution images, A1 was a residential urban cover early before 2007. All surveyed participants believe that this area was originally an agriculture land; 4 households of the participants confirmed this as they were living there since birth (average 57 years old) (Table 4). In the contrast to other study areas, roads in A1 are semi paved and plane but still narrow; in addition, A1 is the most served area of the four study areas in terms of accessibility to water and energy resources and provided infrastructure. However, residents of A1 complain about new emerging problems due to increased population density. These problems include increased waste generated, spreading of garbage in the streets, the proximity of newly built houses generating more noise, frequently cut-out of water in addition to failure of sewage system.

Figure 16: Study area A1

4.1.2. Study area A2 (17477 m^2)

High resolution Google Earth's images indicates that A2 was an agricultural land in 2007. This area represents a clear complete encroachments over agricultural land in an informal way (Figure 17).

Figure 17: Road infront of study area A2

Figure 18 shows the evolution of the study area A2 over time sourced from Google Earth. It shows how agricultural lands converted due to urban sprawl through the last 10 years. Urban sprawl starts with scattered few houses over the agricultural lands, then these buildings gradually increase to form clusters till the whole area turned into urban cover

Currently, roads are completely unpaved and not planed but they are not muddy anymore. Houses are mainly red brick. There is a polluted drainage "masraf" directly in front of this area where residents throw garbage on its sides and burn it. Due to the complete transformation of A2 from rural to informal urban cover, residents settled and they currently have accessibility to water and energy resources, which developed gradually from primitive systems along the past 10 years. Although residents of this area adapted to the place and cooperated to introduce proper infrastructure. However, they face many problems in fulfilling their needs due to informality, insecurity and far distance between A2 and the main streets. The raised problems include severe failure in the sewage system, spread of insects and snakes, danger of walking in the street after sunset, difficulty of reaching markets and unavailability of tuk-tuk because of the far distances.

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Figure 18: Illegal encroachments over agricultural land in study area A2 from 2007 to 2017 (Google Earth, 2018)

4.1.3. Study area A3 (5131 m^2)

Figure 19: Study area A3

Study area 3 included fragmented agricultural lands confined within buildings that directly affect these remaining agricultural lands. All the urban cover surrounding these agricultural pockets wasn't there in 2007. The constructions in A3 represents a middle stage of urban sprawl. Residents in A3 includes farmers and non-farmers (immigrants) who moved recently to this area (5 to 10 years). A3 shows clear tension between farmers and non-farmers dwellers because of the residents' practices that significantly influences the farming activity. Roads are informal unpaved, still muddy and unpaved. Transportation to A3 is very difficult and unaffordable. All built houses are in red brick with very primitive services such as using underground water pumps and poor quality septic tanks. The area is almost disconnected from the governmental water and electricity grid.

4.1.4. Study area A4 (10000 m^2)

This area represents the first stage of how urban sprawl on agricultural lands occurs. Only few houses were recently built in the middle of open agricultural lands. Other houses were still under construction. Residents of A4 moved recently to this area (less than 5 years). Urban sprawl hasn't shown significant influences on the near agricultural land yet. Farmers still practice the traditional farming activity; there is no conflicts between farmers/ land owners and the new dwellers. Residents and construction workers in A4 were afraid and nervous about participating in the field study due to their ongoing illegal situation. The area is totally quiet, disconnected from main roads and there is no public transportation reaching it. It is totally disconnected from the governmental services and networks. Dwellers of this area haven't settled their situation yet; they rely on primitive services and almost no infrastructure.

Detailed description for the transportation system, available resources and services of each area in 2007 and 2017 is discussed in the coming sections; to identify the changes occurred because of urban sprawl.

4.2. Causes of urban sprawl on agricultural areas in Tersa

Most of the surveyed households were originally living in Tersa (Figure 20). Table 4 shows the responses of surveyed households in each study area about where originally they come from and the number of years they have been living in each area.

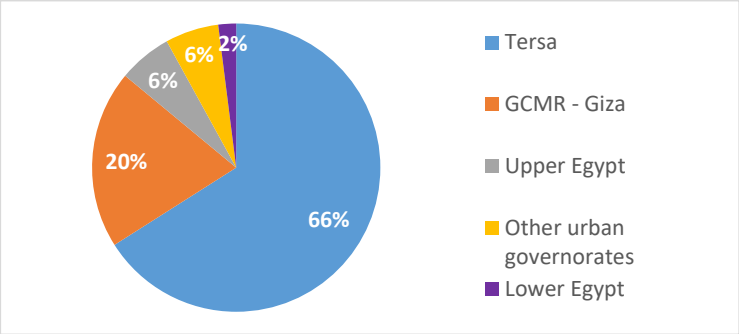


Figure 20: Regions where surveyed households originally come from

About 65.7 percent of the total surveyed households who built or bought houses on the agricultural area in A2, A3 and A4 were originally living in Tersa El-Omomi or in the early existing urban areas in Tersa. They left their houses because sewage spills out and the low prices of agricultural lands and low renting prices in the inner parts of Tersa compared to higher land prices in Tersa El-Omomi or outside Tersa.

The remaining one third of the residents came from other parts of Giza governorate, Upper Egypt and other urban governorates. The main reasons of their move was looking for job opportunities or marriage. Most of dwellers of A1 have been living there for more than 10 years, dwellers of A2 have been living there for more than 5 years (5 to 10 years), while most of dwellers in A3 and A4 have been living there less than 5 years in the neighborhood of the agricultural lands (Table 4).

Table 4: Regions where surveyed households originally come from in each study area

	Area (n = 15)	1Area (n = 10)	2Area (n = 19)	3Area (n = 6)	41Total (50)
Origin of participants					
Tersa	10	7	14	2	33
GCMR - Giza	3	1	3	3	10
Others	2	2	2	1	7
Number of years lived in Tersa					
Less than 5 years	0	3	11	4	18
5 – 10 years	1	7	6	1	15
More than 10 years	10	0	2	1	13
Since birth	4	0	0	0	4

4.3. Land ownership

Figure 21: Collapsed house build on agricultural land in A3

Despite the presence of many constructed houses on the agricultural lands in Tersa, the agricultural land is not suitable for the construction of buildings. Collapsed houses were viewed over the muddy agricultural land. Most of the houses are built on high elevated hills to avoid land sliding. In addition, houses and required infrastructure were built with poor standards. According to Gamal ElSayed –Resident-, he once opened the septic tank and surprisingly he found it totally empty. This indicates the absence of proper lining for these tanks which result in the wastes being diffused through the land forming a severe pollution problem in water and soil. Forty-five of the fifty surveyed households own their houses, they either built it themselves or bought it from the land owner. All of them stated that the origin of the land was an agricultural land. Despite the mandatory requirements for construction work and the penalization of building on agricultural lands as legislated in the Egyptian Law "Building law: 119/2008), none of residents obtained a building license before constructing on the agricultural land. Nevertheless, residents feel safe and strongly believe that no one can force them to leave. This is against to findings in the literature in other countries. In these countries, urban sprawl residents usually feel insecure and exposed to expulsion or evacuation. Only in A4 residents were relatively more nervous and afraid of any governmental surveillances for their illegal situation as they were still in the middle of the construction works.

4.4. Transportation system

Nearest subway station to Tersa is El-Munib. On the other side of El-Munib, there is a microbuses and tuk-tuk station. A microbus or tuk-tuk can be picked to the main street in Tersa "Tersa El-Omomi". However, tuk-tuk is the only transportation method to reach side and inner streets of Tersa.

Although tuk-tuk is available all the time in the main streets but it is not easy to find one strolling in the inner areas due to the condition of the streets (narrow and unpaved roads). It is also not affordable for daily use specially to reach inner areas like El-Konaiesa (near A4). Tuk-tuk takes EGP 20-25 from Tersa El-Omomi to El-konaiesa and it takes EGP 5 from A2 to Tersa El-Omomi, which still considered expensive to be used on daily basis by all family members. (Magdy Sayed, employee) mentioned that he walks daily for 30 minutes from his house in A2 to El-Munib station then he picks up a microbus or subway to his work. The further areas from Tersa El-Omomi, the less accessible and less affordable to pick up a tuktuk (Figure 21).

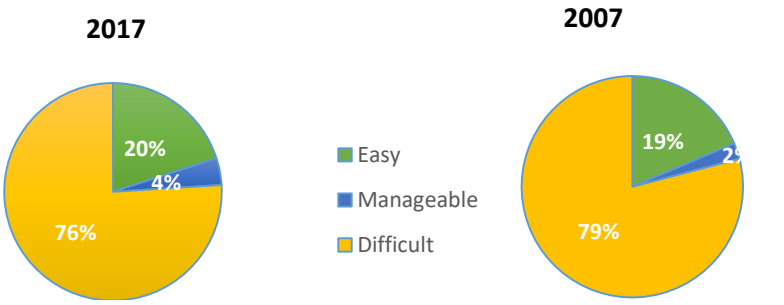


Figure 22: Total responses -easiness of transportation within Tersa in 2007 and 2017

Although most of the surveyed households said that the mobility within Tersa is difficult in terms of accessibility and affordability, 10 years ago, the situation was more difficult in terms of availability (Figure 22). About 65 percent of the surveyed households who reported the difficulty the transportation in 2007, referred this to the absence of any means of transportation within Tersa and they used to walk or use livestock.

Figure 23 shows the responses of households in each study area about the easiness and availability of transportation system in 2007 and 2017. Most of residents in A1 do not face any problem

regarding the availability, accessibility or affordability of transportation system from or to their place, nine of A1 dwellers reported the easiness of transportation due to closeness of A1 to the main roads while five dwellers reported the difficulty of transportation due to the narrow semi paved roads of their area. However they believed that the transportation is more available compared to 10 years ago in 2007. In contrast, Dwellers of A2, A3 and A4 reported the difficulty of transportation for being isolated from the main roads, in addition, the informality of the roads make it harder for transportation means to reach these areas.

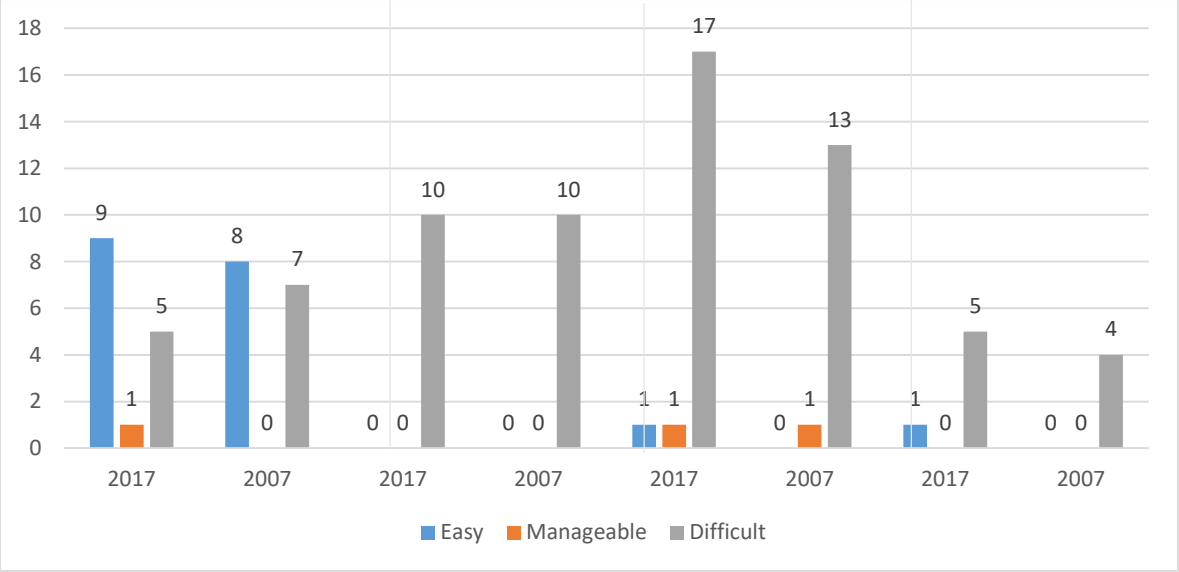


Figure 23: Responses about Easiness of transportation in each study area in 2007 and 2017.

4.5. General environmental characteristics in Tersa

This section describes the general environmental conditions in the four area. Noise, indoor air quality, and waste collection were the main environmental conditions investigated in the surveyed households (Table 5).

Though many agricultural lands converted into urban cover, the rural features are still predominantly in Tersa. The four study areas are almost quiet. Few households in A1 reported the presence of some noise due to population increase and buildings being very close to each other. In addition, shops and markets in the main streets were a main source of noise in A1. While the other three areas are totally quiet and unsafe due unequipped roads, absence of lampposts and poor improper infrastructure.

Residents reported the absence of sufficient garbage bins in the streets; which was also observed during the field study. Most of them throw the garbage in the streets until it accumulates then they burn it. Others stated that they throw garbage in the water canal. Among all the surveyed answers regarding garbage collection, Only 3 households living in A1 pay for a garbage collector who takes EGP 1 per day. The garbage situation has deteriorated over the past 10 years as reported by one resident (Yousria Saleh –housewife- said that 10 years ago there were no garbage in the streets like today). Construction and demolition wastes are also observed everywhere. Burned garbage, contaminated water canal, sewage and dead animals also causes diffusion of bad smells, odors and smoke in all four areas. Households in most of study areas also suffer from presence of insects and pests such as flies, mosquitos, lizards, mice, snakes and other insects.

Figure 24: Burning of garbage in Tersa

Despite of the previously mentioned external environmental problems, as shown in table 5, most of the residents cared about the indoor air quality of the built houses including the ventilation and the inner exposure to sunlight. More than 90 percent of the total surveyed households reported that their houses has good ventilation and good exposure to sunlight.

Table 5: Responses about gneral environmental issues

Parameter		2017 (n = 50)	2007 (n = 43)
		No.	**No.**
Presence of Noise	There is **NO** noise pollution in the area	38	40
Garbage disposal	The garbage is thrown in the street	43	41
	The garbage is thrown in the water canal	3	1
	Private garbage comes to collect the garbage	3	0
	The garbage is thrown in garbage bins	1	0
	There were no garbage like today	0	1

Indoor air quality	Ventilation is good	48	42
	Ventilation is bad	2	1
	Good exposure to sun light	47	41
	Bad exposure to sun light	3	2

4.6. Resource use: Households

This section analyzes households' responses about the availability of two main resources; namely water and energy in the study areas. The four areas show gradual development in introducing services according to their stage of urban sprawl. Newly sprawled areas begin with limited primitive services and infrastructure. Accordingly, there is a noticeable difference between 2007 and 2017 in terms of resource availability and accessibility particularly in the complete transformed areas.

4.6.1. Water and sanitation

4.6.1.1. Water security

Water security is defined according to UN as the inaccessibility to sufficient quantity of acceptable quality of water to sustain the livelihood of human wellbeing and protect them against water-borne diseases.

Accessibility

Except for Tersa El-Omomi and the long term existing urban areas such as A1 which were connected to the governmental water grid in 2007 (Figure 25), two main patterns can be observed with regard to connectivity to governmental water network. The first pattern is represented by recently urban sprawled areas. These areas have no access to the governmental network. This is mainly because these areas were not planned by the government and buildings were not licensed. Therefore, these areas were not served by the governmental water grid. Residents depend on water from underground water pumps. This was clear in the two areas A3 and A4. The second pattern can be observed in areas that transformed from rural to urban long years ago (10 years ago), such as A2. In these areas, as residents of the area stabilized, residents cooperate and establish communal water pipes to get connected to the governmental water network.

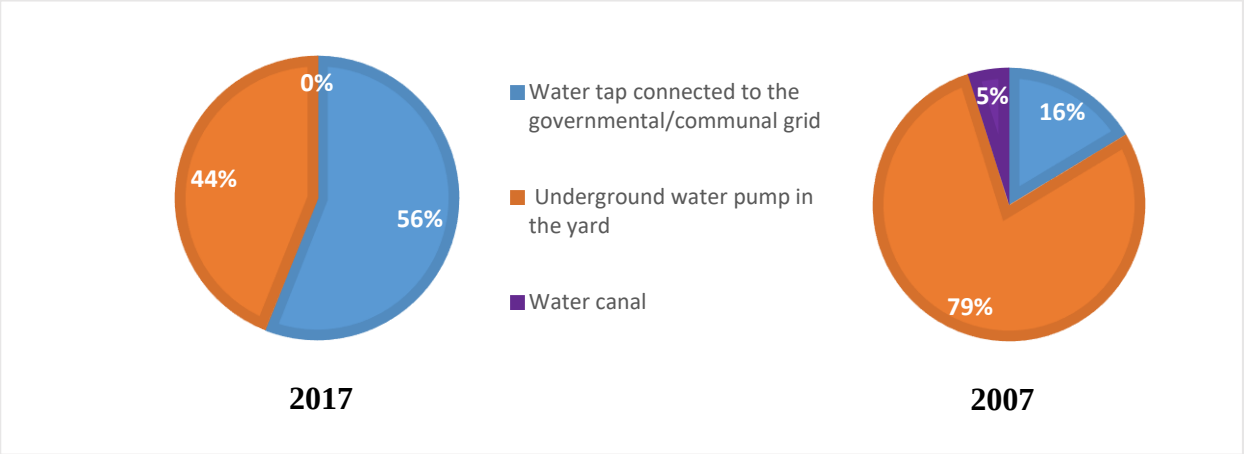


Figure 25: Total responses about accessibility to water sources in Tersa in 2007 and 2017

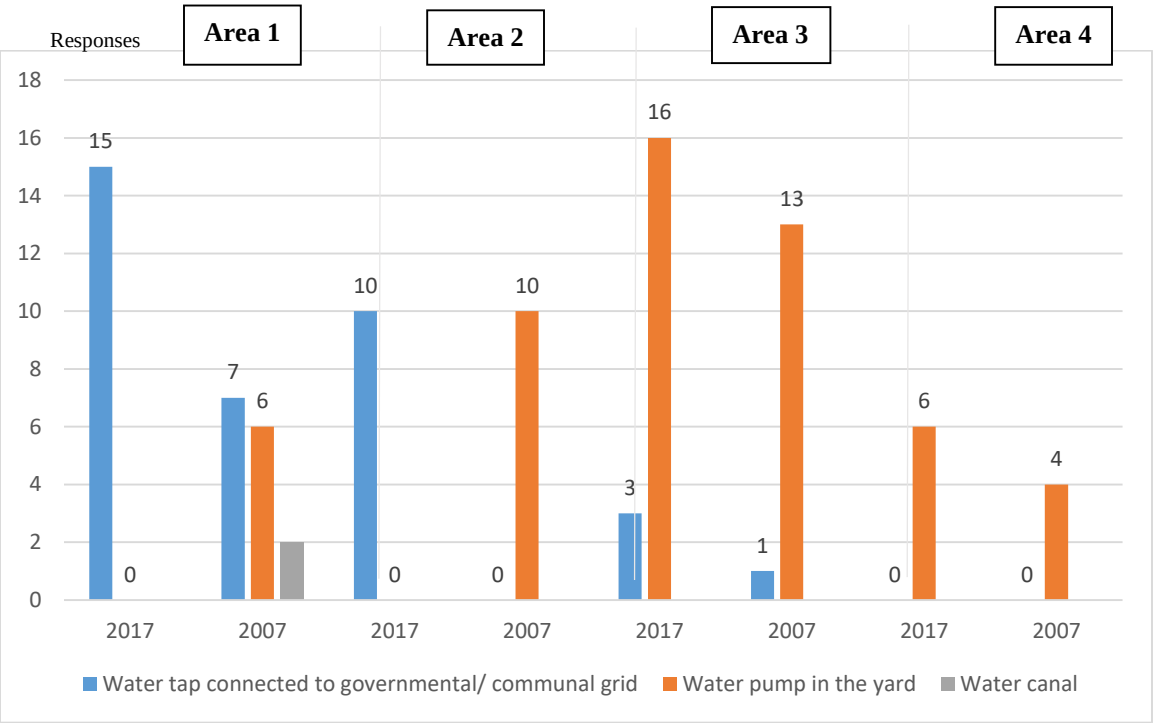


Figure 26: Accessibility to water in each area in 2007 and 2017

Availability and continuity

Although most of the transformed areas including A1 and A2 currently have access to the governmental water grid (Figure 26), each area faces problems related to the availability of water when needed, continuity and the quality of the available water. Most of the households complain about continuous water cuts. Figure 27 highlights the number of responses who approved the

availability of water when needed. Dwellers in A1 reported the continuous availability of water in 2017 though they may face occasional cut-outs compared to responses about 2007 where only six of fifteen dwellers confirmed water availability which proves the improvements of the water network, all dwellers of A2 reported the unavailability of water, while A3 and A4 who confirmed the availability of water. Table 6 shows the households' responses about how frequently they are exposed to water cut-outs in each area.

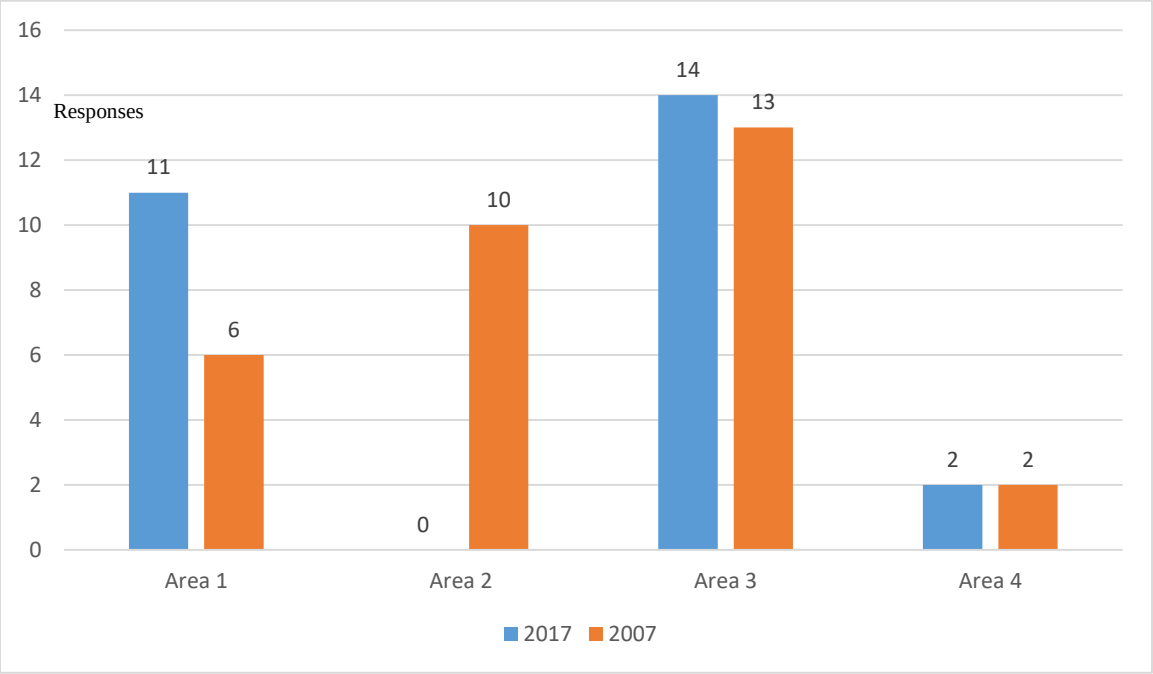


Figure 27: Availability of water in each study area

Table 6: Frequent water cut-outs (continuity)

	Area 1		Area 2		Area 3		Area 4	
	2017 (n = 15)	2007 (n = 15)	2017 (n = 10)	2007 (n = 10)	2017 (n = 3)	2007 (n = 1)	2017 (n = 6)	2007 (n = 4)
Yes, continuously	4	4	10	0	1	0	1	1
Yes, sometimes	11	2	0	1	5	1	2	0
No cut outs	0	9	0	9	13	13	3	3

Households in A1 believe that the main reason of the occasional water cut-outs is the pressure caused by the increased population density in the area. Households in A2 do not know the exact

reason behind the continuous unavailability of water which remains cutting for days and sometimes it comes back only at night.

During water outages, residents resort to use water that they previously saved, get water from the mosque or go to other streets where water is available. This process may takes them more than 30 to 60 minutes to obtain water. In these areas, the average water bill is EGP 130 to EGP 150.

Study areas, which currently use water pumps such as A3 and A4, or those who used to use it 10 years ago like A2, are not exposed to water cuts. Only households whose water pumps are connected with electric power may suffer from water cuts when electric power cuts. They also do not pay any expenses for the water they get. The main concern that delays these areas from getting connected to the governmental water network rather than using water pumps is the initial capital cost of establishing the network itself which should be carried out by their own.

Water quality

Most of the surveyed households complain about the quality of water. Figure 28 indicates that thirty six out of the total surveyed households reported bad quality of water. The water quality problem increased compared to the situation 10 years ago. Only twelve households out of the existing surveyed households in 2007 reported bad quality of water. It is clear that Tersa suffers from failure of the sewage system; both the governmental established sewage network and the communal sewage network. Figure 29 shows the number of responses indicating the presence of water quality problems in each study area.

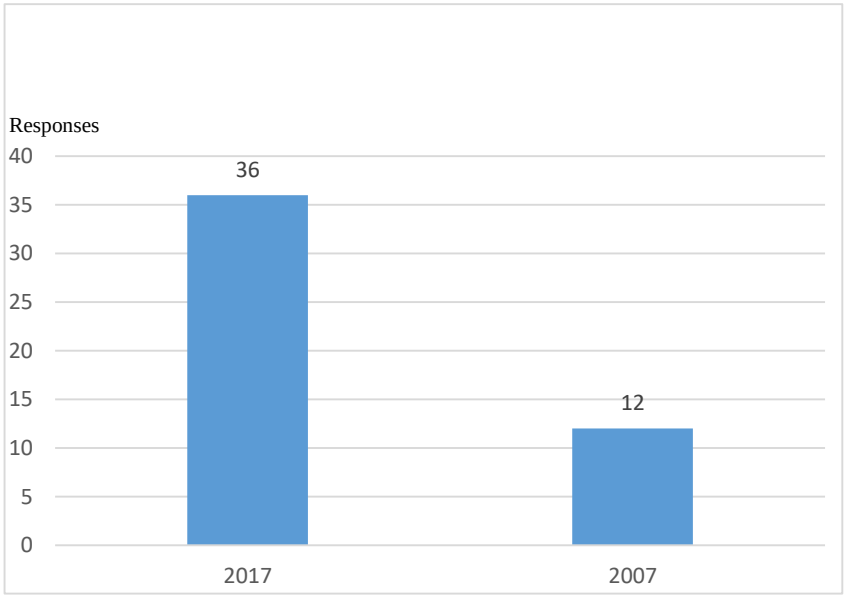


Figure 28: Households responses about facing problems in water quality

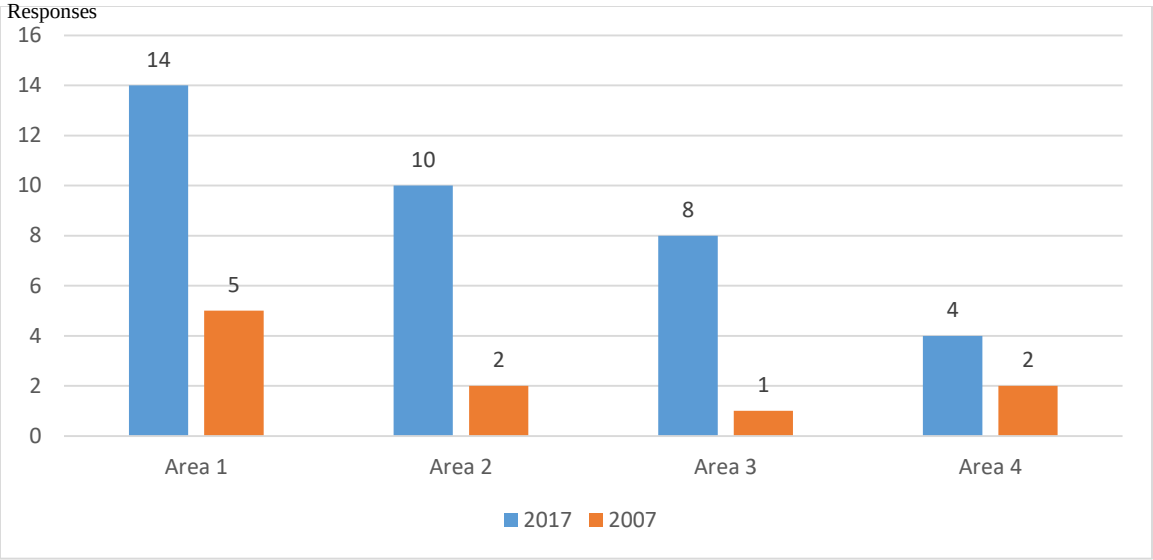


Figure 29: Households Responses about the presence of water quality problem

As presented in figure 30, water quality complaints include water mixed with sewage, impurities, smelly, abnormal color and sour taste. Almost all responses agreed on water mixed with sewage and impurities as a main problem. Even households who use water pump faces the same problems. Mohamed Abu El-Mwaheb pointed out that most of the residence in Tersa suffer from renal failure and hepatic disease due to the polluted drinking water. All these problems increased significantly in 2017 compared to responses about 2007.

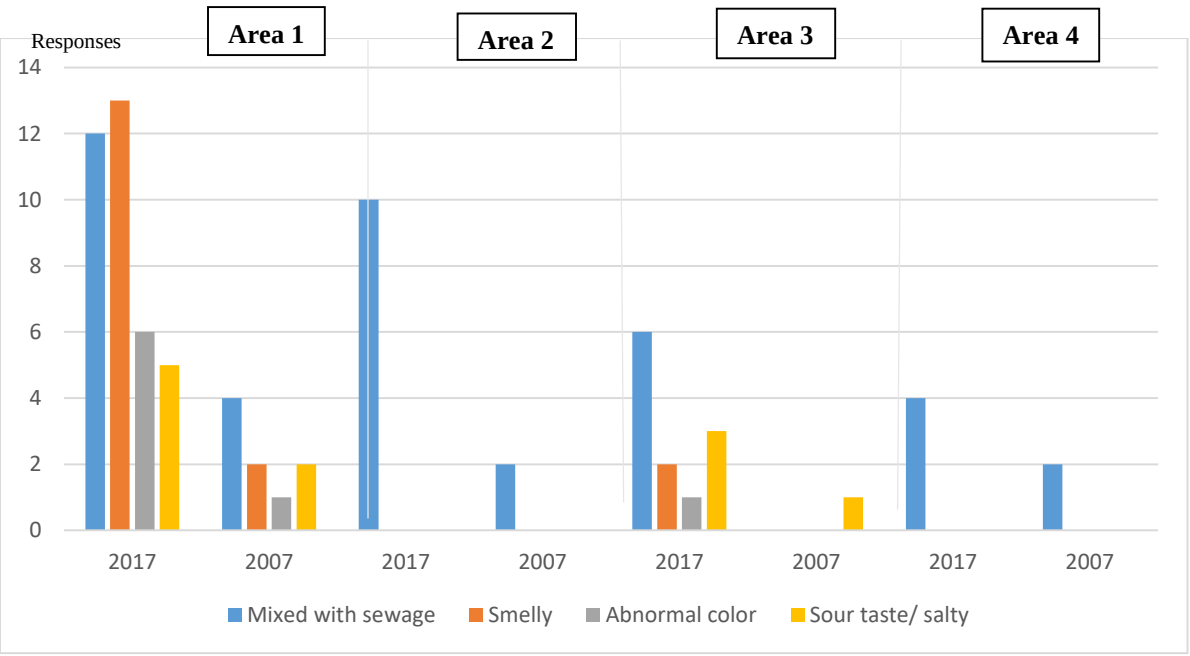


Figure 30: Households responses about common water quality problems

4.6.1.2 Sewage system

As indicated in figure 31, Tersa El-Omomi and the early existing urban areas were previously connected to the governmental sewage pipes. Whereas households in the recent formed urban areas including A3 and A4 build 4 to 5 meters depth septic tanks which are only a primitive hole of red brick poorly lined (trench). Again, when residents settle down they cooperate to install a communal grid sewage system. Residents of each street collect money together and install the pipelines on their own without any institutional or governmental intervention or supervision releasing wastewater into the water canal. It is obvious that sewage spills out is a common problem in Tersa either due to the pressure by the increased population density on the available infrastructure or the poor quality of the communal installed pipelines. Sewage floods in the main streets was one of the main reasons which pushed households to move into the inner far areas.

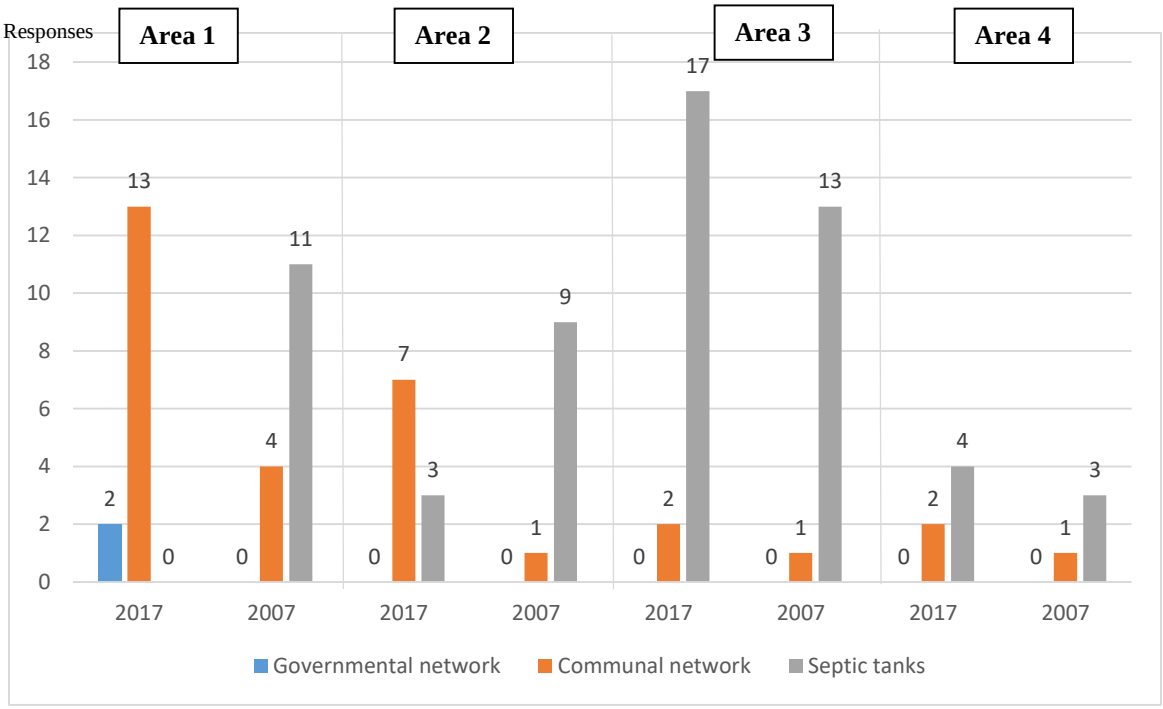


Figure 31: Sewage system in each study area

Main problems of the sewage in Tersa include sewage spills out, opened manholes and spread of insect. These problems increased over the last 10 years ago (Figure 32). Failure in the sewage system in Tersa is also the main contributor to the contamination of water canal and underground water. Households who use septic tanks were asked about the last time they emptied their tanks, they stated that they never emptied it. They believe that the ground absorbs the contents of the tanks. Furthermore, they reported that emptying the septic tank is very expensive as renting a truck

to suck the wastes costs nearly EGP 150 per load, emptying a tank takes 3 loads, so the average cost of disposing the septic tanks is EGP 450 to 500 per time; which is never done as mentioned.

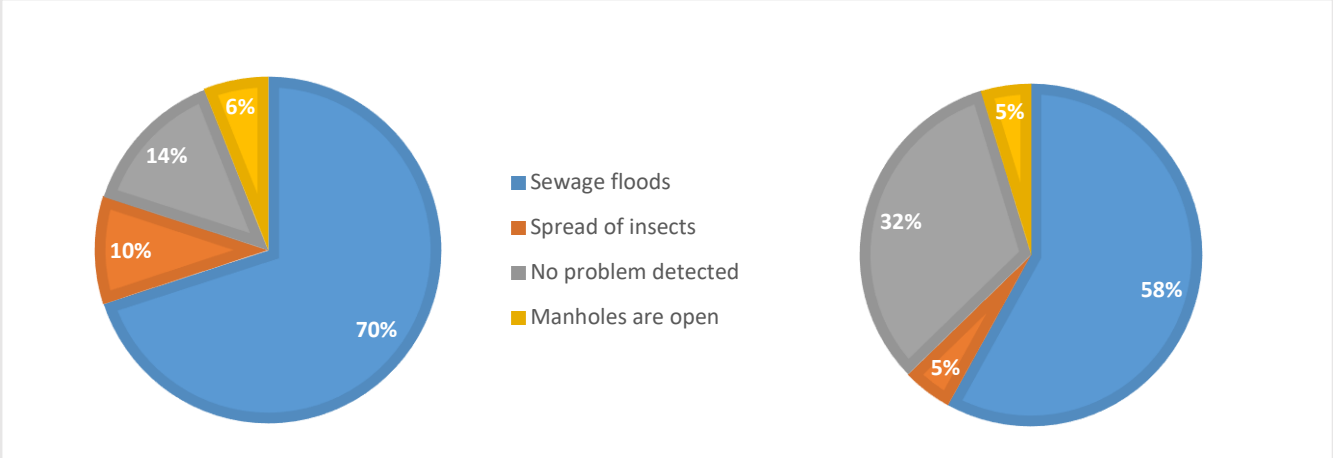


Figure 32: Main problems of the sewage system in Tersa

4.6.2. Energy Use

There is no significant difference in energy use between the four study areas in terms of type of the energy used. Natural gas pipelines network is installed from Tersa El-Omomi till its intersection with Gamal Abd El-Nasser Street reaching A1. Nearly all respondents in the four areas use gas cylinders for cooking and electricity for lighting currently and through the previous10 years. Only **one** household in A1 uses natural gas for cooking and another household in A4 uses electric generator for lighting.

4.6.2.1. Electricity

As shown in figure 33, study area A1 was connected to the governmental grid many years ago. However, other study areas used to get electricity illegally from a connection to a main cable. Ten years ago, all households in A2 used to get their electricity from a connection to a main cable, then they settle their situation and currently pay for utilization “momarsa” or charge a monthly smart card. Some operate workshops for blacksmithing or carpentry inside their houses using the main electric cable. Illegal usage of electricity from the main cables puts pressure on the grid, increases the consumption without paying in return, leads to frequent electricity cut outs and damages the utilities.

Figure 34 indicates households' responses confirming the frequent exposure to electricity outage. Most of the studied areas suffer from frequent electricity outage which duration varies from 30 minutes in A1 and A2 per time reaching to complete blackouts for couple of days as shown in table 7. However, the service improved compared to 10 years ago. The frequent exposure to electricity outage leads to damage of some electric appliances for some residents.

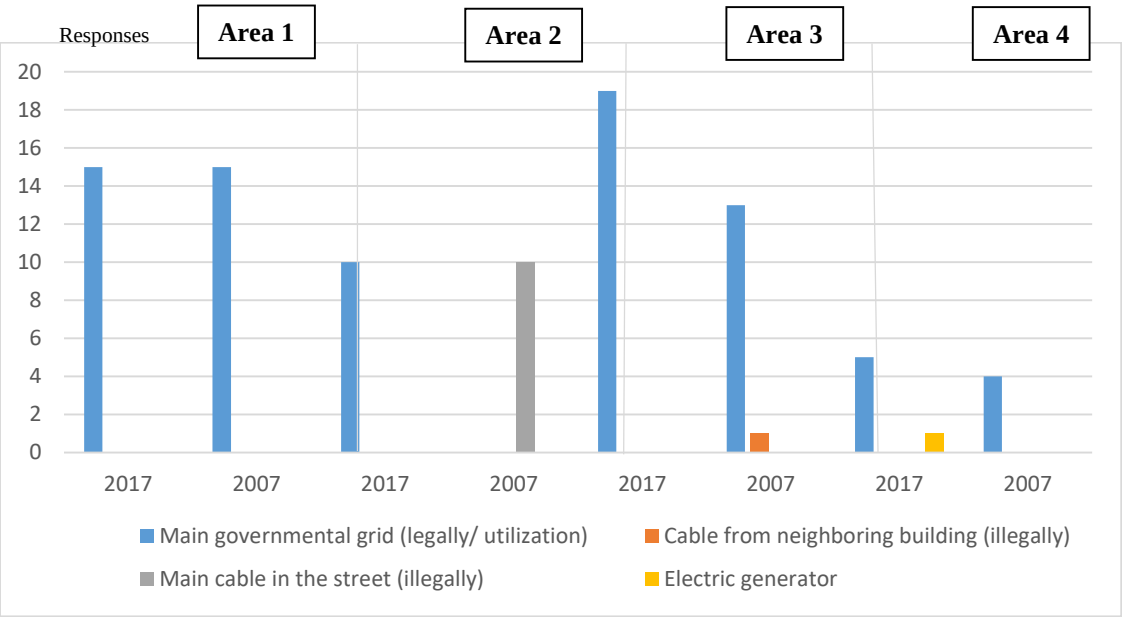


Figure 33: Accessibility to electricity in each study area

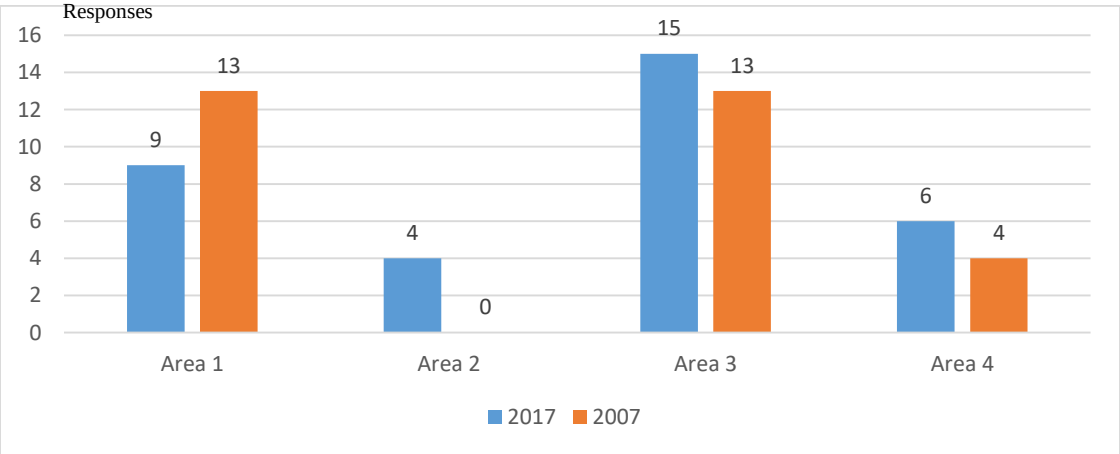


Figure 34: Responses confirming frequent electric outage in each study area

Table 7: Frequent exposure to electric outage in each study area

For 2017	Area 1	Area 2	Area 3	Area 4
Average number of electric outage per month	3	6	4	5
Average duration of electric outage per time	Less than 30 mins	30 mins or more		Couple of days

4.6.2.2. Gas cylinders

There is no gas cylinder warehouse inside Tersa. The nearest gas cylinder warehouse is in El-Munib and Abo El-Nomros. However, households get gas cylinder from trucks strolling daily in the streets. Figure 35 presents the households' responses about the availability and accessibility to exchanging the gas cylinders when required. In the current period, almost all surveyed households in the four areas doesn't face any problem regarding the availability of gas cylinders when required. However, they face a relative difficulty in the accessibility to the warehouse or the strolling trucks due to the far distance which consequently influences their price. Price average of the gas cylinder in the warehouse is EGP 45 (2017) which is cheaper than those in the strolling truck. There are two gas cylinder trucks stroll in Tersa; one of them is under the governmental supervision named "Shbab Al-kherigin project". Prices of the gas cylinders sold by this truck vary from EGP 55, which is the average price, to EGP 80 for the inner far areas of Tersa. "Shbab Al-kherigin project" truck usually stands in "El-shlaiesh" street near the main street in Tersa. It goes into the inner far streets **only** when they have excess cylinders. Other private trucks sell with black market prices especially when the governmental truck is not available.

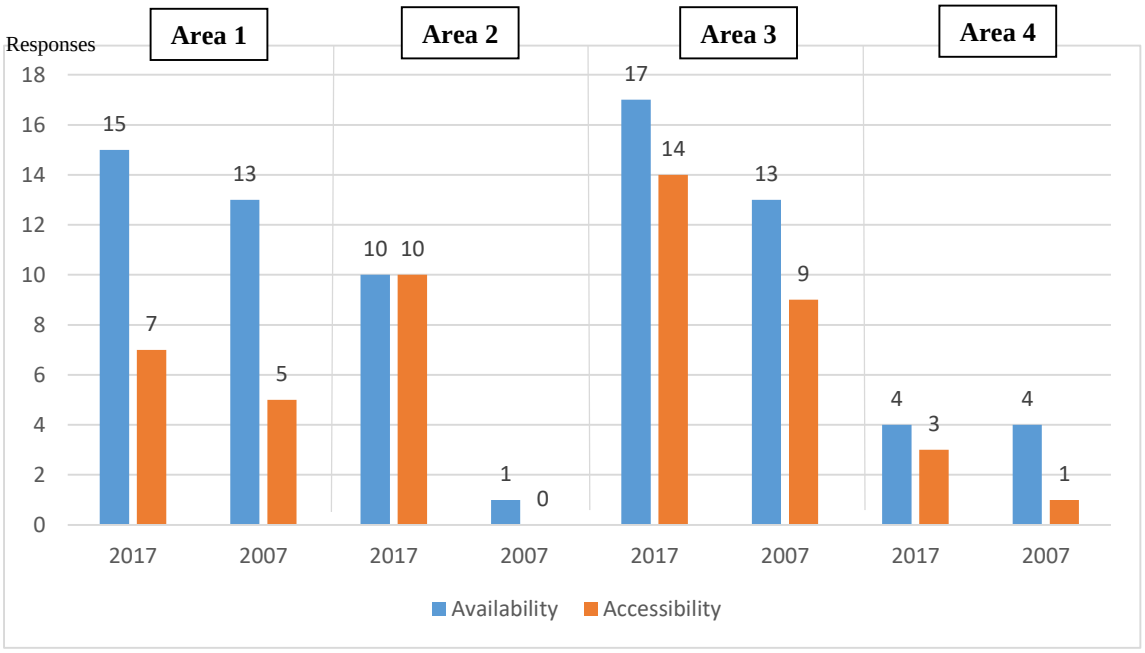


Figure 35: Availability and accessibility of gas cylinders in Tersa

4.7. Main Results

In conclusion; there is a significant change in Tersa between 2007 and 2017 years ago. Many constructions were built over the agricultural lands, population density increased, and the governmental grid systems become more extended into some inner areas of Tersa. Sahar Mohsen –housewife- contended that she now finds all her needs inside Tersa. However, none of the surveyed households mentioned presence of any development project to improve the introduced settlements during the last 10 years. All households stated that the region still need many services which includes development of electricity, security of water, maintenance of sewage system, security of the streets, presence of sufficient schools and other recreational services.

Table 8 gives a summarized overview about the four study areas compared to each other in 2007 and 2017 based on the previously detailed provided data in the previous section.

Table 8: Summarizing up the four study areas

	A1		A2		A3		A4	
	2017	2007	2017	2007	2017	2007	2017	2007
General description	Previously existing urban cover		Complete transformed agricultural lands		Fragmented agricultural pockets		Few buildings in the middle of open agricultural lands	
Roads	Narrow and semi-paved		Narrow unpaved roads		Informal muddy roads		Informal roads between agricultural lands	
Easiness of transportation	Easy	Easy	Difficult	Difficult	Difficult	Difficult	Difficult	Difficult
Connection to water network	Governmental / communal grid	Some are connected to grid, the rest use underground water pumps	Governmental / communal grid	Underground water pumps	Underground water pump		Underground water pump	
Sewage system	Communal network	Septic tanks	Communal network	Poorly designed septic tanks	Poorly designed septic tanks		Poorly designed septic tanks	
Connection to electricity network	Governmental grid		Governmental grid	Main cable in the street (illegal)	Governmental grid		Governmental grid	

CHAPTER 5. Agriculture in Tersa (farmers responses)

This chapter identifies the impact of urban sprawl on the dimensions of the agricultural process based on the conducted field study and analyzing farmers' responses.

According to the interview with Engineer Mohamed Zaki, -General manager of land improvement department in the Ministry of Agriculture and Land Reclamation of Egypt- total agricultural land in Tersa and El-Munib was 1607 feddans in 2004. He asserted that the salinity and alkalinity of Tersa's soil was perfect which makes it suitable for producing wide variety of vegetation such as wheat, maize, vegetables and forage, while it is unsuitable for building due to the muddy nature. He further stated that Abu Al-Nomros water canal feeds the main water stream in Tersa "Tersa El-Omomia" water canal, which subdivides into 3 branches.

There were 2 drainages in Tersa which are: Bukbashy in the eastern side and El-Konayesah in the western side. Engineer Zaki noted that the nature of the farming activity in Tersa has totally transformed due to urban sprawl and the resulted pollution.

Thirty farmers were surveyed in their lands. Twelve of them representing 40 percent own their land (Figure 36). Farmers tried to adapt to the changes in Tersa that affected the agricultural process. However, they do not count on farming activities in Tersa like before due to the challenges and difficulties that they are currently facing due to urban sprawl.

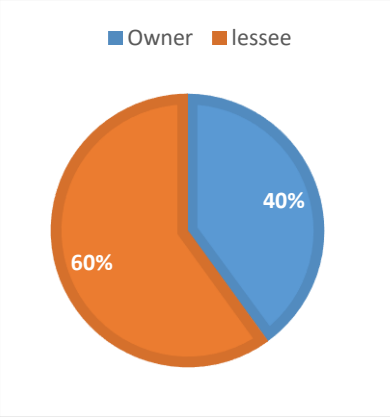


Figure 36: Agricultural land ownership of the surveyed farmers

5.1. The impact of urban sprawl on the fragmented agricultural lands

5.1.1. Crop type

As mentioned; the agricultural land in Tersa used to have good quality of fertile soil suitable for cultivating many types of crops. Ten years ago, farmers used to cultivate different kinds of vegetables such as tomato, onions, cabbages, eggplant, zucchini, etc., fruit crops such as grapes, and mango and field crops such as wheat and maize. Farmers used to provide food and livestock's production to their local area. Sever water contamination and the presence of residents in the surrounding neighborhood of the agricultural lands led to total shift in the agricultural products in Tersa. All farmers shifted into fodder crops such as berseem and sugar maize (Table 9). Only one

of the surveyed farmers cultivate his 7 kirat owned land with variety of vegetables for his family consumption using underground water pump.

Table 9: Cultivated crops in 2007 and 2017

Cultivated crops	2017	2007
	n=30	n=30
Vegetables	1	30
Fodder	29	0

According to Sayed Abd El-Azim –farmer-, people in Tersa used to eat from the cultivated production and sell the remaining. In contrast, currently, they cannot cultivate edible crops and they have to rely on food products that they buy from outside Tersa. Consequently, they are totally affected with food prices fluctuation instead of previously being producers. Mohamed Imam –farmer- added that if they tried to cultivate wheat or any crops other than fodder crop, the crop does not grow well because of the water quality, the yield decreases or damaged and accordingly they cannot sell it properly.

Challenges faced by farmer from urban sprawl in Tersa not only prevented farmers from cultivating vegetables but it also led them to cultivate barseem which requires intensive irrigation (Misri & Serkan, 2014). This adds more stress on the available underground water that they totally rely on for irrigation.

5.1.2. Irrigation

Water and irrigation system is a primary activity in the agricultural process. Availability, accessibility and the quality of the water resource are important parameters to achieve the targeted crop yield.

Most of the previous studies investigating causes of urban sprawl indicated that deteriorating the water quality comes as a core impact results due to lack of proper sewer system in the settlements built due to sprawl. Al-Kharabsheh and Ta'any (2003) investigated in their study the impact of urban sprawl on deteriorating the water quality of water surfaces and the underground water in Jordan. Accordingly, agriculture activity and other uses of fresh water were significantly influenced.

Figure 37 illustrates the conceptual framework representing direct and indirect relationship between polluted water and the dimensions of the agricultural process. Sprawled population over agricultural lands usually occupy unplanned poor served settlements with improper infrastructure. Leading to loss of agricultural lands.

This also stresses the sewage system whose capacity may be insufficient for the released wastewater. Poor constructed sewage systems (pipes or septic tanks) release wastewater into open water surface or leak into the underground water, accordingly water quality and land are significantly influenced.

Poor water quality deteriorates soil fertility, influences crop yield, affects livestock health and leads to changing the crop type to cope with water quality. In addition, poor water quality leads to group of indirect impacts on the farming activities such as changing type and/or quantity of the consumed fertilizers and changing type of machinery or stressing them.

Other practices of sprawled non-farmer residents include stealing or destroying cultivated crop, they also may steal farmers' livestock. As a result agricultural productivity changes, some farmers opt-out farming practices leading to deficiency of labor force and decrease the mass unit of farmers in the community. Subsequently institutional support and subsidies for farmers decrease which significantly influences the provided services to the remaining farmers such as providing free machinery and subsidized fertilizers.

Each dimension is explained in details according to Tersa's case study throughout the following sections of this chapter.

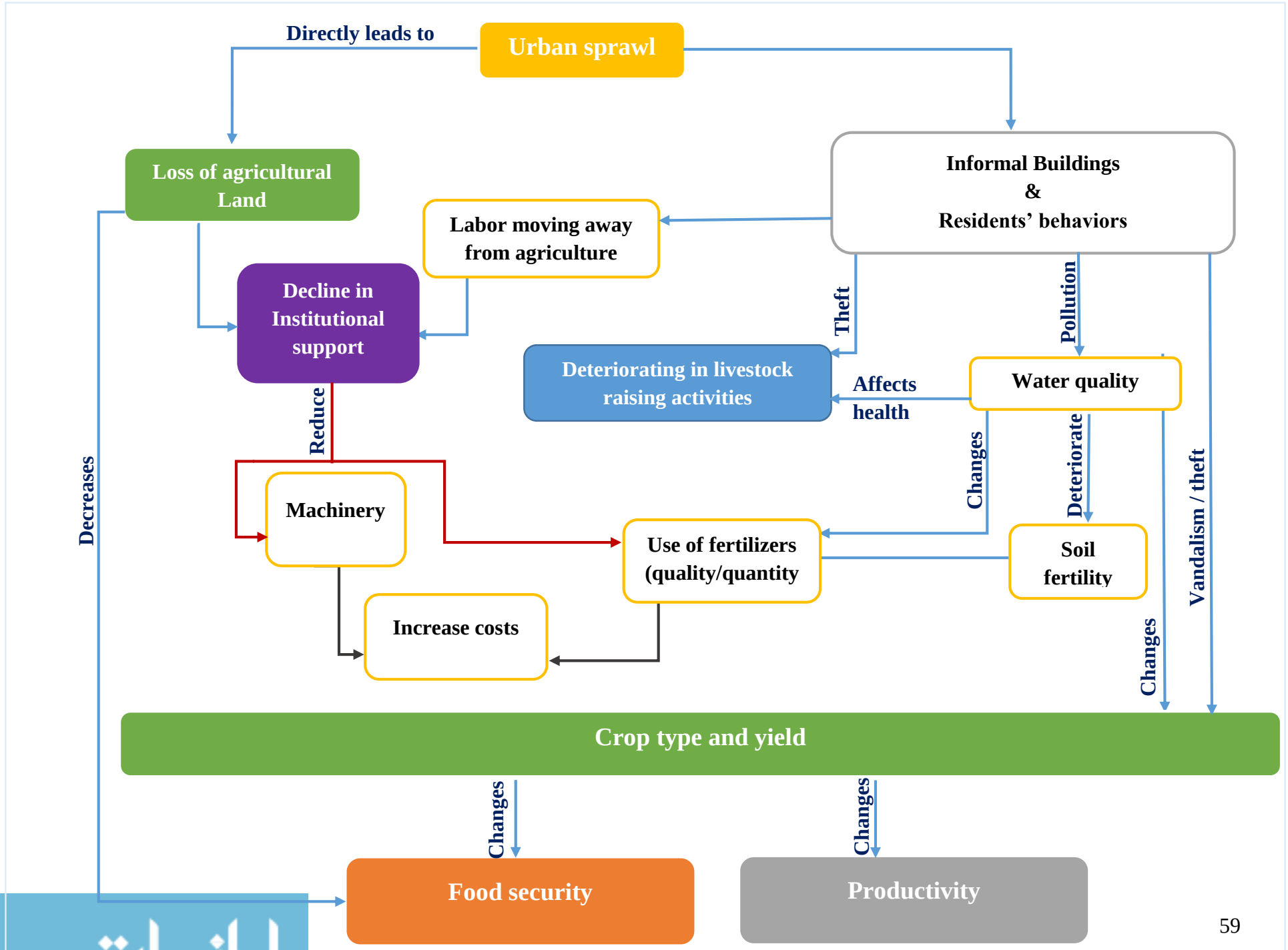


Figure 37: Conceptual framework for the impacts of urban sprawl on the dimensions of the agricultural sector (Author)

Presence of residents surrounding the agricultural lands highly affected the water resource used for irrigation in Tersa. Ten years ago, all farmers used to irrigate their farmlands from Tersa Al-Omomia water canal and its branches. In 2008, parts of the water canal dried as it was partially covered and roads were built. In 2011 after January events, people started to cover it by themselves, and many houses were build. Residents provide their houses with water pipes and construct communal sewage systems. Failure of the sewage systems due to the increased population density and the poor quality of the installed network led to contamination of the water canal. In addition to accumulation of the garbage and throwing dead animals contributed to increase the levels of contamination in these canals. As a result, farmers were forced to change the source of irrigation. Currently all surveyed farmers use pumps to irrigate their lands from underground water. According to the observational study by the researcher, water pump are usually found at the top of each farmland. Though the water source become closer and more accessible than before (water pump at the top of each land), but the rate of irrigation decreased and it takes long time to obtain water for irrigation. In addition, farmers believe that underground is not rich in silt, which is needed to nourish their land and hence land loses its fertility over time.

Figure 39: Irrigation water machine

Ismail Radwan –farmer- said: "*soil used to nourish with the silt present in the water canal coming from the Nile river*", Hani Moustafa and Sobhy Imam continue: "*We used to irrigate using rich clean water coming from water canal, now we had to use pumped underground water which will stress the land through successive use*". While Omar Ali –farmer- who still use water canal for irrigation said that he never cultivates vegetables or any edible plants now due to the poor water quality.

Moreover, sometimes while pumping water from the canal the irrigation machine is damaged due to the garbage and plastic blocking the machine and the absence of screens on it. Moreover, as previously stated, septic tanks of the near houses have poor lining and residents rarely emptied

them. This results in the diffusion of wastewater through the ground which in return affect the quality of underground water. Farmers frequently notice change in water color or odor.

Water analysis results

In assess the validity of the above stated and observed problems with the irrigation water, water analysis for water canal sample and three underground water samples used for irrigation in A3 (near the fragmented agricultural lands) was carried out. The chemical and biological analysis of the collected water samples confirmed what was observed and reported by the farmers.

a) Water Quality Guidelines

Table 10 shows the general range of irrigation water quality standard guidelines according to FAO. The limits of some parameters in the FAO guideline are categorized into three degrees of restrictions according to the restrictions in using the water resource and the crops sensitivity to certain elements as detailed in table 12. The first category (None- restriction) indicates the absence of any restrictions in using the water; accordingly, water resource can be used for cultivating all types of crops. The second category (slight to moderate) indicates the gradual selection of certain crops to be cultivated with much care in addition to applying management alternatives for achieving complete yield potential. The third category shows the rigid limits which if exceeded will lead to yield potential reduction, cropping problems as well as harming the soil.

1) FAO Guidelines

Table 10: FAO guidelines for evaluating water quality for agriculture

Parameter	Symbol	Unit	Range
Electrical Conductivity	EC_w	dS/m	0 – 3
Total Dissolved Solids	TDS	mg/l	0 – 2000
Calcium	Ca^{++}	me/l	0 – 20
Magnesium	Mg^{++}	me/l	0 – 5
Sodium	Na^{+}	me/l	0 – 40
Carbonate	CO^{--}_3	me/l	0 – 0.1
Bicarbonate	HCO_3^{-}	me/l	0 – 10
Chloride	Cl^{-}	me/l	0 – 30
Sulphate	SO_4^{--}	me/l	0 – 20
Nitrate-Nitrogen	NO_3-N	mg/l	0 – 10
Ammonium-Nitrogen	NH_4-N	mg/l	0 – 5
Phosphate-Phosphorus	PO_4-P	mg/l	0 – 2
Potassium	K^{+}	mg/l	0 – 2
Boron	B	mg/l	0 – 2

Manganese	Mn	mg/l	0 – 0.2
Iron	Fe	mg/l	0 – 5
Copper	Cu	mg/l	0 – 0.2
Zinc	Zn	mg/l	0 – 2
Acid/Basicity	pH	1–14	6.0 – 8.5
Sodium Adsorption Ratio	SAR	(me/l)	0 – 15

Table 11 shows the limits of the Egyptian Law 48/82 for protection of the Nile and waterways from pollution.

2) Egyptian regulations

Table 11: Egyptian Law 48/82 for protection of the Nile and waterways from pollution

Parameter	**Symbol**	**Unit**	**Range**
Total Dissolved Solids	TDS	mg/l	0 – 500
Nitrate-Nitrogen	NO_3-N	mg/l	0 - 2
Ammonium-Nitrogen	NH_4-N	mg/l	0 – 0.5
Boron	B	mg/l	0 – 0.5
Manganese	Mn	mg/l	0 – 0.2
Iron	Fe	mg/l	0 – 0.5
Copper	Cu	mg/l	0 – 0.01
Zinc	Zn	mg/l	0 – 0.01
Acid/Basicity	pH	1–14	6.5 – 8.5
Chemical Oxygen Demand	COD	mg/l	0 – 10
Biological Oxygen Demand	BOD	mg/l	0 – 6
Dissolved Oxygen	DO	mg/l	More than 6
Fecal Coliform		cfu/ 100ml	1000

Table 12: Physical and chemical analysis of the collected water samples compared to the FAO guidelines and the Egyptian law 48/82

Parameters	Unit	Pump 1	Pump 2	Pump 3	Water canal	FAO guidelines Degree of restriction on use			Egyptian guidelines Law 48/82 "Article 49"
						None	Slight to Moderate	Severe	
pH		7.50	7.50	7.20	6.80	Normal Range 6.0 – 8.5			6.5 – 8.5
TDS	mg/l	883.0	1177.0	1030	1295.0	< 450	450 – 2000	> 2000	500
EC	dS/m	1.38	1.84	1.61	2.02	< 0.7	0.7 – 3.0	> 3.0	n/a **
CO_3^{-2}	meq./l	-	-	-	-	0 – 0.1			
HCO_3^-	meq./l	4.72	5.19	5.66	5.94	0 – 10			
SO_4^{-2}	meq./l	6.16	9.94	7.95	6.51	0 – 20			4.2*
Cl^-	meq./l	4.24	4.92	4.41	7.12	< 4	4 – 10	> 10	n/a
Ca^{+2}	meq./l	5.00	7.89	9.47	5.53	0 – 20			
Mg^{+2}	meq./l	4.52	5.20	5.29	5.43	0 – 5			
Na^+	meq./l	5.48	6.80	3.07	7.80	0 – 40			
K^+	meq./l	0.11	0.14	0.18	0.82	0 – 2			
SAR		2.51	2.66	1.13	3.33	< 3	3 – 9	>9	
NH_3^+	mg/l	1.82	1.05	1.19	26.6	0 – 5			0.5
NO_3^+	mg/l	8.87	10.15	6.51	15.68	< 5	5 – 30	> 30	2
P	mg/l	0.002	<1.5	<1.5	<1.5	0 – 2			2
Fe	mg/l	0.167	0.197	0.107	0.388	5.0			0.5
Mn	mg/l	0.966	1.255	1.351	0.606	0.2			0.2
Zn	mg/l	0.047	0.04	0.07	0.061	2.0			0.01
Cu	mg/l	0.029	0.026	0.025	0.049	0.2			0.01
B	mg/l	0.066	0.060	0.077	0.104	< 0.7	0.7 – 3.0	> 3.0	0.5
COD	mg/l	Not detected			65				10
BOD	mg/l				18				6
Total coliform	cfu/ml				272×10^3				n/a
Fecal coliform	cfu/ml				154×10^3				1000 (cfu/100 ml)
Salmonella & shegilla	cfu/ml				$41\ 10^3$				

*** Originally 200 ppm in the law 48/82**

** No available data about these parameters in law 48/82

b) Discussion of the water analysis results

- All water samples has high concentration of TDS exceeding the Egyptian law 48/82, in addition EC of all samples shows slightly to moderate use restriction according to FAO guidelines. These results indicate a slightly high salinity level that may consequently affect the soil salinity. Accumulation of salts in the plant roots leads to reduction of the crop yield, the salinity problem can be solved through leaching below the root depth
- Sulfate concentrations exceed the Egyptian law limit in all water samples. Sulfates occur naturally in water or result from municipal or industrial discharges. Normal concentrations of sulfates are not toxic to plants; however, high concentration of sulfates affects the soil salinity, decreases the plant and toxic to cattle
- All water samples have slightly high concentration of chloride (Cl^-) which lies in the moderate usage restriction section according to the FAO guideline

  Although chloride is essential for photosynthetic process and osmotic adjustments, high concentrations of chloride leads to chloride toxicity. Chloride moves through the transpiration stream and then accumulated in the crop leaves. If chloride exceeds the tolerance limit of the crop, it causes injuries such as crop burns, dryness of leaf tissue and leads to yield loss.
- Concentration of magnesium exceed the limits of the FAO guideline in all water samples except pump 1

  High concentrations of magnesium in water affects the soil infiltration rate. Magnesium cations act slightly like calcium; whereas magnesium is adsorbed by the soil with a higher degree than sodium but slightly less than calcium. Accordingly, sodium adsorption rate (SAR) may be damageable in water with Ca/Mg ratio less than 1 (magnesium dominated water) (Rahman & Rowell, 1979).
- All water samples contain manganese concentration (Mn) exceeds both: FAO guidelines and Egyptian law 48/82. This increases the toxicity level of water and makes it unsuitable for long-term irrigation. Accumulation of heavy metals is hard to be removed. It leads to damage of vegetation tissue and these in turn become severely harmful to human and animals who fed on these crops.
- Concentration of ammonia ions (NH_3-) in the water stream is noticeably very high exceeding both: the FAO guidelines and the Egyptian law 48/82, ammonia concentration of the 3

underground water exceeds the Egyptian law limits. High concentrations of ammonia is a clear indication for water contamination with sewage/ waste water. Whereas, nitrate (NO_3^-) concentration lies in the slight to moderate restriction use range of the FAO guideline and all samples exceed the Egyptian law limits. Both ammonia and nitrates contribute to the total nitrogen concentration

Nitrogen is a naturally needed nutrient for stimulating vegetation growth; however high concentrations of nitrogen in water will act like excess use of fertilizers. Excess of nitrogen will lead to over stimulation growth, poor quality crops and delayed maturity.

- Naturally COD, BOD, Coliform bacteria, Salmonella and shegilla bacteria are not detected in water used for irrigation. The highly detected COD and bacterial forms is another indication about the contamination of water with sewage which makes the water source is unsuitable for irrigation. Due to this contamination, the water canal of Tersa goes under the category wastewater. According to WHO and the Egyptian regulation; the maximum concentration for Fecal Coliform in water for agricultural uses is 1000 cfu/100 ml. The bacteriological analysis of the water stream sample shows high risk if being used, not only for the cultivated crops but also the workers and farmers exposed to this water.

  In this case, the water should undergo treatment levels to comply with the Egyptian code (ECP 501/2015) before reusing water in irrigation. The Egyptian code mentions 4 level of treatment and determines the suitable uses for treated waste water according to the treatment level (Appendix 3).

  According to ECP 501/2015; it is prohibited to use treated municipal wastewater –regardless the level of treatment- in cultivating raw eaten vegetables or export crops, it is prohibited to use D- level treated municipal wastewater in cultivation of any vegetable crops, fruit crops, field crops or medicinal plant crops. In addition, it is prohibited to use B, C and D- level treated municipal wastewater in irrigating green surfaces of educational institutes, public and private parks.

  Table 13 summarizes the water analysis parameters that showed non-compliance with the FAO guidelines and/or the Egyptian law limits (48/82).

Table 13: Summarizing the analyzed parameters not complying with FAO and/or Egyptian law limits

Parameter	Don't comply with				
	FAO			Egyptian law 48/82	
	Sample		Degree of restriction	Sample	
TDS				√	All
EC	√	All	Slight to moderate	n/a **	
SO_4^{-2}				√	All
Cl^-	√	All	Slight to moderate		
Mg^{-2}	√	Water canal, pump 2 & pump 3	Severe	n/a	
SAR	√	Water canal	Slight to moderate		
NH_3^+	√	Water canal	Sever	√	All
NO_3^+	√	All	Slight to moderate	√	All
Mn	√	All	Severe	√	All
Zn				√	All
Cu				√	All
COD				√	Water canal
BOD	n/a			√	Water canal
Fecal Coliform				√	Water canal

** No available data about these parameters

5.1.3. Surrounding urban residence

Urban sprawl over agricultural lands did not only lead to loss of the arable lands, but it also highly affected the remaining agricultural lands. Some agricultural lands became confined and surrounded with houses from all directions such as in A3.

Figure 40: Confined agricultural land in A3

The presence of residents in the surround of the agricultural lands increased the tension between farmers and the neighboring households. On one hand, surrounding residents harass farmers with vandalism. According to Darwish Ismail -farmer-, "*Farmlands are like human being, land need space; presence of buildings and residents stifle the land*", Mahmoud Salem and Ahmed El-Sayed –farmers- continued: "*Children take off plants while playing*". They also added: "*We never plant maize or vegetable, surrounding residents will steal what we cultivate*". Practices of the surrounding residence are another reason beside poor water quality that pushed farmers to shift into cultivating non-edible crops. On the other hand, residents complain about the health status of livestock, and report their complaints to the governmental authority, which affects the farming activity as well.

5.1.4.Land

Between 2007 and 2017, the estimate of agricultural land loss in Tersa under urban sprawl is 19.43 percent. The expansion over peripheral agrarian lands decreases their spatial extent and fragments the land leading to reduced patch sizes of average 1 to 2 Faddens (Figure 40). Nineteen farmer of the thirty surveyed farmers currently cultivate smaller area than the area they used to cultivate 10 years ago (Table 14). Eleven lessees cultivate smaller area mainly because landowners sold part of the agricultural land for urban uses, or for the rising renting costs significantly. Other than selling the agricultural lands, some land owners currently cultivate smaller area because the land was inherited and distributed among brothers.

Table 14: Cultivated agricultural areas in 2017 compared to the area 10 years ago

Current cultivated agricultural land	Total respondents	Owner	Lessee
	n=30	n=12	n=18
Smaller area	19	8	11
Same area	11	4	7

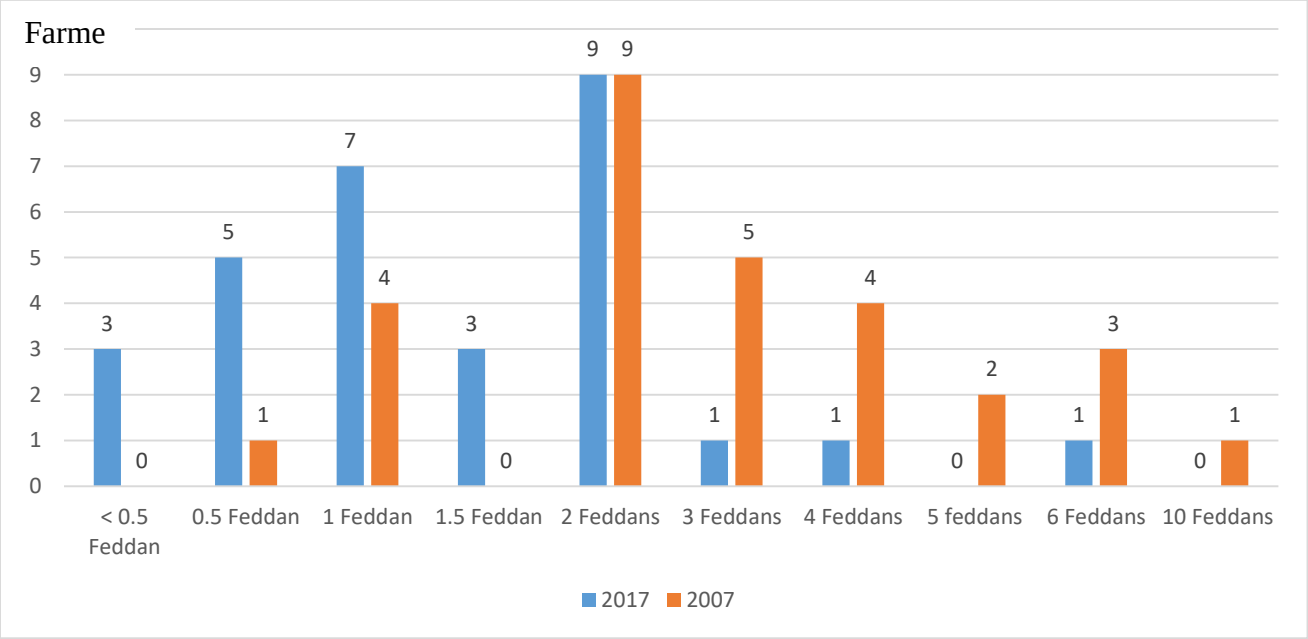


Figure 41: Cultivated areas by the surveyed farmers

5.1.5. Labor force

Most of the surveyed farmers cultivate their farmlands by themselves and their families. About 21 farmers (70 percent) stated that they do not need more labor force with them due to the small farmland area while the remaining nine mentioned that they need more labor force (Figure 41). However, they do not find farming workers as most of them abandon agricultural practices for other jobs mainly related to construction work. Mohamed Antr –land owner- indicated that agricultural workers leave farming activities and go for construction works and this scarcity of labor resulted in raising the wages for the available workers. He added that; workers were very flexible ten years ago, they used to work in the farmland in return to any amount of money for the full day. The average farming workers' wage in 2007 was EGP/day 30-35 from

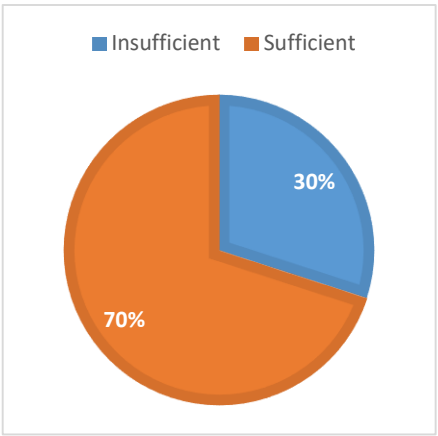


Figure 42: Need for more farming workers

sunshine to sunset, however, in the meantime (2017), their wage reaches EGP/day 100 from 8:00 only to 13:00.

5.1.6. Fertilizers

Farmers currently use chemical fertilizer such as nitrates and urea, livestock dung or both. Figure 42 indicates farmers' responses about the types of fertilizers they use in the meantime, nineteen farmers (63 percent) reported that they use chemical fertilizers in addition to livestock dung, while eleven farmers use only chemical fertilizers. Changing the water used for irrigation from the canal water to underground water affected the fertility of the soil. Subsequently, many of them had to change fertilizer type through conversion into more effective chemical fertilizer instead of depending on livestock dung only. Others had to increase the quantity of fertilizers compared to the amount they used to consume for their land 10 years ago, keeping in consideration that all of them cultivate same or smaller area than before.

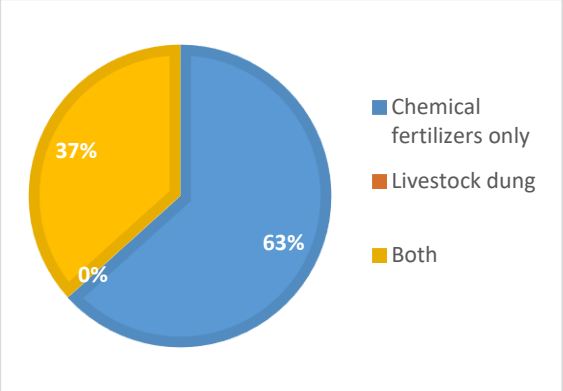


Figure 43: Fertilizers consumption by type in 2017

Figure 43 shows the procedures that farmers followed regarding the consumed fertilizers. In comparison with their traditional practice in 2007, twelve farmers (40 percent) reported that they had to change both type and quantity of the consumed fertilizer, seven farmers (23 percent) said that they had to increase the quantity of the consumed fertilizers, one farmer reported changing on the type of fertilizer, while the remaining ten farmers haven't done any changes.

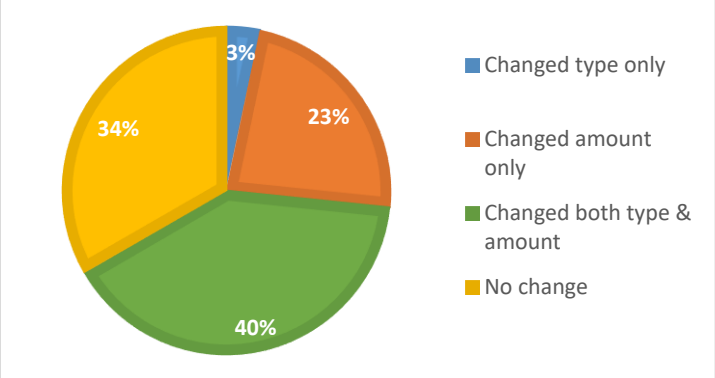


Figure 44: Current changes which farmers applied in fertilizers consumption in 2017

Moreover, some of the farmers indicated that they currently need extra amount of fertilizers over what they receive from the agricultural cooperation association. Saied Marzouk –farmer- mentioned that the agricultural cooperation association does not support farmers as it used to do before. Their share of subsidized fertilizers significantly decreased, in addition lessees do not receive a share of subsidized fertilizers.

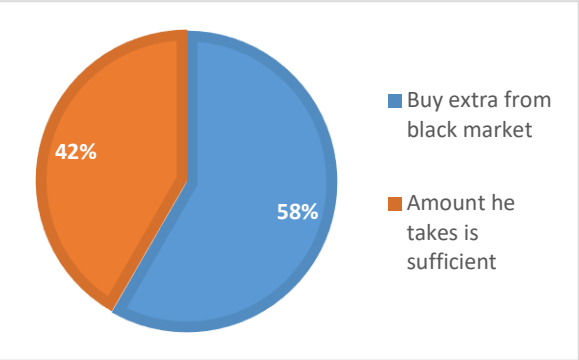


Figure 45: Need of extra subsidized fertilizers in 2017

Figure 44 presents the farmers' responses when they were asked if the amount they receive from the agricultural cooperation association is sufficient for their consumption or not. Eight out of twelve (58 percent) landowners reported that the amount they receive is insufficient; five of these landowners currently cultivate smaller area compared to the area they used to cultivate in 2007. Four landowners reported that the received amount of fertilizers is sufficient for their need. While the eighteen lessee reported that the agricultural cooperation association doesn't provide subsidized fertilizers for lessees anymore; accordingly they buy it with higher prices.

Furthermore, the weakness of control and follow up one behalf of the agricultural cooperation association and the governmental authorities encouraged many landowners to maintain the use of their landownership document to receive their share of the fertilizers and sell it in the black market even after they have sold their land or have constructed over it.

5.1.7 Machinery

All surveyed farmers have manual equipment needed for agricultural activities. However, all of them hire the needed automated machinery, which includes the plow, the tractor and the irrigation machine. The renting fees include the fuel needed for the machine and they do not pay for the machine maintenance. However, recent increased fuel prices affected the renting fees of machinery. In addition, the agricultural cooperative organization used to provide the farmers with needed machinery for free to support them. However, the agricultural cooperative association's support to farmers dramatically decreased parallel to the decreased farming activity in Tersa because of urban sprawl.

5.1.8. Livestock

Raising livestock is the main agri-business in Tersa in the meantime. As previously mentioned, all farmers depend on cultivating fodder, even those who do not have livestock in their farmland. Fourteen of the thirty surveyed farmers raise livestock. The majority of them stated that they sell from the livestock dairy production on a limited scale within Tersa, whereas three of them reported that they only use it for the family consumption only.

Raising livestock also lost the concerned authorities' support. Previously, the governmental authority used to provide health insurance and free health care services for livestock. Furthermore, farmers complaint of the surrounding residents harassing the animals, stealing them or stealing their product.

5.1.9. Productivity

Productivity of the agricultural land is the ratio between the outputs and inputs of the agriculture process. Many factors affected the agricultural process in Tersa; not only the impacts of the urban sprawl on the agricultural process but also the noticeable increase in prices during the last period in Egypt. Since farmers totally shifted into another crop type as a result of urban sprawl, farmers were asked about agricultural productivity in terms of profitability. No doubt that the profitability of vegetables crop is higher than the profitability of fodder crops on the long term. However, surveyed farmers stated that the profitability of fodder crops is high as well due to its short cultivation cycle. Generally, farmers believe that the agricultural productivity has decreased compared to its level 10 years ago for many reasons including: high prices of seeds, fertilizers, fuel, machinery, and the decreased support provided to farmers of Tersa in the meantime.

5.2. Summary

In conclusion of the previously explained changes in Tersa, urban sprawl has highly influenced the remaining fragmented agricultural lands and the farming activity. Figure 45 and 46summarize up the overall all impacts of urban sprawl on the farming practices as reported by the surveyed farmers and the adaptation steps that they followed to face these challenges. As shown in Figure 45, out of the 30 surveyed farmers, 29 complaint of poor quality of water, 24 decreased quantity of water.

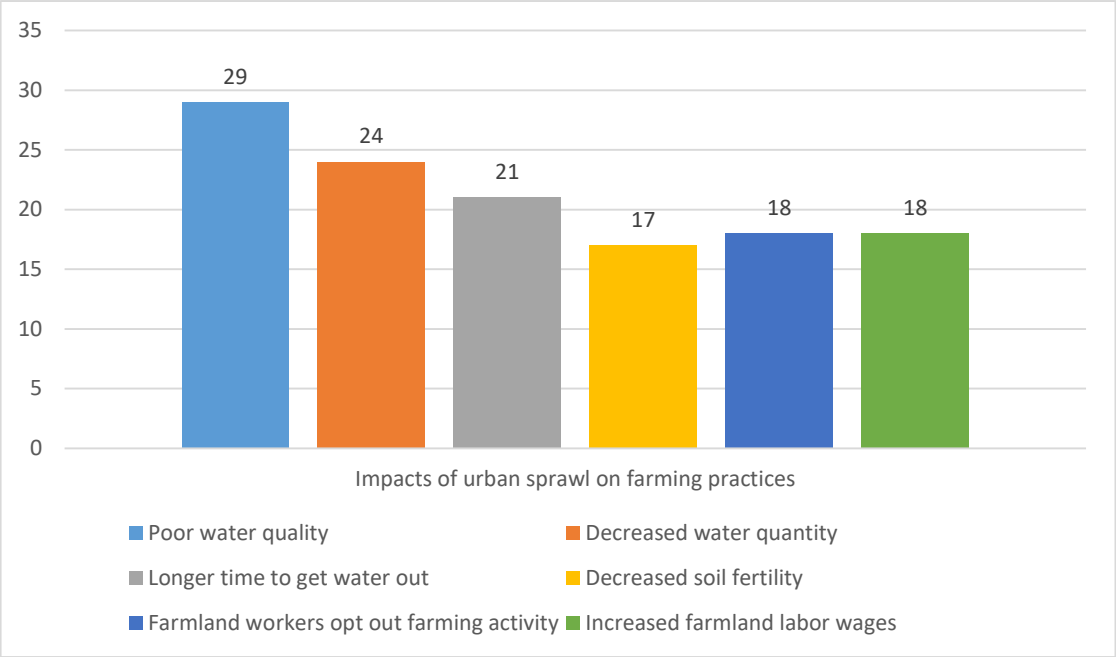


Figure 46: Farmers responses about how urban sprawl affected their activity

Consequently, farmers were forced to change some farming practices in order to adapt with the difficulties they are facing due to urban sprawl. Figure 46 illustrates the adaptation strategies that the surveyed farmers followed to face the challenges of urban sprawl. Out of the 30 farmers, 29 were obliged to use underground water for irrigation instead of irrigating from the water canal, 30 had to cultivate fodder crops instead of edible crops, and 20 changed their fertilizers' consumption strategy (type, quantity or both), 18 were obliged to decrease the number of workers because of the unavailability of farming workers, their increased or due to the reduced cultivated area.

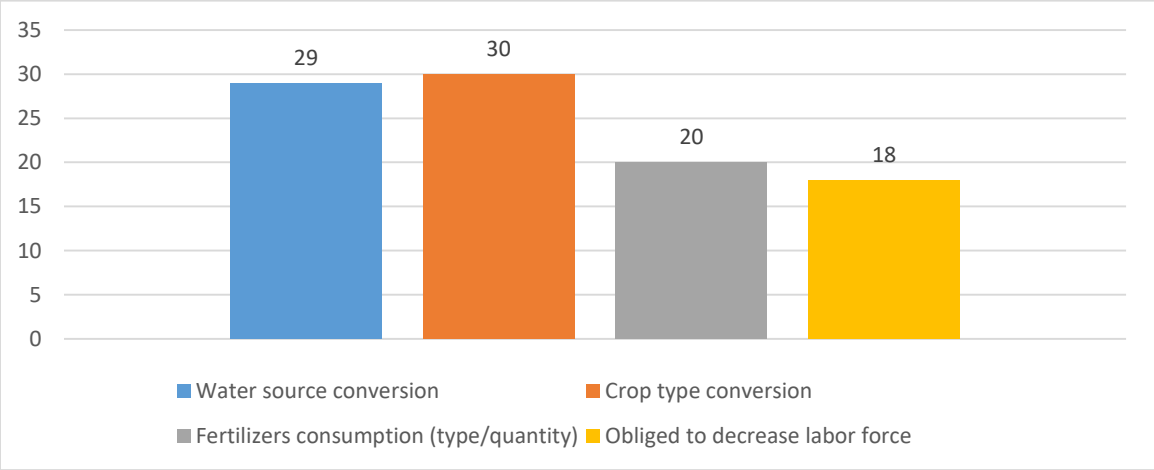


Figure 47: Farmers responses about how they adapted to urban sprawl challenges

Figure 47 represents a simplified diagram showing the changes came across Tersa through the previous 10 years between 2007 and 2017 because of urban sprawl. These changes include building over the agricultural lands, covering up parts of the water canal, installing sewage network flowing to canal, changing the source of water used in irrigation, and unification of the cultivated crops.

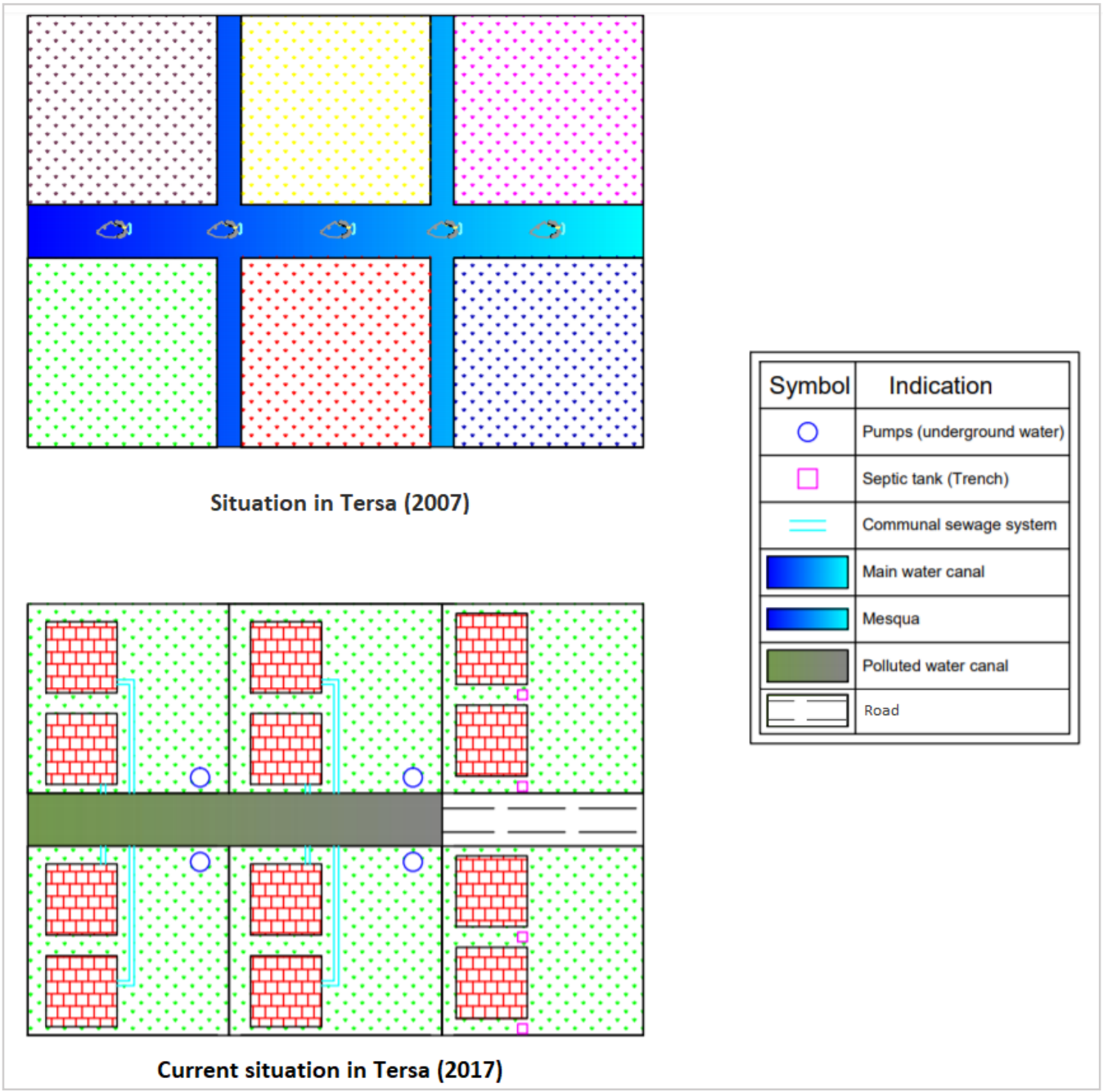


Figure 48: Changes over the agricultural lands in Tersa between 2017 and 2007

CHAPTER 6. Conclusions and Recommendations

6.1. Conclusions

Though urbanization nourishes the economy and contributes to the growth of countries, it can lead to pernicious consequences if not managed and controlled properly. This research aimed to study the impacts of urban sprawl on the fragmented agricultural lands and to highlight the status of the available resources in the settlements resulted by urban sprawl. The study was conducted in an administrative village named Tersa in Giza; based on the spatial selection through remote sensing images carried out by CSD team at AUC. Field visits were carried out to study the influences of urban sprawl in Tersa. Water analysis was carried out on samples of canal and underground water. The main results of the study can be summarized as follows:

- Urban sprawl noticeably affected Tersa in different ways. Urban sprawl has direct and indirect impacts on the agricultural lands.
- Direct impacts of urban sprawl include encroached over nearly 19 percent of Tersa's fertile agricultural lands as shown through the high resolution remote sensing images and confirmed by the conducted field visits. Furthermore, it led to formation of poorly served residential areas.
- The indirect impacts of urban sprawl is represented in the impacts of sprawl on the remaining fragmented agricultural lands and the negative impacts on the farming practices
    - Sewage failure problem of the available pipeline network, the poor quality of the constructed communal sewage systems as well as the unmanaged disposal of the septic tanks are the main contributors to contaminating the water canal and the underground water used in land irrigation
    - Farmers were forced to convert into using underground water for irrigation instead of relying on the water canal
    - The contaminated irrigation water forced farmers to change the cultivated crop type into fodder rather than cultivating edible crops that they used to cultivate 10 years ago
    - Presence of the surrounding neighborhood to the agricultural lands was another reason that pushed the farmers to shift the crop pattern due to vandalism and theft

- Due to decreased in farming activity in Tersa; the governmental and institutional support, services and subsidies provided to farmers decreased significantly
- Many farm-workers opt out of the farming activity to other off-farming jobs, accordingly the wages of labor force increased
- Alterations of the crop type reduced the contribution to fulfilling the local food needs within Tersa.

Looking at the bigger picture, Tersa's case study represents a small example being repeated on the macro-level all over GCMR and Delta. Accordingly urban sprawl is a major threat to the national food security. In addition, it leads to serious environmental, social and economic impacts.

The impacts of urban sprawl cut across the environmental, societal and economic pillars of sustainable development. Accordingly, urban sprawl influences the progress towards sustainability. The following diagrams summarize up the overall impacts of urban sprawl in the case study of Tersa distributed among the pillars of sustainable development.

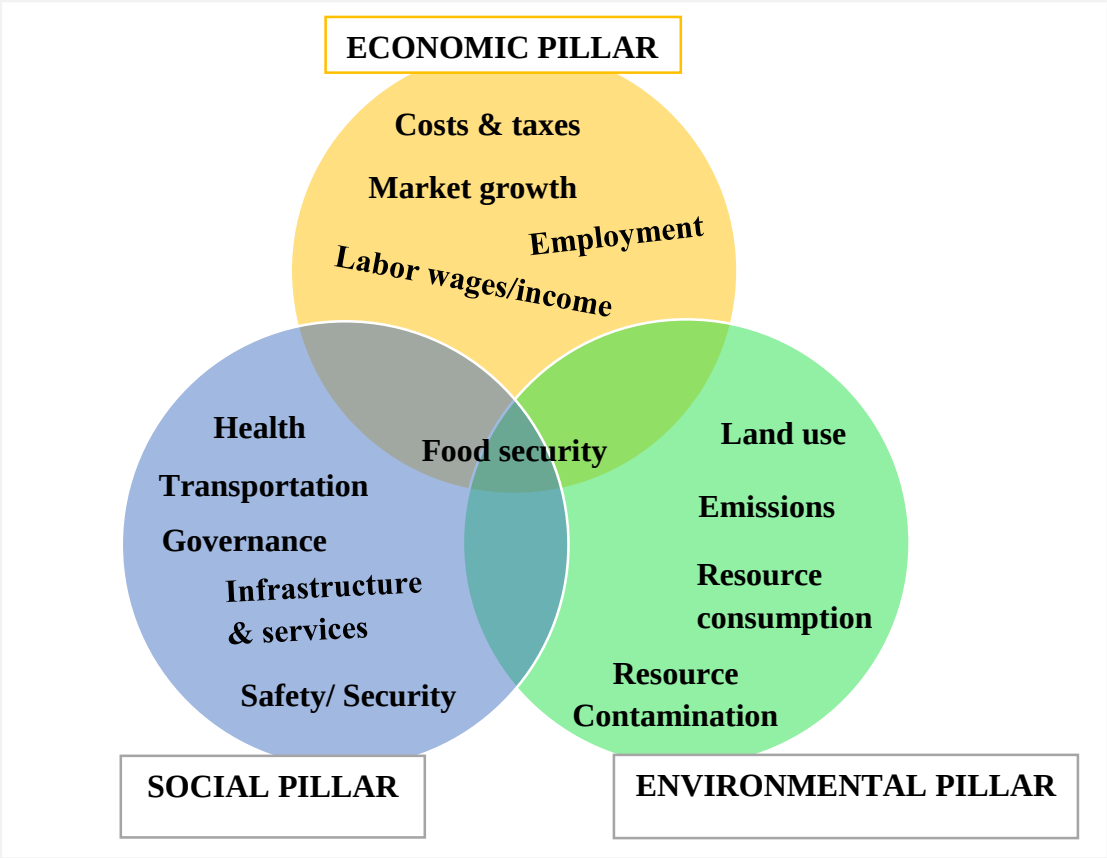
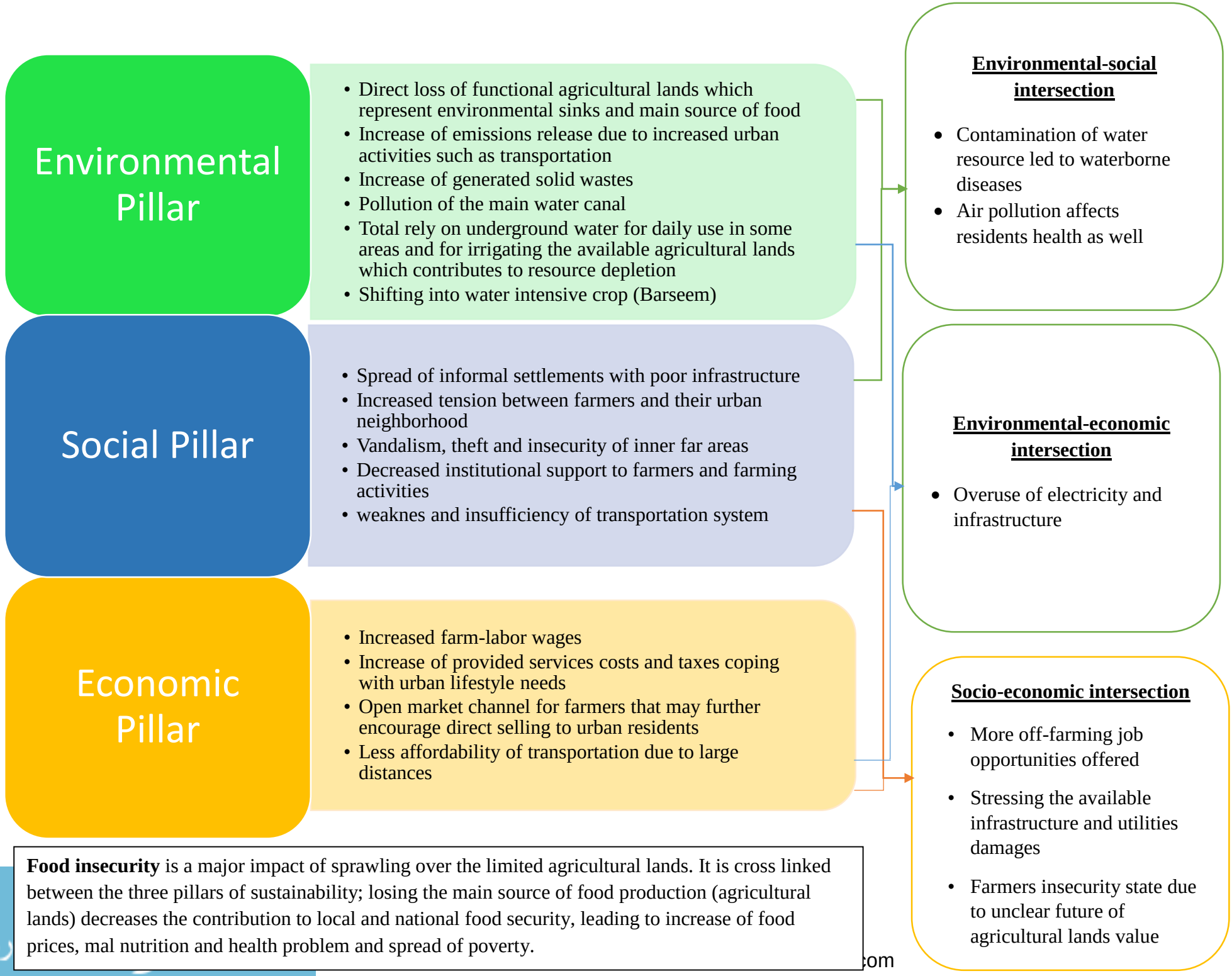


Figure 49: Pillars of Sustainable Development

Figure 50: Pillars of sustainable development



Food insecurity is a major impact of sprawling over the limited agricultural lands. It is cross linked between the three pillars of sustainability; losing the main source of food production (agricultural lands) decreases the contribution to local and national food security, leading to increase of food prices, mal nutrition and health problem and spread of poverty.

6.2. Recommendations

Controlling urban sprawl requires an integrated multidimensional strategy in order to achieve sustainable urbanization. Despite the presence of enacted laws in Egypt that incriminate building on agricultural lands, there are no deterrent actions or controlling criteria to prevent such illegal action.

On the macro-level, giving an accurate estimates and projections for the future urban growth is an important step required from urban planners and involved stakeholders' side to pave the road for figuring out solutions to contain the expected growth. These projections should be based on solid establishment of good comprehension of the probable trends and patterns of urban change accompanied with high quality statistics. This step is important to generate realistic scenarios, accordingly developing sustainable management practices and proper policies.

It comes to the developers and urban planners to shoulder the responsibility of generating acceptable planned solutions to contain projected urban growth. For example, some countries were able to set a successful developing plan included redevelopment of brownfield sites instead of going towards the rural fringe and magnifying the role of urban agriculture. It is also beneficial to invest in developing the available infrastructure and transportation system to reduce the sprawl into other areas

For the particular case of Tersa:

- It is recommended for future research projects to study the changes in other areas within Tersa rather than the mentioned ones (A1, A1, A3 and A4) in this research study and collect more water, soil and crop samples for chemical and bacteriological analysis.
- For water stream samples, it is highly recommended to analyze the following parameters: E.Coli, Fecal Coliform, Salmonella and shigella due to high contamination with sewage system
- Checking and repairing the sewage infrastructure system in Tersa is highly required to prevent further contamination. The available infrastructure system represents a real threat to groundwater
- It is highly advised to set a treatment program for the point sources of contamination in the water canal in Tersa to enable the healthy proper use of the available water, this may include constructing treatment hydroponic basins and in addition to a biological treatment criteria. Raising awareness between residents and farmers is a major step in order to clarify and limit the risk resulted from exposure to the contaminated water service.

- Irrigation machines should be supported by screens to prevent machinery blockage by garbage
- It is also important to increase the support provided to farmers and protect their right to farm in a comfortable environment, in addition to enhance social cohesion and connectivity through creating beneficial relationship between farmers and the surrounding urban inhabitants to reduce the tension complaints raised between both sides.
- It is important to prepare a proper farming practices adaptation strategy and a training program to the farmers of the remaining fragmented agricultural lands based on the current situation they are facing. Adaptation strategy should include using suitable fertilizers with less nitrogen content due to the high saturation of ammonia and nitrates (high total nitrogen content) in the water used for irrigation and introducing simple organic farming techniques such as the suitable time for yield harvesting to allow a suitable gap between last irrigation and harvesting time

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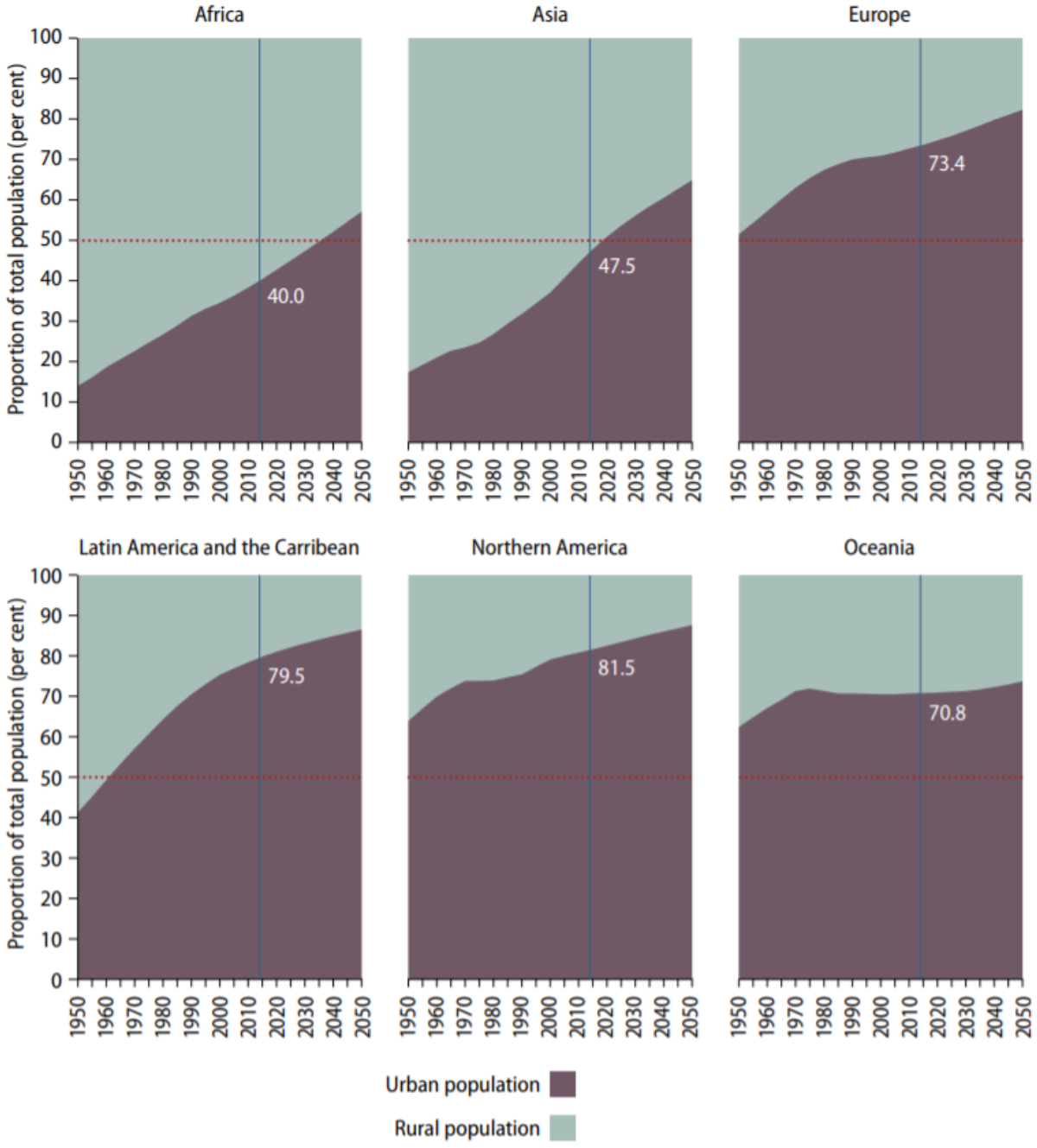
APPENDICES

Appendix 1: Historical overview for the population distributions (UNDESA, 2014)

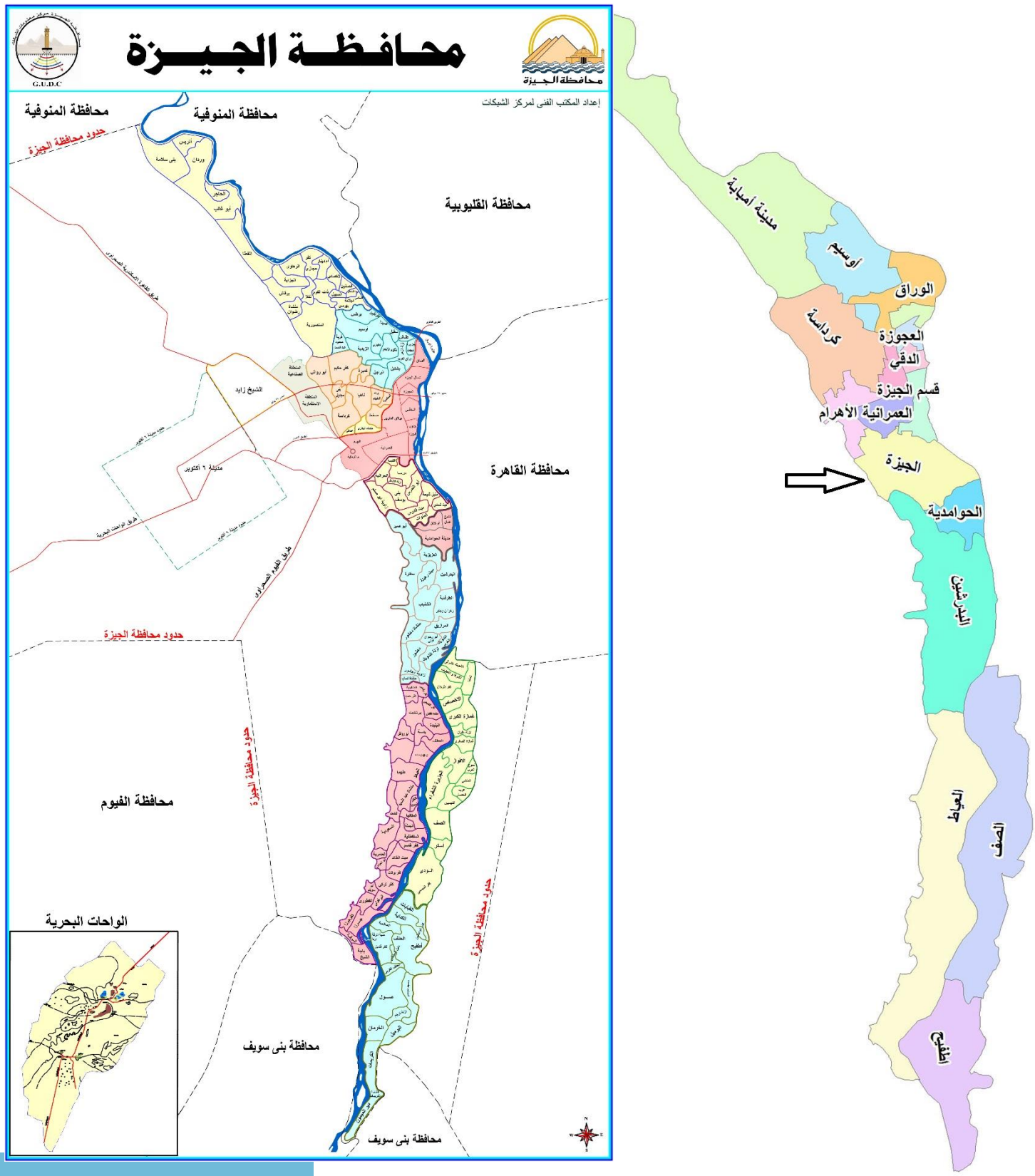
Region	Urban population (thousands)			Rural population (thousands)			Proportion Urban (percent)			Average annual rate of change (percent)
	1990	2014	2050	1990	2014	2050	1990	2014	2050	2010 - 2015
World	2285031	3880128	6338611	3035786	3363656	3212333	43	54	66	0.9
More developed regions	830952	980403	1113500	317326	275828	189610	72	78	85	0.3
Less developed regions	1454079	2899725	5225111	2718460	3087828	3022723	35	48	63	1.2
Least developed countries	107335	283855	895701	402019	635275	914889	21	31	49	1.7

- More developed regions includes Europe, Northern America, Australia, New Zealand and Japan
- Less developed regions include all regions of Africa, Asia (excluding Japan), Latin America and the Caribbean plus Melanesia, Micronesia and Polynesia
- The least developed countries are overall 49 countries, 34 in Africa, 9 in Asia, 5 in Ocenia and one in Latin America and the Caribbean

Appendix 2: Proportions of urban and rural areas in each major region (UNDESA, 2014)



Appendix 3: Giza Governorate



Appendix 4: Egyptian law 48/82

مادة ٤٨ - يجب على المكلف بأخذ العينة أن يملأ بدقة بخط واضح النموذج الخاص بذلك (سجل حيازة العينة) وأن يحصل على توقيع صاحب الشأن أو مندوبه على النموذج (سجل حيازة العينة) . وأن يقوم بإرساله فوراً مع العينة إلى الإدارة العامة للمعامل المركزية بوزارة الصحة بالقاهرة أو المعامل الإقليمية التابعة لها بالمحافظات .

الباب السادس

الضوابط والمعايير والمواصفات الخاصة

بصرف المخلفات السائلة المعالجة إلى مجارى المياه

أولاً - فى الصرف على مسطحات المياه العذبة :

مادة ٤٩ - يجب أن تبقى مسطحات المياه العذبة التى يرخص بصرف المخلفات الصناعية السائلة المعالجة إليها فى حدود المعايير والمواصفات الآتية :

البيـــــــــان	المعايير والمواصفات (ملليجرام / لتر ما لم يذكر غير ذلك)
المواد الصلبة الذائبة الكلية	لا يزيد عن ٥٠٠
الأكسجين الذائب	لا يقل عن ٦
الأس الإيدروجينى	٦,٥ - ٨,٥
الأكسجين الحيوى الممتص	لا يزيد عن ٦
الأكسجين الكيميائى المستهلك (دايكرومات)	لا يزيد عن ١٠
نتروجين عضوى	لا يزيد عن ١
النشادر NH_3 as (N)	لا يزيد عن ٠,٥
نترات NO_3 as (N)	لا يزيد عن ٢
النتروجين الكلى (TN) as N	لا يزيد عن ٣,٥
الفسفور الكلى (TP) as P	لا يزيد عن ٢
شحوم وزيوت	لا يزيد عن ٠,١
كبريتات	لا يزيد عن ٢٠٠
الزئبق	لا يزيد عن ٠,٠٠١

البيـــــــان		المعايير والمواصفات (ملليجرام / لتر ما لم يذكر غير ذلك)
حديد		لا يزيد عن ٠,٥
منجنيز		لا يزيد عن ٠,٢
نحاس		لا يزيد عن ٠,٠١
زنك		لا يزيد عن ٠,٠١
فلوريدات		لا يزيد عن ٠,٥
فينول		لا يزيد عن ٠,٠٠٢
زرنيخ		لا يزيد عن ٠,٠١
كادميوم		لا يزيد عن ٠,٠٠١
كروم		لا يزيد عن ٠,٠٥
السيانيد الحر		لا يزيد عن ٠,٠٠٥
رصاص		لا يزيد عن ٠,٠١
سيلينوم		لا يزيد عن ٠,٠١
البورون		لا يزيد عن ٠,٥
المولبيديوم		لا يزيد عن ٠,٠٧
النيكل		لا يزيد عن ٠,٠٢
المبيدات وتشمل :		
ألدرين ، داى إلدرين	Aldrin and dieldrin	لا يزيد على ٠,٠٠٠٣
الألكلور	Alachlor	لا يزيد على ٠,٠٢
الديكارب	Aldicarb	لا يزيد على ٠,٠١
أترازين	Atrazine	لا يزيد على ٠,٠٠٢
بنتازون	Bentazone	لا يزيد على ٠,٠٣
كاربوفيوران	Carbofuran	لا يزيد على ٠,٠٠٧
كلوردان	Chlordane	لا يزيد على ٠,٠٠٠٢
٤،٢ داى كلوروبروب	2,4-Dichloroprop	لا يزيد على ٠,٠٣
فينوبروب	Fenoprop	لا يزيد على ٠,٠٠٩
ميكوبروب	Mecoprop	لا يزيد على ٠,٠١
٢،٤،٥ – ت	2,4,5- T	لا يزيد على ٠,٠٠٩

Appendix 5: Egyptian code 501/2015

جدول رقم (٥-١): تصنيف النباتات والمحاصيل المسموح بريها بمياه الصرف الصحى المعالجة*

درجة المعالجة	المجموعة الزراعية	التوصيف
أ	مج ١-١ المسطحات الخضراء للمنشآت التعليمية والمتنزهات العامة والخاصة	النجيل بكافة أنواعه ونباتات السور والزهور بجميع أنواعها
	مج ١-٢ محاصيل الفاكهة	الفاكهة التى تؤكل طازجة بدون تقشير مثل: التفاح والمشمش والخوخ والعنب، إلخ.
ب	مج ٢-١ محاصيل الحبوب الجافة والخضر المطبوخة والمصنعة	الخضروات بأنواعها (المصنعة) والمحاصيل الاستراتيجية الجافة بكافة أنواعها مثل: القمح – الذرة – الشعير – الأرز – الفول – العدس – السمسم
	مج ٢-٢ محاصيل الفاكهة	جميع أنواع أشجار الفاكهة مستديمة ومتساقطة الأوراق مثل: الموالح – الزيتون – النخيل – المانجو – البيكان – الرمان، والتين بغرض التجفيف
	مج ٢-٣ محاصيل النباتات الطبية	مثل: الينسون – الكركديه – الكمون – البردقوش– الخلة – الحلبة – المغات – الشمر – البابونج – المرمرية
جـ	مج ٣-١ محاصيل الحبوب الجافة ومحاصيل الفاكهة ومحاصيل النباتات الطبية الواردة بالمجموعة (ب)	نفس الأنواع بالإضافة إلى نبات عباد الشمس ونبات بنجر السكر بشرط عدم استخدام طريقة الرى بالرش
	مج ٣-٢ البذور غير الغذائية	جميع بذور الإكثار للمحاصيل الغذائية الرئيسية مثل: القمح والذرة وبذور الخضروات بكافة أنواعها بشرط زراعة هذه البذور فى أماكنها المستديمة فيما بعد
	مج ٣-٣ جميع أنواع الشتلات والتى يتم نقلها بعد ذلك الى الحقول المستديمة	مثل: شتلات الزيتون – الرمان – الموالح – خلفات الموز – فسائل النخيل – شتلات التين – المانجو – التفاح – الكمثرى
	مج ٣-٤ الورود وزهور القطف	مثل: الورد البلدى – ورد النسر – مجموعة الأبصال مثل الجلاديولس وعصفور الجنة وكافة أنواع نباتات الزينة

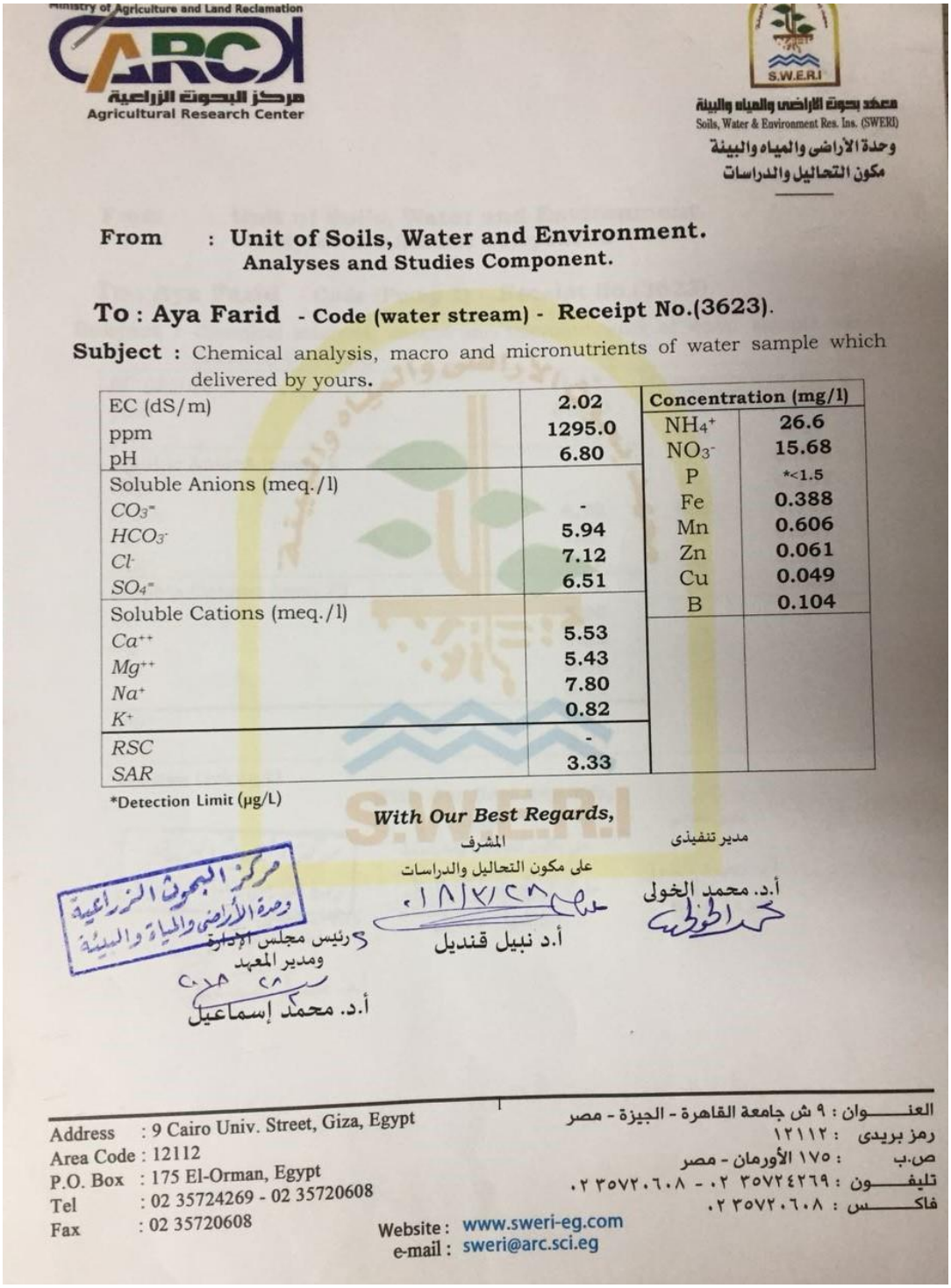
"تابع" جدول رقم (٥-١): تصنيف النباتات والمحاصيل المسموح بريها بمياه الصرف الصحى المعالجة*

درجة المعالجة	المجموعة الزراعية	التوصيف
"تابع" جـــ	مج ٣-٥ الأشجار الملائمة لتشجير الطرق السريعة والأحزمة الخضراء	مثل: الكازورينا – الكافور – الدفلة – الأثل – أنـــواع نخيل الزينة
	مج ٣-٦ جميع محاصيل الألياف	مثل: القطن – الكتان – الجوت – التيل
	مج ٣-٧ محاصيل الأعلاف النجيلية والبقولية	مثل: أنواع السورجم وأنواع النفل
	مج ٣-٨ التوت لإنتاج حرير القز	مثل: جميع أصناف التوت
	مج ٣-٩ جميع مشاتل نباتات وأشجار الزينة	مثل: الفيكس ديكورا – الفيكس نيتـــدا – الســـفندر – الأكاسيا
د	مج ٤-١ محاصيل الكتلة الحيوية الصلبة	جميع المحاصيل التى يتم تحويلها إلى فحم (أقراص مضغوطة) مثل: الصفصاف والحور والمورنجا
	مج ٤-٢ محاصيل الكتلة الحيوية السائلة	جميع محاصيل إنتاج وقود الديزل الحيوى وزيـــوت الطاقة مثل: فول الصويا – بذور اللفت – الجوجوبا– الجاتروفا – الخروع
	مج ٤-٣ محاصيل إنتاج السليولوز	جميع المحاصيل غير الغذائيـــة لإنتـــاج الجلوكـــوز ومشتقاته مثل: الإيثانول وحمض الخليك – الإيثانول الجيل
	مج ٤-٤ الأشجار الخشبية	جميع الأشجار لإنتـــاج الأخشـــاب مثـــل: الكايـــا – الكافور – والماهوجنى

مج: مجموعة

* يجب مراعاة ما يلى:
- يجوز استخدام مياه بدرجة معالجة أعلى لزراعة مجموعات زراعية نظيرة لمياه معالجة بدرجة معالجة أدنى بما لا يتعارض مع ما ورد بالبند (٤-٧).
- يراعى التحمل النسبى لكل محصول زراعى لملوحة مياه الرى وتركيز عنصر البورون طبقاً لما هو وارد بالملحق (ب) والملحق (جـــ) من هذا الكود.
- يراعى ملخص الاشتراطات الخاصة باستخدام مياه الصرف الصحى المعالجة لرى المجموعات الزراعية طبقاً لما هو وارد فى الملحق (أ) من هذا الكود.

Appendix 6: Water analysis results



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Soils, Water & Environment Res. Ins. (SWERI)
وحدة الأراضى والمياه والبيئة
مكون التحاليل والدراسات

From : Unit of Soils, Water and Environment.
Analyses and Studies Component.

To : Aya Farid - Code (water stream) - Receipt No.(3623).

Subject : Chemical analysis, macro and micronutrients of water sample which delivered by yours.

		Concentration (mg/l)	
EC (dS/m)	2.02	NH_4^+	26.6
ppm	1295.0	NO_3^-	15.68
pH	6.80	P	*<1.5
Soluble Anions (meq./l)		Fe	0.388
$CO_3^=$	-	Mn	0.606
HCO_3^-	5.94	Zn	0.061
Cl^-	7.12	Cu	0.049
$SO_4^=$	6.51	B	0.104
Soluble Cations (meq./l)			
Ca^{++}	5.53		
Mg^{++}	5.43		
Na^+	7.80		
K^+	0.82		
RSC	-		
SAR	3.33		

*Detection Limit (µg/L)

With Our Best Regards,

المشرف
على مكون التحاليل والدراسات
أ.د نبيل قنديل

مدير تنفيذى
أ.د. محمد الخولى

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ص.ب : ١٧٥ الأورمان - مصر
تليفـــون : ٠٢ ٣٥٧٢٤٢٦٩ - ٠٢ ٣٥٧٢٠٦٠٨
فاكـــس : ٠٢ ٣٥٧٢٠٦٠٨

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لتدوير المخلفات الزراعية

المهندسة / أيه فريد.

تحية طيبة وبعد ،،،

فيما يلى تحليل عينة المياه الواردة الى المعمل بمعرفتكم وتحت مسئوليتكم بتاريخ ٢٠١٨/٣/٢٥ وتم تسديد الرسوم بأيصال رقم (٧٤٥).

التحليل	الوحدة	(مياه ترعه)
الأكسجين اللازم لأكسدة المادة العضوية كيماوياً (COD)	مليجرام / لتر	٦٥
بكتيريا القولون الكلية	خلية / مللى	٢٧٢×١٠^{٣}
بكتيريا القولون البرازية	خلية / مللى	١٥٤×١٠^{٣}
بكتيريا السالمونيلا والشيجلا	خلية / مللى	٤١×١٠^{٣}

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المشرف على المكون
أ. د./ سمير على السيد

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Soils, Water & Environment Res. Ins. (SWERI)
وحدة الأراضى والمياه والبيئة
مكون التحاليل والدراسات

From : Unit of Soils, Water and Environment.
Analyses and Studies Component.

To : Aya Farid - Code (Pump 1) - Receipt No.(3623).

Subject : Chemical analysis, macro and micronutrients of water sample which delivered by yours.

		Concentration (mg/l)	
EC (dS/m)	1.38	NH_4^+	1.82
ppm	883.0	NO_3^-	8.87
pH	7.50	P	0.002
Soluble Anions (meq./l)		Fe	0.167
$CO_3^=$	-	Mn	0.966
HCO_3^-	4.72	Zn	0.047
Cl^-	4.24	Cu	0.029
$SO_4^=$	6.16	B	0.066
Soluble Cations (meq./l)			
Ca^{++}	5.00		
Mg^{++}	4.52		
Na^+	5.48		
K^+	0.11		
RSC	-		
SAR	2.51		

*Detection Limit (µg/L)

With Our Best Regards,

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على مكون التحاليل والدراسات
أ.د نبيل قنديل

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تحية طيبة وبعد ،،،

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التحليل	الوحدة	طلمبه ١ (١٧ متر)
بكتيريا القولون الكلية	خلية / مللى	لم تكتشف
بكتيريا القولون البرازية	خلية / مللى	لم تكتشف
بكتيريا السالمونيلا والشيجلا	خلية / مللى	لم تكتشف

وتفضلوا سيادتكم بقبول فائق الاحترام

المدير التنفيذى
أ. د./ صابر محمود احمد

المشرف على المكون
أ. د./ سمير على [illegible]

مركز البحوث الزراعية
وحدة الأراضى والمياة والبيئة

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فاكـــس : ٠٢٣٥٧٢٠٦٠٨

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وحدة الأراضى والمياه والبيئة
مكون التحاليل والدراسات

From : Unit of Soils, Water and Environment.
Analyses and Studies Component.

To : Aya Farid - Code (Pump 2) - Receipt No.(3623).

Subject : Chemical analysis, macro and micronutrients of water sample which delivered by yours.

		Concentration (mg/l)	
EC (dS/m)	1.84	NH_4^+	1.05
ppm	1177.0	NO_3^-	10.15
pH	7.50	P	*<1.5
Soluble Anions (meq./l)		Fe	0.197
$CO_3^=$	-	Mn	1.255
HCO_3^-	5.19	Zn	0.040
Cl^-	4.92	Cu	0.026
$SO_4^=$	9.94	B	0.060
Soluble Cations (meq./l)			
Ca^{++}	7.89		
Mg^{++}	5.20		
Na^+	6.80		
K^+	0.14		
RSC	-		
SAR	2.66		

*Detection Limit (µg/L)

With Our Best Regards,

مدير تنفيذى
أ.د. محمد الخولى

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فاكـــس : ٠٢ ٣٥٧٢٠٦٠٨

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وحدة الأراضى والمياه والبيئة
مكون النظم المتكاملة
لتدوير المخلفات الزراعية

المهندسة / أيه فريد.

تحية طيبة وبعد ،،،

فيما يلى تحليل عينة المياه الواردة الى المعمل بمعرفتكم وتحت مسئوليتكم بتاريخ ٢٠١٨/٣/٢٥ وتم تسديد الرسوم بأيصال رقم (٧٤٥).

التحليل	الوحدة	طلمبه ٢ (١٧ متر)
بكتيريا القولون الكلية	خلية / مللى	لم تكتشف
بكتيريا القولون البرازية	خلية / مللى	لم تكتشف
بكتيريا السالمونيلا والشيجلا	خلية / مللى	لم تكتشف

وتفضلوا سيادتكم بقبول فائق الاحترام

المدير التنفيذى
أ. د./ صابر محمود احمد

المشرف على المكون
أ. د./ سمير على السيد

مركز البحوث الزراعية
وحدة الأراضى والمياة والبيئة

مدير المعهد
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رمز بريدى : ١٢١١٢
ص .ب : ١٧٥ الأرومـــان – مصـــر
تليفـــون : ٠٢٣٥٧٢٤٢٦٩ – ٠٢٣٥٧٢٠٦٠٨
فاكـــس : ٠٢٣٥٧٢٠٦٠٨

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وحدة الأراضى والمياه والبيئة
مكون التحاليل والدراسات

From : Unit of Soils, Water and Environment.
Analyses and Studies Component.

To : Aya Farid - Code (Pump 3) - Receipt No.(3623).

Subject : Chemical analysis, macro and micronutrients of water sample which delivered by yours.

		Concentration (mg/l)	
EC (dS/m)	1.61	NH_4^+	1.19
ppm	1030.0	NO_3^-	6.51
pH	7.20	P	*<1.5
Soluble Anions (meq./l)		Fe	0.107
$CO_3^=$	-	Mn	1.351
HCO_3^-	5.66	Zn	0.070
Cl^-	4.41	Cu	0.025
$SO_4^=$	7.95	B	0.077
Soluble Cations (meq./l)			
Ca^{++}	9.47		
Mg^{++}	5.29		
Na^+	3.07		
K^+	0.18		
RSC	-		
SAR	1.13		

*Detection Limit (µg/L)

With Our Best Regards,

مدير تنفيذى
أ.د. محمد الخولى

المشرف
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أ.د نبيل قنديل

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ص.ب : ١٧٥ الأورمان - مصر
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فاكـــس : ٠٢ ٣٥٧٢٠٦٠٨

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التحليل	الوحدة	طلمبه ٣ (١٧ متر)
بكتيريا القولون الكلية	خلية / مللى	لم تكتشف
بكتيريا القولون البرازية	خلية / مللى	لم تكتشف
بكتيريا السالمونيلا والشيجلا	خلية / مللى	لم تكتشف

وتفضلوا سيادتكم بقبول فائق الاحترام

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أ. د./ سمير على السيد

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رمز بريدى : ١٢١١٢
ص .ب : ١٧٥ الأرومـــان – مصـــر
تليفـــون : ٠٢٣٥٧٢٤٢٦٩ – ٠٢٣٥٧٢٠٦٠٨
فاكـــس : ٠٢٣٥٧٢٠٦٠٨

Appendix 7: Permissible limits for heavy metals accumulation in water for irrigation

Recommended limits for constituents in reclaimed water for irrigation. (Adapted from Rowe and Abdel-Magid, 1995)

Constituent	Long-term use (mg/L)	Short-term use (mg/L)	Remarks
Aluminum (Al)	5.0	20	Can cause nonproductivity in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity.
Arsenic (As)	0.10	2.0	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Beryllium (Be)	0.10	0.5	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans.
Boron (B)	0.75	2.0	Essential to plant growth, with optimum yields for many obtained at a few-tenths mg/L in nutrient solutions. Toxic to many sensitive plants (e.g., citrus) at 1 mg/L. Most grasses relatively tolerant at 2.0 to 10 mg/L.
Cadmium (Cd)	0.01	0.05	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L in nutrient solution. Conservative limits recommended.
Chromium (Cr)	0.1	1.0	Not generally recognized as essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants.
Cobalt (Co)	0.05	5.0	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Copper (Cu)	0.2	5.0	Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solution.
Fluoride (F^-)	1.0	15.0	Inactivated by neutral and alkaline soils.
Iron (Fe)	5.0	20.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum.
Lead (Pb)	5.0	10.0	Can inhibit plant cell growth at very high concentrations.
Lithium (Li)	2.5	2.5	Tolerated by most crops at up to 5 mg/L; mobile in soil. Toxic to citrus at low doses recommended limit is 0.075 mg/L.
Manganese (Mg)	0.2	10.0	Toxic to a number of crops at a few-tenths to a few mg/L in acid soils.
Molybdenum (Mo)	0.01	0.05	Nontoxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high levels of available molybdenum.
Nickel (Ni)	0.2	2.0	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Selenium (Se)	0.02	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of added selenium.
Vanadium (V)	0.1	1.0	Toxic to many plants at relatively low concentrations.
Zinc (Zn)	2.0	10.0	Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils.

Appendix 7: Nile River water quality measures in 2015 (CAPMAS 2018)

Environment **البيئة**

بعض قياسات جـودة المياه بنهر النيل 2015

Some Measures of Water Quality in River Nile 2015

Governorate	COD	BOD	DO	المحافظة
Cairo	19.1	8.5	6.5	القاهرة
Alexandria	33.3	3.8	6.2	الأسكندرية
Port-Said	14.8	2.4	6.9	بورسعيد
Suez	16.9	2.2	7.2	السويس
Damietta	11.8	4.9	6.6	دمياط
Dakahlia	11.4	6.9	6.8	الدقهلية
Sharkia	19.6	6.3	7.7	الشرقية
Kalyoubia	33.8	11.2	...	القليوبية
Kafr- El sheikh	26.4	6.2	...	كفر الشيخ
Gharbia	13.9	4.4	6.9	الغربية
Menoufia	17.5	4.5	8.3	المنوفية
Behera	14.4	5.6	7.8	البحيرة
Beni-Suef	14.6	4.0	8.0	بني سويف
Fayoum	10.7	4.0	7.6	الفيوم
Menia	16.2	5.0	8.3	المنيا
Asyout	6.7	2.8	7.7	أسيوط
Suhag	10.8	3.7	7.7	سوهاج
Qena	30.1	11.3	7.2	قنا
Aswan	9.9	5.3	6	أسوان
Luxor	8.0	5.2	6.3	الأقصر

(DO) الأكسجين الذائب: يجب ان لا يقل عن 6 مجم / لتر

(DO) Dissolved Oxygen:must not be less than 6 miligrams / liter

(BOD) الأكسجينالحيوى الممتص: يجب ان لا يزيد عن 6 مجم / لتر

(BOD) Biological Absorbed Oxygen : must not be more than 6 miligrams / liter

(COD) الأكسجين الكيماوي الممتص: يجب ان لا يزيد عن 10 مجم / لتر

(COD) Chemical Absorbed Oxygen :must not be more than 10 miligrams / liter

(T.D.S) الأملاح الذائبة الكلية : يجب ان لا تزيد عن 500 مجم /لتر

(T.D.S) Total Dissolved Salts:must not be more than 500 miligrams / liter

Source:Ministry of Health & Population. المصدر: مركز الرصد البيني - وزارة الصحة والسكان

Appendix 8: Field study questionnaire

Impacts of urban sprawl on resources in Tersa, Giza

The information in this form is confidential and will not be used anywhere other than scientific research

General Information

Governorate	:	Giza
District	:	Tersa
Chiefdom	:	
Area	:	
Building number	:	
Housing unit number or location of the unit	:	
Number of family members	:	
Detailed Address	:	
Household Phone Number (if possible)	:	
Head of household name	:	
Subject's name	:	

Subject visits			
Visits:	**1**	**2**	**3**
Date:	----/-------/----	----/-------/----	----/-------/----
Visit results:	**( )**	**( )**	**( )**
Time: **Beginning of visit** **End of visit**	**Hours** ☐ **Minutes** ☐	**Hours** ☐ **Minutes** ☐	**Hours** ☐ **Minutes** ☐

Result Codes:

1. **Done**
2. **No household members are at home during visiting time.**
3. **Family has been absent for a long time**
4. **Postponed**
5. **Denied**
6. **Partially Done**
7. **House is empty or address is wrong**
8. **House has been demolished**
9. **Other *(specified)* _____**

	Researcher	**Supervisor**	**Field Revision**	**Office Revision**	**Coding**	**Data Entry**
Name:	----------	----------	----------	----------	----------	----------
Date:	------/------/------	------/------/------	----- /------ /------	------/------/------	------/------/------	----/------/----
Signature:	----------	----------	----------	----------	----------	----------

Household Members

For the researcher, please circle the cases that are eligible for participating

	1. Respondent name	2. Relationship to the head of the household	3. Gender	4. Age	5. Last achieved educational level	6. Marital status	7. Occupation
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

Code for question #2	1. Head of household 2. Husband/wife 3. Son/daughter 4. Son-in-law/daughter-in-law	5. Grandson/granddaughter 6. Mother/Father 7. Brother/Sister 8. Stepson/Stepdaughter	9. Mother-in-law/Father-in-law 10. Other relative 11. Not related
Code for question #3	1. Male	2. Female	
Question #5	• **Ask about ability to read (and) (or) write if the person is in primary school**		
Code for question #4	(0) Children < 1 year	(98) Does not know	
Code for question #6	1. Never been married 2.Married 3. Divorced	4. Widowed 5. Separated	
Question #7	• **Mention any extra activities/tasks the person does to make extra money (sewing, handcrafts, cleaning vegetables, helping others, etc.)**		

Question #8	• **Where was the head of the household born?**	1. Same area (Tersa) 2. Rural northbound 3. Urban northbound 4. Rural southbound 5. Urban southbound	6. Other urban governorates 7. Greater Cairo - Giza 8. Greater Cairo 9. Border Governorates 10. Other country

Question #9	• **When did (name) come live here? (entire family)** ***For the researcher:*** *record time in years*	**( )** (0) less than 1 year (98) Does not know	
Question #10	• **What were the reasons that drove him/her to live here?**	1. Searching for better income 2. Moving nearer to the workplace 3. Moving nearer to educational and health facilities	4. Marriage 5. Other…….
<u>Characteristics of the living space:</u> **Note to researcher: do not directly ask these questions; observation is enough.**			
Question #11	• **What material is mostly used for the flooring?**	1. Parquet 2. Tiles 3. Ceramic 4. Marble 5. Stained Wood	6. Plastic/Vinyl/Plastic sheets 7. Carpet 8. Cement 9. SandOther *(please specify)*
Question #12	• **What material is mostly used for the roof?**	1. Concrete Cement (with concrete rods) 2. Asbestos sheets 3. Wooden sheets/tree branches	4. Tin sheets 5. Straw/hay/mud 6. Other *(please specify)*
Question #13	• **Condition of the roof**	1. Roof is intact and has no damage or faults 2. Roof is uneven 3. Roof has holes and patches 4. Other *(please specify)*	
Question #14	• **What material is mostly used in building the walls?**	1. Concrete Cement (with concrete rods)/stone 2. Red bricks/cement bricks 3. Wooden sheets/tree branches 4. Tin sheets	5. Stone 6. Unbaked bricks 7. The unit has no walls 8. Other *(please specify)*
Question #15	• **What type of unit is the family living in?**	1. Independent House (built) 2. Independent apartment in a building 3. One or more rooms in the same apartment	4. One or more independent rooms in a building 5. Tent/kiosk 6. Other *(please specify)*
Question #16	• **How many rooms, including the living room/reception and excluding the kitchen and bathroom, are in the unit?**	Number of rooms ( )	
Question #17	• **How many rooms are used as bedrooms?**	Number of rooms ( )	

Water sources at home:

Question #18	• **What is the primary source of water in your residence for each of the following**	**Drinking Water**	**Bathing and washing water**	**Sewage water**	**(A) Now**	**(B) 10 years ago**
		Connected to the main water grid --20 1. Water tap at home 2. Water tap in the front yard/backyard 3. Public water tap 4. Local/Communal tap	**Not connected to the main water grid – 19** 5. Water tap at home 6. Water pump in the front yard/backyard 7. Mineral water 8. Water carts/street water vendors 9. Canal 10. Other *(specify)*			
		For sewage water 1. Government grid sewage pipes -> 20	2. Communal grid sewage pipes 3. Sewage trenches			
Question #19	• **What is the main reason causing the residence to be disconnected from the main grid?**	1. Can't afford the cost of connecting to the grid 2. Can't afford paying for the water bill The building is not licensed (slums) 3. The grid is under construction in the area	4. The area is fully or partially not connected to the grid 5. Other *(specify)* 6. Don't know			
Question #20	• **Do you have a water meter?**	1. Yes, for the household 2. Yes, for the entire building	3. No 4. Don't know			
Question #21	• **Is water available when you need it? (do you get the amount you need in the time you need)**	1. Yes -> 23 2. No				
Question #22	• **What is the main reason that water is now not as available as it used to be?**					
Question #23	• **Do you pay for the drinking water you receive? If you do, how often do you pay? (How often does the bill come to the residence)**	1. Yes, Number of months ( )	Average cost of consumption per month ( )			
		1. No 2. Don't know				

Question #24	• **Does the household or the building require a water pump to get water?**	1. There is a water pump for the building 2. There is a special water pump for the household	1. Don't use a pump 2. Don't know
Question #25	• **Does your residence suffer from water cut-offs?**	1. Yes, often 2. Yes, sometimes 3. Never	
Question #26	• **How often does the water get cut off?**	1. Water is only available for a few hours (during the day) 2. Water is only available for a few hours (during the night) 3. Water has no specific time, but it gets cut off often	4. Water has no specific time, but rarely gets cut off 5. Other *(specify)*
Question #27	• **Why does the water cut off?**	1. Maintenance on the grid in neighboring areas 2. Water pump is broken, so water pressure is very low	3. Water pressure is very low 4. I don't know 5. Other *(specify)*
Question #28	• **What alternative water sources do you use when the water cuts off?**	1. We save water 2. We buy water from water carts or passing street vendors 3. Other *(specify)*	
Question #29	• **How often do water carts or street water vendors pass by?**	1. Every day 2. 3 times per week 3. 2 times per week 4. 1 time per week	5. Biweekly 6. Monthly 7. Other *(specify)*
Question #30	• • **30. How do you pay for the water you buy from the street carts or vendors? Do you pay per carload or per jerrycan or per bottle?**	1. By carload 2. By jerrycan	3. By bottle 4. Other *(specify)*
Question #31	• **How many carloads/jerrycans/bottles do you need per day?**	Number ( )	
Question #32	• **How much do you pay per carload/jerrycan/bottle?**	1. Free Price( )	
Question #33	• **How long does it take you to get drinking water from (____) and go back home?**	1. Don't know Minutes ( )	
Question #34		1. Yes 2. No -> 36	

	• **Do you face any problems with the color, smell or taste of the water?**		
Question #35	• **If you do, what are these problems? *(for the researcher, find out what else?)***	1. Water is mixed with sewage 2. Water has impurities 3. Water tastes sour 4. Water color is abnorm	5. Water smells foul 6. Water smells like chemicals/chlorine 7. Other (specify)
Question #36	• **Are these problems consistent or do they happen at a certain time?**	1. Consistent 2. At a specific time *(specify)*	
Question #37	• **What do you do when the color or taste of the water is abnormal?**	1. Use a filter 2. Boil the water 3. (3) Other *(specify)*	
Question #38	• **Do you face any problems related to water pressure/water flow?**	1. Yes, water flow is very weak 2. Yes, other 2. No	
Question #39	• **Does this happen all the time, or sometimes, or rarely?**	1. All the time 2. Sometimes	3. Rarely 4. Don't know

Sewage/Sanitation:

Question #40	• **If the residence is not connected to the sewage grid, where do you drain bathing water and washing water?**	(a) (b)	
Question #41	• **What kind of bathroom does the residence use? (Multiple answers are allowed)**	1. Western toilet with a flush 2. Western toilet without a flush 3. Squatting pan with a flush	4. Squatting pan without a flush 5. Ground hole 6. Other *(specify)*
Question #42	• **How much do you pay to empty the sewage trench per family (how much does each family pay)?**	( ) Egyptian Pounds	
Question #43	• **How often does this process take place?**	( )	Last time the trench was emptied (1) Don't know
Question #44	• **Do you know where the sewage that is sucked up by the trucks emptied? *(for the researcher, find out what else?)***	1. Treatment plant 2. Main dump/manhole/utility hole 3. Agricultural sewage 4. Empty land	5. Canal 6. Sewage well 7. Other *(specify)* 8. Don't know

Question #45	• **What are the main problems that face you with sewage? *(for the researcher, find out what else)***	1. Sewage floods/spills out 2. Manholes are open 3. Insects are spreading in the area	4. Other *(specify)* 5. There are no problems				
Question #46	• **What source of power does your residence use? (Multiple answers are allowed)**	1. Natural gas 2. Cooking gas cylinder 3. Electricity (connected to the main electricity grid) 4. A connection to the neighboring building	5. A connection to a street light pole 6. A connection to a main cable 7. Electric generator 8. Kerosene lamp / كلوب 9. Kerosene (gas) 10. Candles 11. Battery-operated torch 12. Other *(specify)*	**For lighting** **(a)** **(b)**	**For cooking** **(a)** **(b)**	**(a) Now**	**(b) 10 years ago**
Question #47	• **Do you suffer from electricity outages often?**	(1) Yes	(2) No				
Question #48	• **How many times did the electricity go out last month?**	Number of times ( )					
Question #49	• **Does the electricity go out for long periods of time? More than half an hour?**	1. Very briefly 2. 0.5 hours	3. More than 0.5 hours 4. Other *(specify)*				
Question #50	• **Haveelectricity outages caused damage to any electric appliances at home?**	1. Yes, number of appliances ( )	2. No				
Question #51	• **How much do you spend on average on electricity at home?**	( ) Egyptian Pounds (1) No expenses					
Question #52	• **Are cooking gas cylinders available when you need to exchange an empty one for a full one? (Question applies generally to any alternative power source to electricity)**	1. Yes 2. No					
Question #53	• **Are you able to reach the place specified for gas cylinder exchanges easily?**	(1) Yes (2) No (why?)					

Question #54	• **How much do you pay these days for a cylinder of cooking gas?**	( ) Egyptian pounds (1) Don't know		
Question #55	• **How much do you pay per month for natural gas consumption? (if applicable)**	( ) Egyptian Pounds (1) There is no natural gas (2) Don't know		
Question #56	• **Which of the following appliances do you have at home, and if you do, how many units do you have per appliance? *(For the researcher: read the list)***	1. Electric refrigerator 2. Deep freezer 3. Fully-automatic washing machine 4. Dishwasher 5. Cooktop 6. Stove with oven (gas/electric) 7. Electric oven 8. Kerosene cooker 9. Kitchenware washer 10. Water heater (gas/electric)	11. Electric fan (ceiling/stand) 12. Heater 13. Air conditioner 14. Sewing machine 15. Electric vacuum cleaner 16. Microwave 17. Iron 18. Landline telephone 19. Television 20. Mobile/cellular phone 21. Laptop 22. Internet connection/cable 23. Radio	24. Cassette player 25. Radio + Cassette player 26. Color TV 27. LCD Screen 28. Video player/DVD player 29. Satellite dish/satellite connectionZ 30. Bicycle 31. Motorcycle 32. Donkey cart 33. Private car 34. Taxi/ *tuktuk*/pickup

Environmental characteristics of the area: ventilation - solid waste - noise pollution)

Question #57	• **Are most of the rooms ventilated and does the sun reach them?**	(1) Ventilation is good and the sun shines inside (2) Ventilation is good but the sun does not shine inside	(3) Ventilation is not good but the shines inside (4) Ventilation is not good and the sun does not shine inside
Question #58	• **Does the area contain smoke and gas or abnormally-smelling air?**	(1) Yes, (Was the pollution as dense ten years ago?) (2) No	

Question #59	• **What do you think is the cause of the smells?**	(1) (2) (3)	
Question #60	• **Do you suffer from the following in your household?** ▪ **Yes** ▪ **No**	(1) Flies (2) Mosquitoes (3) Cockroaches (4) Ants (5) Fleas (6) Bed bugs	(7) Lizards (8) Mice (9) Weasels (10) Scorpions (11) Snakes (12) Other *(specify)*
Question #61	• **How do you get rid of the garbage in your household?**	(1) A hired person collects the garbage (2) A government-specified person from a garbage collection company collects the garbage (3) The garbage is thrown in a box//container/dumpster (4) The garbage is thrown out in a specific piece of land	(5) The garbage is thrown in the street (6) The garbage is thrown in a dump/landfill (7) It is used as fuel (8) Other *(specify)*
Question #62	• **How much do you pay the garbage collector each month?**	( ) Egyptian Pounds	
Question #63	• **Do you pay extra money on the electricity bill for the garbage collection service**	(1) Yes (2) No (3) Don't know	

Question #64	• **In the area where you live now:**		*(1) Yes*	*(2) To some extent*	*(3) No*	*(4) Not applicable*	*(98) Don't know*
	a) Now	a) Are the number of trash cans/dumpsters enough? b) Are the locations of these cans dumpsters convenient? c) Are the cans/dumpsters maintained periodically? d) Is the garbage removed every acceptable/relevant amount of time? e) Is the garbage burned in the street?					
	b) 10 years ago	a) Are the number of trash cans/dumpsters enough? b) Are the locations of these cans dumpsters convenient? c) Are the cans/dumpsters maintained periodically? d) Is the garbage removed every acceptable/relevant amount of time? e) Is the garbage burned in the street?					

Tenure security			
Question #65	• **How long have you been living in this residence?**	(1) Less than 5 years (2) 5 - 10 years (3) More than 10 years	(4) Since I was born (5) Other *(specify)*
Question #66	• **What made you leave your previous residence and come live here?**	(1) Marriage (2) Work (3) We rented this residence for a better price (4) We bought a residence	(5) We built this house (6) Evacuation/earthquake (7) Expulsion (8) Other *(specify)*
Question #67	• **Do you own or rent this residence, or is there another case?**	(1) Own the house (2) Own the apartment	(3) Rent (4) Other *(specify)*
Question #68	• **Do you know anything about the land that this residence was built on?**	(1) Agricultural land (2) Barren land (3) Construction lan	(4) Other *(specify)* (5) Don't know
Question #69	• **Who owns this land now**	(1) Belongs to the subject alone (2) Belongs to the subject and relatives (3) Belongs to relatives	(4) Ownership by occupation (5) Belongs to the government (6) Other *(specify)*
Question #70	• **Are there any documents that prove the ownership of this piece of land?**	(1) Yes	(2) No
Question #71	• **Did you build this residence, or did you buy it or did someone locate you here?**	(1) Built the house (2) Bought the house from relatives of the father or the mother (3) Bought the house from non-relatives (4) Bought from the government	(5) Specified to me by the government (6) Specified to me by the company I work for (7) Other *(specify)*

Question #72	• **Did you acquire a license to build on this land from the district administration?**	(1) Yes	(2) No		
Question #73	• **Do you have any documents that prove that you own this residence?**	(1) Yes	(2) No (98) Don't know		
Question #74	• **What rental system does this residence follow?**	(1) Old rental law contract (long term contract) (2) Furnished rental contract (3) New rental law contract	(4) Subcontracted (5) In-kind benefit (6) It was offered without rent		
Question #75	• **Do you have the rent contract for this residence?**	(1) I have a registered contract, length of the contract ( ) (2) I have a contract that is not registered (3) I unofficially agreed on terms with the owner (written down)	(4) I have no contract (5) Other *(specify)* (6) Don't know		
Question #76	• **Do you feel safe in this residence, or do you feel like you can be forced to leave at any moment?**	(1) I feel very safe and no one can force me to leave (2) I feel safe, but I can be forced to leave	(3) I don't feel safe (4) Other *(specify)*		
Characteristics of the area:					
Question #77	• **What do you think of the area here compared to the state it was 10 years ago?**	(1) Better (2) Worse	(3) No change (4) Don't know	(A) Now	(B) 10 years ago
Question #78	• **In your opinion, what changes have taken place here since then?**	(1) (2) (3)			

Question #79	• **What methods of transportation reach this area? (Multiple choices are allowed)**	(1) No transportation reaches this area (2) Bus (3) Microbus (4) Miniubus	(5) Metro, (how far is the nearest station?) (6) *Tuktuk* (7) Taxi Other *(specify)*
Question #80	• **Do you think transportation to and from this area is tough, manageable or easy?**	(1) Easy (2) Manageable (3) Tough	
Question #81	• **In your opinion, what makes transportation difficult in this area? (Multiple choices are allowed)**	(1) Transportation ceases to exist very early (2) Available transportation is outside the area (3) Cars face a lot of difficulty to enter the area due to narrow roads	(4) Cars face a lot of difficulty to enter the area due to unpaved road (5) Other *(specify)*
Question #82	• **Are there street janitors who sweep the ground here?**	(1) Yes (2) No (3) Don't know	
Question #83	• **Who often do they sweep the ground?**	(1) Every day (2) 2-3 times per week (3) One per week (4) Once every two weeks	(5) Once a month (6) Depends on the circumstances (7) Other *(specify)*
Question #84	• **Does waste accumulate in this area?**	(1) Yes, often (2) Sometimes (3) No	
Question #85	• **Does the area have trucks that spray insect/mosquito repellent, especially in the summer?**	(1) Yes (2) No -> 87	
Question #86	• **How often do these trucks spray the repellent?**	(1) Every day (2) 2-3 times per week (3) One per week	(5) Once a month (6) Depends on the circumstances (7) Other *(specify)*

		(4) Once every two weeks	
Question #87	• **Do you think the area suffers from noise pollution that affects the well-being of the residents here? (Multiple choices are allowed)**	(1) Yes, the noise pollution has a negative effect (2) There is noise pollution, but it has no negative effect (3) There is no noise pollution in the area	
Question #88	• **What do you think is the cause for the noise pollution here? (Multiple choices are allowed)**	(1) Heavy population (2) Buildings are extremely close together (3) Streets are packed with cars (4) The train is close to the area (5) There is a bus stop for transportation and taxis in the area (6) There are workshops in the area	(7) There are street vendors in the area (8) There is outdoor entertainment for children (9) People play music and radio very loudly in the street (10) There is a marketplace in the area (11) Other *(specify)*
Question #89	• **In the past 10 years, or since you came to live here, has there been any development in the area? (road paving, tree planting, lamp posts, etc.)**	Yes, *(specify)* No -> 96	
Question #90	• **Can you tell me how many developmental projects have taken place in this area in the past ten years (or since you came to live here)?**	Number of projects: ( ) They are: (1) (2)	(3) (4)
Question #91	• **Did you and your family benefit from there projects?**	1) Yes they benefit from all of them 2) Yes, they benefit from part of it 3) No benefit	
Question #92	• **What projects did you benefit from? (name the projects you benefited from the most in order, starting with the most beneficial)**	1) 2) 3)	
Question #93	• **Were you charged any expenses for these projects?**	1) Yes. Amount: ( ) 2) No	

Question #94	• **What is your general opinion on the services this area provides?**	1) Good 2) Bad 3) It's different 4) I Don't know	
Question #95	• **In case of multiple projects, what project do you think was the most beneficial to the residents in area? *(For the researcher: write down the project number)***	Name of Project: 1. None	
Question #96	• **In your opinion, what services does this area lack? (Multiple choices are allowed)**	1. Electricity 2. Sanitation 3. Clean water 4. Sufficient light on streets 5. Attention to street pavement 6. Attention to street cleanliness 7. Providing public parks and clubs	8. Providing hospitals or clinics 9. Building schools 10. Providing transportation 11. Public Square/Youth Center 12. Cinema/Theater 13. Presence of Security/Police 14. Other (*specify*):
Farmers' Section			
Question #97	• **How long have you working in the agricultural activity?**	Number of years ( )	(1) Does not work in the agricultural field
Question #98	• **Do you own or rent his land?**	1. Own 2. Rent	3. Other (*specify)*
Question #99	• **What is the total area of this plot of land?**	( ) acres	
Question #100	• **What is the size of the area that is actually being used for farming now?**	( ) acres	
Question #101	• **Is this the same area the same size you used to farm 10 years ago?**	1. Yes -> 103 2. No, less	3. No, more
Question #102	• **What caused this area to change in size?**		
Question #103	• **How much does this land produce?**		
Question #104	• **Who farms this land?**	1. Myself 2. My sons and I 3. I employ agricultural workers	4. I rent it to farmers 5. Other (*specify)*

Question #105	• **Do you have enough labor force or do you need more?**	1. Enough -> 107	2. Not enough
Question #106	• **Why don't you hire more labor force?**	1. Expensive wages	2. Other (*specify*)
Question #107	• **What do you harvest in this land? *(For the researcher: read the list)***	1. Vegetables 2. Crops like wheat, corn, etc. 3. Fruits	4. Feed crops 5. Other (*specify)*
Question #108	• **What cattle/poultry do you raise in the farm?**	(1) (2) (3)	
Question #109	• **Do you benefit from their products, or do you only use them for your family's consumption?**	1. I sell from livestock production on a large scale 2. I sell from livestock production on a limited scale	3. Only for family consumption 4. Other (*specify*)
Question #110	• **What agricultural tools do you have?**	**Manual → 112** 1. Axe 2. Scythe 3. Other (*specify*)	**Automatic: (specify the quantity)** 1. None 2. Tractor ( ) 3. Plow ( ) 4. Generator ( ) 5. Other (*specify*)
Question #111	• **What fuel do you use for the agricultural machines?** • ***For the researcher (find out if there are more)***	1. Diesel 2. Kerosene	3. Benzene 4. Other
Question #112	• **Do you use fuel/power for anything else in your farm/land?**	1. Yes. (What is the type and why is it needed)	2. No
Question #113	• **Do you get this fuel easily when you need it? (Regarding the quantity you need and the time when you need it)**	1. Yes → 115	2. No
Question #114	• **Why is it hard to get fuel?**		3.
Question #115	• **How much do you spend on average for fuel per month?**	( ) L.E. 1. No spending	4.
Question #116	• **Do your agricultural tools need periodic maintenance?**	1. Yes. Cost ( ) L.E. 2. No → 118	5.
Question #117	• **How often?**	1. Daily 2. Weekly 3. Monthly 4. Quarterly	5. Semiannually 6. Annually 7. Other (*specify*)
Question #118	• **How often do you irrigate the farm?**	1. Daily 2. Weekly	3. Monthly 4. Other (*specify)*
Question #119	• **What sources of water do you use for irrigation? *(for the researcher, find out what else?)***	1. Canal 2. Fountain	3. Other (*specify)*

Question #120	• **Has the place of your source of irrigation changed in the past 10 years?**	1. Further because 2. Closer because	3. Hasn't changed 4. Other (*specify)*
Question #121	• **Is irrigation water consistently available when you need it?**	1. Yes	2. No
Question #122	• **Is the water equally distributed between farmers on their lands?**	1. Yes	2. No
Question #123	• **Has the water quality changed in the past 10 years?**	1. Yes, because…….	2. No
Question #124	• **What problems do you face regarding irrigation?**	(1) (2)	
Question #125	• **Do you use any fertilizers?**	1. Yes	2. No
Question #126	• **What type of fertilizer do you use?**	1. Livestock Dung 2. Other (Please Specify)	
Question #127	• **Do you need more fertilizer than you get from the agricultural assosciation?**		
Question #128	• **Are these fertilizers safe?**	1. Yes	2. No
Question #129	• **Do you suffer from agricultural pests?**	1. Yes	2. No
Question #130	• **How do you get rid of them?**	1. Using pesticides 2. Fumigation	3. Other (Please specify)
Question #131	• **Do pest repellents affect the fertility of the soil?**	1. Yes	2. No
Question #132	• **How often do you use repellents/insecticides on your personal land?**	1. Semiannually 2. Quarterly	3. More than Quarterly 4. Other (Please specify)
Question #133	• **How do you get rid of agricultural waste?**	1. Burning 2. Dumping in canal	3. Other (Please specify)
Question #134	• **What effect has taken place on your land and your business in the past 10 years due to urban sprawling in the area around you? (For the researcher: find out how the farmer was affected both positively and negatively)**	1. Decrease in labour rate has led to a rise in wages 2. Sewage from nearby buildings has led to a decline in water quality 3. The amount of water reaching the land has decreased 4. It is more difficult for water to reach the land (takes more time) 5. It is easier to reach markets 6. It is easier to distribute the crop 7. The soil has been affected (.....) 8. Others (specify)	

Question #135	• **Have you been forced to change any of these to cope with the change that has happened through the last ten years?**	**Type of Crop** 1. Yes 2. No	**Irrigation Method** 3. Yes 4. No	**Fertilizer consumption** 5. Yes 6. No	**Labor** 7. Yes 8. No	**Other Changes** 9. Yes 10. No
Question #136	• **How has your daily life been affected by urbanization around your land?** • **(*noise, transportation, pollution, reaching markets, availability of services, etc…)***					
Question #137	• **Are there any other problems relating to agriculture?**	1. Yes		2. No		
Question #138	• **What are these problems?**					