Master Thesis in Geographical Information Science nr 68

Developing a GIS Model for the Assessment of Outdoor Recreational Facilities in New Cities
Case Study: Tenth of Ramadan City, Egypt

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Abstract

With population that exceeds 90 million inhabitants, Egypt is one of the large Arab developing countries where the government policies headed towards constructing new urban communities to absorb the vast increase in population. Although the physical planning of the new urban settlements took into consideration the existence of outdoor recreational services and facilities, the quality and adequacy of these services cannot be measured only by their presence. The study develops a Geographical Information Systems (GIS) model that acts as a decision support tool for the assessment of recreational facilities in new urban communities based on the dimension of physical geography. The model focuses on: sufficiency, accessibility and equity as indicators on their quality; Sufficiency (Ratio Model) based on national and international standards; Accessibility (LCPA Model) through pedestrians and mass transportation routes; and Equity Analysis Model based on the different residential classes. The study uses the capabilities of GIS especially the network analysis tools that enable measuring the pedestrian and mass transportation accessibility areas from a realistic approach. The model is applied on Tenth of Ramadan City, one of the first generation of new communities with a population of 430,000 inhabitants and can accommodate up to more than one million. The results show that the city suffers from lack of recreational facilities where the recreational facilities are sufficient for only one sixth of its population. The accessibility model implied that the number and distribution of recreational facilities in Tenth of Ramadan City (10RC) is inconvenient for users in addition to the high concentration of uses other than the residential use within the service areas of recreational facilities. The equity model implied that there is inequity in the distribution of the recreational facilities and that the low residential class buildings are in high need of new mass transportation routes in order to access the recreational facilities. The findings highlight a serious need to consider aspects of sufficiency, accessibility, and equity in the planning of future recreational facilities in Egypt’s new cities.

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List of Abbreviations

ESIS	The Egyptian State of Information Service
GIS	Geographic Information Systems
10RC	Tenth of Ramadan City
CAPMAS	Central Agency for Public Mobilisation and Statistics
NUCA	New Urban Communities Authority
EMA	Egyptian Meteorological Authority
GOPP	General Organization for Physical Planning
LCPA	Least Cost Path Analysis
COE	Council of Europe
EUC	European Urban Charter
WHO	World Health Organization
GWA DSR	Government of Western Australia – Department of Sports and Recreation
WMO	World Meteorological Organization

1. Introduction

1.1 Background

Egypt is one of the Arab developing countries with population that exceeds 90 million (CAPMAS 2015) and still expanding rapidly. Hence, the government policies headed towards constructing new urban settlements to absorb this vast increase. However, according to recent surveys, planning doesn’t take into consideration the needs of citizens, thus the good quality of Egyptian life has been lost (Adel 2011). Sesar (2005) highlighted the inexperience of the individuals who planned and designed the majority of the new Egyptian cities. She also implied that the help of experts who use modern and scientific technologies will be beneficial in order to enhance the deteriorated status of the new cities in need.

Presence and quality of public facilities is considered as one of the indicators on the quality of life in new urban settlements. Recreation has always been a valuable asset to human communities. It provides many environmental and social services that contribute to the quality of life. However, just the presence of recreational facilities cannot be considered the only indicator on their quality and adequacy. There are other parameters that can be measured to contribute in the process of assessing the quality of recreational facilities. Assessment parameters include levels of accessibility to the facilities, whether the total area of recreational facilities is sufficient in relation to the population number or who actually has the access to the recreational facilities.

Tenth of Ramadan City (10RC) – the study area – is one of the first generation of new cities in Egypt that were planned to host new civilized communities and contribute to the welfare and economic prosperity of citizens. Over the last 30 years, the city has developed as the largest industrial city in Egypt with population of 430,000 inhabitants (GOPP 2011) and can accommodate up to more than a million inhabitants. The city was planned to include a number of recreational facilities that followed the Egyptian standards for new urban settlements. The study attempts to give answers to questions about whether the standards used in the planning process took into consideration the distribution of recreational facilities in a way that ensures high levels of accessibility and equity for the different sections of the society.

This study used Geographic Information Systems (GIS) to measure the sufficiency, accessibility and equity of recreational facilities to the population in 10RC, thus giving indications on the levels of adequacy of recreational facilities to citizens. Network analysis is used to measure levels of accessibility to pedestrians as well as the users of public mass transportation. Socioeconomic characteristics of population are measured to determine levels of equity in the distribution of recreational facilities in the city. This might help the planners to assess the existing and future plans of new cities in Egypt periodically. The assessment process helps to enhance the quality of services presented to the public and therefore enhancing their quality of life.

1.2 Aim and Objectives of Study

The study aims at:

Developing a GIS model that can be used as a decision support tool for the assessment of outdoor recreational facilities in new urban communities, focusing on: sufficiency, accessibility and equity.

The GIS model is designed to meet the following specific objectives:

- Identifying the suitable methods and indicators for assessing outdoor recreational facilities efficiency in an attempt to answer the following questions:
  - Whether the recreational facilities total areas sufficient to the population as per the new cities planning standards or not and where does this stand in terms of international standards.
  - How easy could the population access the recreational facilities in new cities, i.e. the levels of accessibility to these facilities.
  - Who is really having access to recreation in new cities.
- Integrating the identified methods and indicators of the assessment of recreational facilities into a GIS model that is able to measure these indicators.
- Verification of the GIS Model through applying and testing it on a case study.

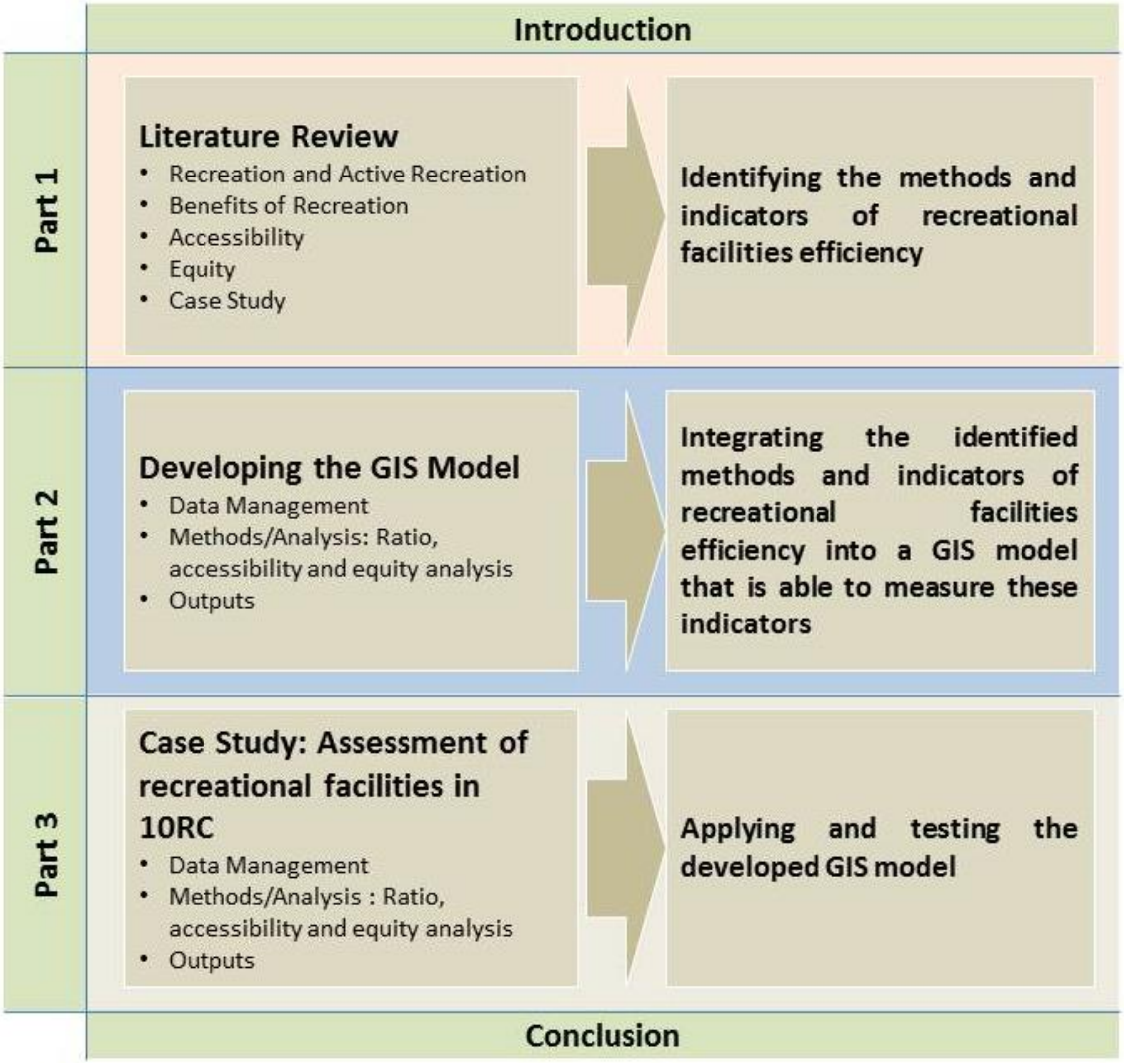

Figure 1 Structure of the study

2. Study Area

2.1 New Cities in Egypt

The Arab Republic of Egypt is located in the north-eastern corner of Africa and south –western Asia. It is bounded on the north by the Mediterranean Sea, on the east by Palestine and Israel, on the south by Sudan, and on the west by Libya. The total area of Egypt is nearly 1,001,450 square kilometers (ESIS The Egyptian State of Information Service 2017). The arable land area is about 2.87% of the total area where the majority of the population lives near the banks of the Nile River. Egypt's population reached 92 million living on just 5.3% of the country's area (CAPMAS 2015). The capital of Egypt is Cairo which is considered the largest city in Africa and the Arab world with population estimated to be around 9.5 million people and more than the double in Greater Cairo (CAPMAS 2015).

Figure 3 Egypt's location in Africa *(Adapted from (ESIS2017))*

Figure 2 Cairo's location in Egypt *(Adapted from (ESIS2017))*

After the revolution in 1952, the idea of establishing new agricultural communities in the desert began to emerge in order to utilize the excess water from the Nile after constructing the High Dam. In the seventies, an organized governmental planning of new urban settlements started. The New Urban Communities Authority (NUCA) was established in 1979 with the objective of creating new urban centers that act as absorbents to the population concentrated on the narrow strip of the Nile valley and along the banks of the river. This will help achieve community stability and economic prosperity through the extension of urban spines in the desert and remote areas (NUCA 2014).

According to NUCA (2014), New urban settlements could be classified in different ways. Dates of establishment, the economic base, and the relationship to the existing settlements are the most common perspectives of classification in Egypt. Three successive generations of cities were established according to the date of establishment with total of 24 cities (*figure 4*). According to the relationship with the existing settlements, new urban settlements can be classified into three categories: Subsidiary settlements, twin cities and independent cities (*figure 5*). Subsidiary settlements maintain their own services and limited economic capabilities; they aim at absorbing the population density of Cairo while depending on the big city economically. Twin cities are considered like extensions of existing cities and are established to absorb the population increase. Independent cities are established relatively far from existing cities in a way that supports their independency and provided with means of economic stability that reinforces their independence.

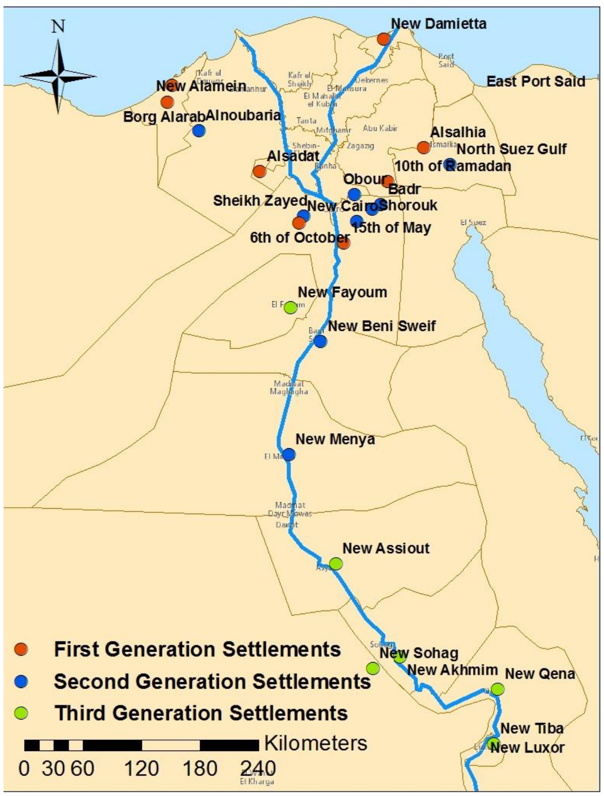

Figure 4 New planned urban settlements in Egypt classified according to generation *(Adapted from NUCA 2014)*

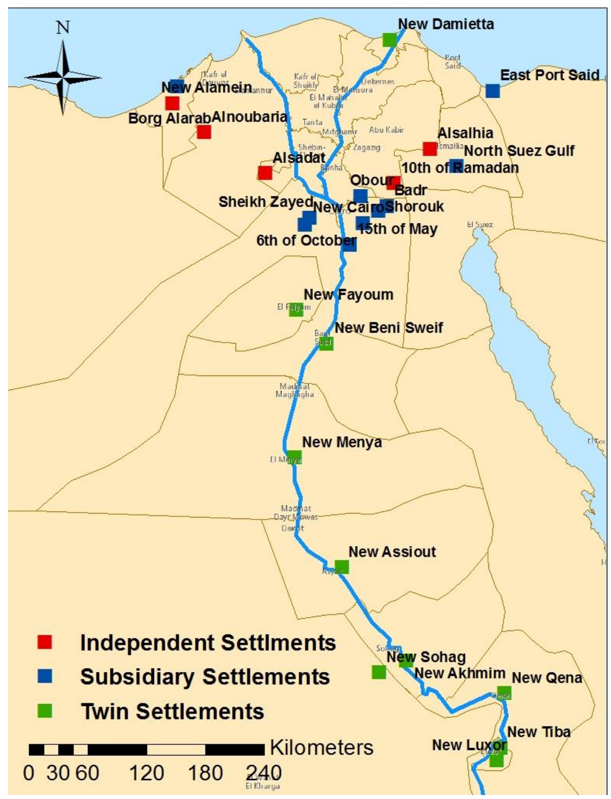

Figure 5 Types of new planned urban settlements in Egypt *(Adapted from NUCA 2014)*

2.2 Case Study Selection: Tenth of Ramadan City (10RC)

10RC was chosen as a case study for the following reasons:

- One of the oldest (first generation cities) and largest new cities planned by the Egyptian government that developed over the past thirty year (GOPP 2011).
- The largest industrial city in Egypt with more than 1700 factories, annual production of more than 28.7 billion EGP and employing about 225,000 workers (NUCA 2015b).
- One of the independent new cities (NUCA 2015b) which means that the city should achieve self-sufficiency from work opportunities, residency and services including recreational services.
- Relatively high population compared to other new cities.
- The environmental problems and pollution that emerged due to the rapid industrial growth in the city (Adel 2011).

2.3 Overview of the Case Study

Tenth of Ramadan city (10RC) was the first city in the first generation to be established in the year 1977 and has developed over the past 30 years as the largest industrial city in Egypt (GOPP 2011). It was aimed to be an integrated independent city with a strong economic base and a distinct location that is easily accessible from the four cities Cairo, Suez, Ismailia and Port Said (Adel 2011).

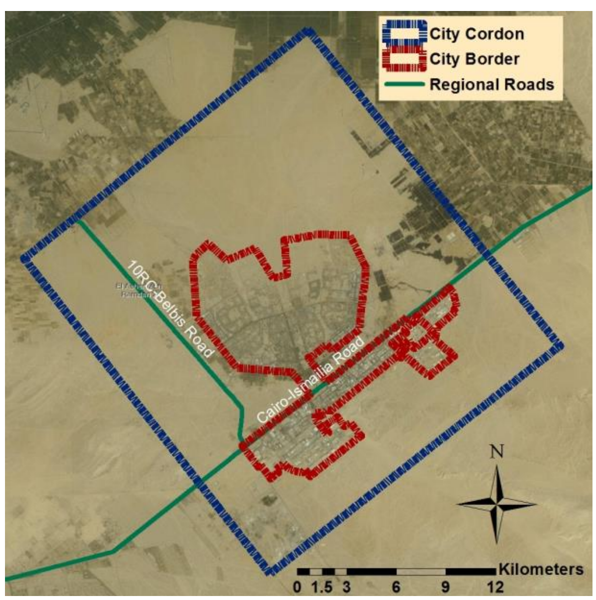

Figure 6 10RC cordon and border *(Adapted from Adel, 2011)*

Location

The city is located between latitude lines 30° 20‘N and 30 degree 30° 17‘N, and longitude lines 31° 37'E and 31° 50'E. The city is 55 km from Cairo and is connected to East Delta, Suez Canal and Sinai with a strong highway network.

Climate

The city’s climate is hot and arid which is characterized by the high disparity in temperatures between winter and summer. The temperature ranges between 13 to 21 degree Celsius minimum and 37 to 46 degree Celsius maximum in summer (from April to September); while in winter (from November to March) the temperature ranges between 6 to 9 degree Celsius minimum and 25 to 28 degree Celsius maximum. The humidity level ranges from 60% to 70%. The summer global radiation ranges from 940 to 1050W/m2, while it ranges from 550 to 750 W/m2 in winter. The monthly average precipitation of rainfall in this region ranges from 1 or 2 millimeter to almost no rain in summer and monthly average of 3 to 7 millimeters in winter with total annual precipitation of 26 millimeters (Climate Data 2017; World Meteorological Organization 2017; World Climate 2017).

2.4 10 of Ramadan City (10RC): The Planning

The city cordon was determined by the General Organization for Physical Planning (GOPP), Ministry of Housing, Utilities and Urban Development. The planning process for 10RC started in 1975 as a part of the first generation of New Cities which were established to alleviate the population increase from major cities and create more investment opportunities in different areas in Egypt. The total area of the city is 388 square kilometers of which 324 square kilometers are built up land that includes uses like: residential areas - services – industrial areas - tourism and recreation, etc. The city was planned to grow in four phases over the span of 25 years (1977 – 2002) (GOPP 2011), however, the 10RC plan has expanded with a new target year (2023) (NUCA 2015b), the master plan of the city is illustrated in figure 7.

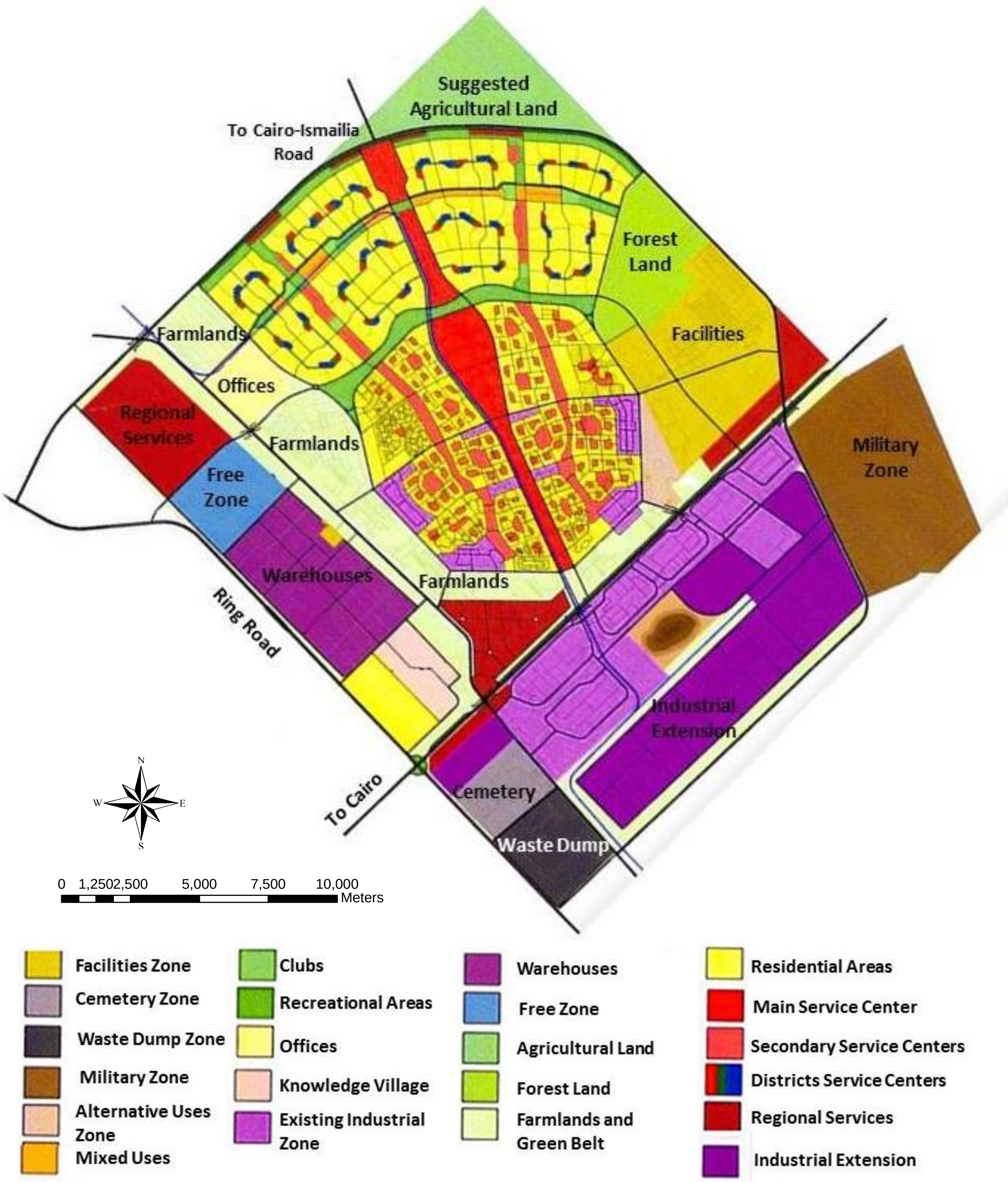

Figure 7 10RC Master Plan for the year 2023 (NUCA 2015b)

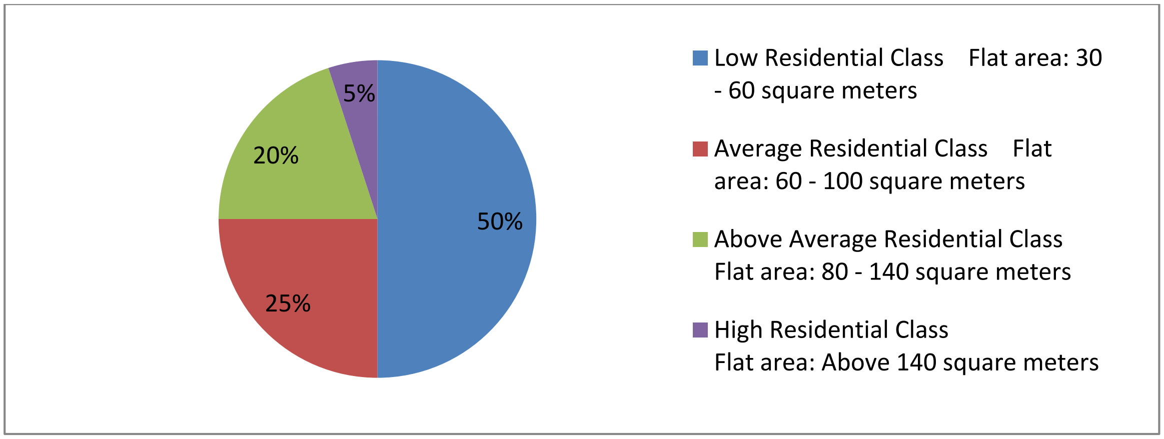

Figure 8 Percentages of residential classes in 10RC according to the master plan

The residential buildings in 10RC are established by both the governmental and private sectors in addition to the "Build your own house" project where the public are responsible of building their own houses (GOPP 2011). Figure 8 illustrates the types of residential units in 10RC and their percentages as aimed by the 10RC plan and areas of flats (apartments) in each class. The low residential class is aimed at the population with low income where the residential unit (flat) area is the smallest in all classes. Average residential classes target the population with average income where the residential unit (flat) area is bigger in area than the low class; but yet smaller than the above-average where the people with the above average income are targeted.

The city was planned in 1977 to achieve a desired population of around 500,000 inhabitants by the year 2002 (GOPP 2011), however, the 10RC plan was altered in 2015 to accommodate 2,300,000 inhabitant by the year 2023 (NUCA 2015b). 10RC has a current population of 430,000 inhabitants (NUCA 2015a). As illustrated in figure 7, the newly planned neighborhoods contain their own service centers that may or may not include recreational facilities. Since detailed plans of these new neighborhoods are not yet available, therefore, the study took into consideration the existing neighborhoods of the city; their current status and the potential population in case all of the city's current residential units are accommodated.

2.5 10th of Ramadan City (10RC): Current Status

10RC hosts about 1718 factories – in addition to 980 factories under construction – and annual production of more than 28.7 billion Egyptian pounds (NUCA 2015a) where the industrial development has exceeded the master plan expectations (GOPP 2011). 10RC originally aimed at housing all economic sections of the society, and at increasing the populated land in Egypt, but it has instead developed as an industrial city over time and the housing concentrated on the low and average cost segment (Adel 2011), in addition, a small percentage of the green belt had been cultivated and most of the spaces allocated to the green belt are vacant lands (GOPP 2011) and thus cannot be considered as recreational areas.

The report generated by the GOPP in the year 2011 has stated that the industrial development has exceeded the master plan expectations, where the number of labor had reached 60,000 at the end of planning period in 2002, and this number reached 225,000 by the year 2010. This increase in labor is considered to be more than 300% of what was required to be achieved at the end of planning period in 2002, and the demand on industrial land is still increasing. Figure 9 illustrates the current (2015) land use of 10RC; where it shows the vacant lands within the residential and the services zones, while the industrial zone barely has vacant lands.

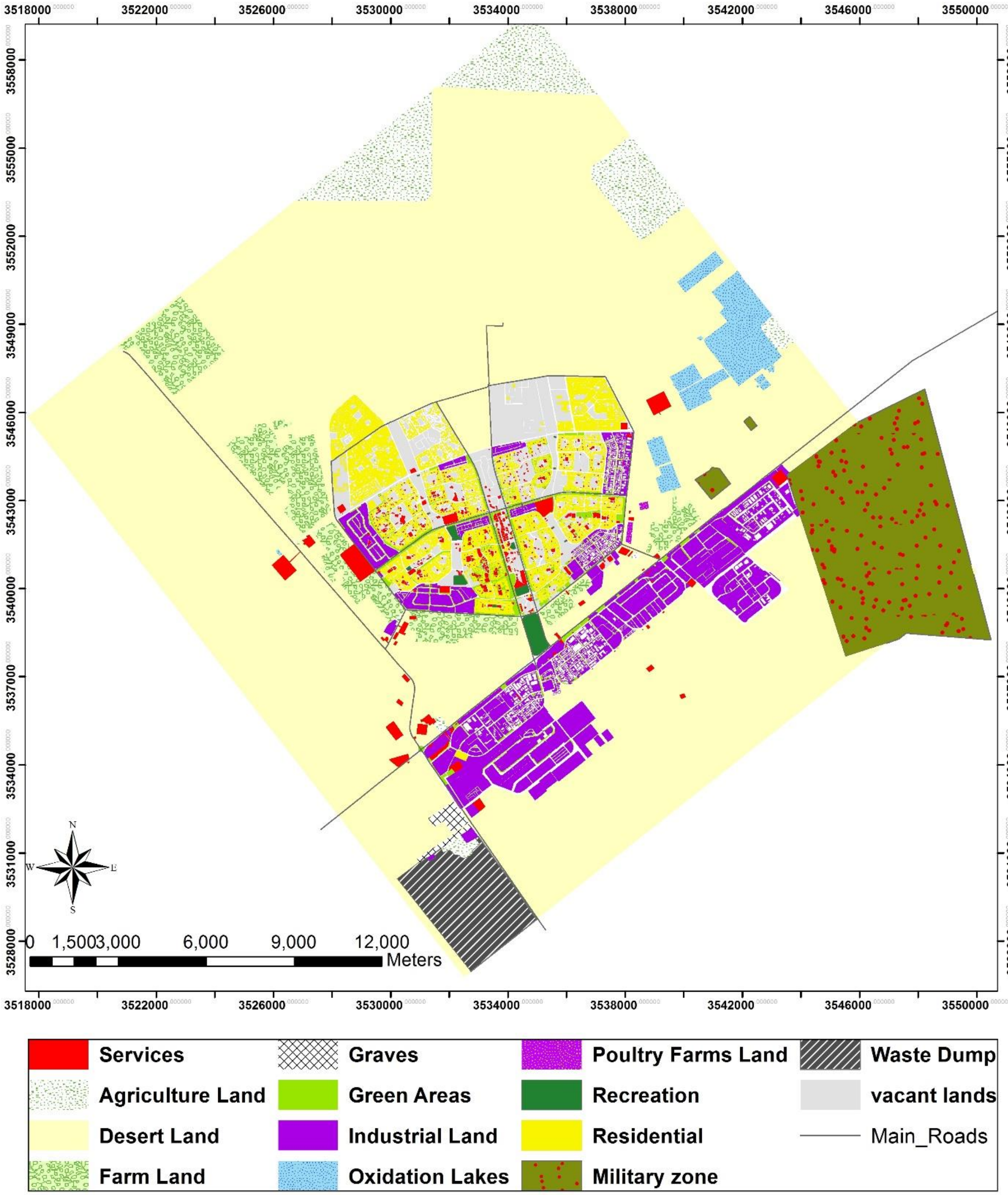

Figure 9 The Current Landuse Map of 10RC *(Source: updated from (GOPP, 2011)*

3. Literature Review

In order to identify the indicators and methods adequate for the measurement of the recreational facilities assessment, a review of the main concepts and definitions in addition to the previous related studies and researches is required. The definitions of recreation and active recreation in general and the concept of recreation in new cities in Egypt define the scope of the study. The benefits of recreation emphasize its importance as a service to be studied. Previous studies performed to assess or measure the quality of recreational services presented to the population and overviewing the indicators used in the assessment process lead to the selection of the indicators that are most convenient to use as parameters of assessment in Egypt.

3.1 Recreation and Active Recreation

> *"Recreation is an activity that people engage in during their free time, that people enjoy, and people recognize as having socially redeeming values" (Hurd and Anderson 2010)*

In order to satisfy individual and also societal requirements that gives fulfilment, joy and pleasure to people, play or recreational exercises are needed where the articulation of abundant energy is directed through socially adequate activities (Yukic 1970). Public organizations, non-profitable associations in addition to private entities powered by membership fees or commercial venues are all different entities that control and organize many recreational services (Yukic 1970). Recreational activities come in many forms; they can be indoor or outdoor, active or passive, private or public. In its glossary of urban planning terms, the General Organization for Physical Planning in Egypt defined Recreation as active recreation (GOPP 2004). The new cities in Egypt are planned by the NUCA (a governmental organization) and the urban terms and standards set by the GOPP are applied. Thus, when dealing with public services offered to people according to the master plan of any city, definitions and standards set by the GOPP are taken as a reference. In that case, the study focuses on the active recreation only as the definition of recreation in new cities in Egypt.

> *"Physical or "active" recreation is a physical activity that a person voluntarily undertakes in their leisure time for the purpose of mental and/or physical satisfaction. It is often associated with fun and play" (Pink 2008).*

Standards set by the GOPP for the active recreation in new cities in Egypt do not refer to the minimum radii required for the various categories of the recreational facilities. The standards state that the inhabitant share of recreational facilities should be 2.016 m^2. The standards also state that the recreational facility – regardless of its size – should serve 50,000 inhabitants (GOPP 2011). On the other hand, international standards differ from one country to the other, they even differ within the same country (Kafafy 2010). However, these different standards revolve around similar values and classifications. The national playing fields association in the United Kingdom sets a minimum standard of 24,000 km^2/1000 inhabitants; this standard should be achieved by the aggregation of the areas of the recreational facilities in the city. Steiner and (2012) elaborated the classification and standards of recreational facilities:

- Neighborhood Parks with areas ranging from 20,234 m^2 to 40,469 m^2

- Community Parks with areas starting from 161,874 m^2
- Large Urban Parks with minimum area of 202,340 m^2
- Regional Parks with areas starting from 2,023,428 m^2

And in the same context, DeChiara & Koppelman (1982) listed in their book *Urban Planning and Design Criteria* more detailed standards for recreational facilities which are generally applicable in typical conditions. *Please refer to Table 1*

Table 1 Standards of recreational facilities (DeChiara and Koppelman 1982)

Type of Facility	m^2/1000 Inhabitants	Size of Site: Ideal (m^2)	Size of Site: Minimum (m^2)	Radius of Area Served (m)
Playgrounds	6,070	16,187	8,094	800
Neighbourhood Parks	8,094	40,469	20,234	800
Playfields	6,070	60,703	40,469	2,414
Community Parks	14,164	404,686	161,874	3,220
District Parks	8,094	809,371	404,686	4,828
Regional Parks	60,703	2,023,428-4,046,856	Varies	16,100

3.2 Benefits of Active Recreation

Active recreation increases the fitness level and relaxation. It involves mainly physical activities which has various benefits:

Health and Wellbeing:

Regular and adequate physical activity contributes in:

- Increasing the muscular and cardiorespiratory fitness levels and relaxation (Pink 2008; WHO 2016)
- Reducing the risk of diseases such as cardiovascular disease, hypertension, coronary heart disease, stroke, type II diabetes, osteoporosis, breast and colon cancer, and injury (Bauman et al. 2002; WHO 2016)
- Facilitating better stress management, alleviating of depression and anxiety, strengthening of self-esteem and confidence, enhancing mood and boosting mental alertness (Bauman et al. 2002)
- Improving bone and functional health (WHO 2016)
- Reducing the risk of falls as well as hip or vertebral fractures (WHO2016).

- Fundamental to energy balance and weight control and reducing the risk of obesity (WHO 2016; Bauman et al. 2002)

Economic Benefits:

- Reducing health care costs (WHO 2016)
- Creating employment (DSR 2008)
- Supporting local business (DSR 2008)
- Reducing absenteeism due to health improvements (DSR 2008)
- Reducing crime. (DSR 2008)
- Increasing hedonic (property) value of properties near green spaces (Adel 2011)

Social Benefits (DSR 2008)

- Encouraging family and community connectedness.
- Improving social skills and networks.
- Reducing isolation and loneliness.
- Creating safer places/ communities.
- Contributing to better performing schools.

Environmental Benefits:

- Replacing car trips with walking and biking contributes in reducing traffic congestion, reducing air pollution, greenhouse emissions and noise pollution (DSR 2008).

And as active recreational facilities contain also areas of green spaces, Kafafy (2010) summarizes the environmental benefits of green spaces:

- Reduction of air temperature and urban heat island.
- Providing shade by trees.
- Active evaporation and glare reduction.
- Enhancing air quality: airflow and wind control, oxygen production and carbon dioxide reduction in addition to the reduction of air pollutants and particulates.

Other Benefits for organizations/ workplaces (DSR 2008)

- Increased morale.
- Better employee relations, improved team spirit and improved job satisfaction.
- Natural close up of nature and providing a sense of seasons while reflecting the character of locality (Kafafy 2010).

3.3 Measuring Efficiency (Quality) of Recreational Facilities

This study focuses on the use of GIS in assessment of the quality of recreational facilities with special focus on the city of Tenth of Ramadan as a case study. This can be achieved by measuring the levels of accessibility and equity for these facilities. From planning and management point of view, some components are crucial for an urban system to work efficiently, among those are the well-recognized components of accessibility and equity (Nicholls et al, 2001). Thus, these two specific parameters are focused on as indicators through the assessment process in order to improve people’s quality of life.

3.3.1 Accessibility

Within a city or region, the accessibility of its inhabitants to essential services is considered a reference for the quality of life of people. These services include outdoor recreational spaces, educational, medical and main public social services (Pred 1977). High or good access implies that a facility or service is easily reached; hence, ‘accessibility' is a measurable dimension that can refer to the level of opportunity or chance given to interact or contact with a certain phenomenon where the level of accessibility is directly proportional to the level of opportunity given (Johnston et al. 1986a; Harvey 2010).

Accessibility has more than one component, geographical (locational) and effective accessibility as proposed by Joseph and Phillips (1984). Geographical (locational) accessibility simply refers to the physical proximity of the recreational facilities which can be assessed using GIS analysis tools. On the other hand, effective accessibility includes more than one dimension such as the quality of the facility and its attractiveness, financial affordability, opening hours of the facility. Information on the factors of the effective accessibility can be collected through surveys on the satisfactions, motivations and expectations of users.

Many models have been used to measure the geographical (locational) accessibility. Stimson (1981) used the ratio models to calculate the number of facilities per population for different geographical zones. Lovett, Haynes, Sunnenberg and Gale (2000) used the least cost path analysis (LCPA) to measure the distance or time between population centers and facilities using the road network. Brabyn and Barnett (2004) used the allocation method where they added a capacity constraint on the facility to the LCPA. This constraint is added when the facility has booking systems or has limited number of users. Talen (1998) introduced the gravity/potential model, which is based on the principle of attraction to facilities where people are attracted to the facilities that provide better service. However, the attraction is inversely proportional with distance i.e. people’s interest in a facility decreases with the long distances taken to reach it. Space-time prisms were introduced by Huisman and Forer (1998) where the travel times are affected by traffic levels. People choose when to visit a facility according to the size of traffic on the roads leading to it. However, many other people choose to travel to facilities at the time of the high traffic “popular travel periods” where they contribute to this congestion. Van Herzele and Wiedemann (2003) conducted a GIS raster analysis to conduct the accessibility areas for green spaces in four Belgian cities taking into consideration physical barriers within a cost map. Oh and Jeong (2007) assessed the sufficiency of the urban parks of Seoul, North Korea to the population in addition to the accessibility to these parks via walking taking into account the barriers that prevent pedestrian movement.

It is important to integrate the factors of effective accessibility with the geographical component in the GIS processes (Brabyn and Sutton 2013), however, only the geographical aspect is covered in this study in addition to the indications on equity *(please refer to section 3.3.2)*. Levels of accessibility are measured by integrating ratio and LCPA models to identify number of population served by recreational facilities and the inhabitant share from these facilities; in addition, finding the serviceability areas of recreational facilities in the city using the road network.

3.3.2 Equity

The term equity generally refers to *"the fairness or justice of a situation or distribution"* (Johnston et al. 1986b). Questions about equity has been risen by many authors, questions about who gets what and who should get what in addition to questions about who bears the expenses (Laswell 1958; Nicholls and Shafer 2001). Equity is widely reflected in planning as in the distribution of resources in a way that fulfills a locational equity (Talen 1998).

Equity is different from equality. Equality means that all types of population have equal access to facilities. Equity on the other hand implies that the population with the higher need should have higher access to facilities. The need can be deduced from the economic classification of the population where the low income groups have the higher need for public facilities access. They depend on the public mass transportation in addition to the high density of the low residential class areas resulting in the lack of open spaces (Besler 2011).

Studies that addressed the accessibility have taken into consideration the geographical (physical) dimension only (Nicholls and Shafer 2001). Geographers highlighted the limitations of this approach where they emphasized the importance of taking the social and economic aspects of accessibility into consideration rather than thinking only of the physical aspect and profits, as the social and economic aspects affect the user directly (Nicholls and Shafer 2001). Land use in addition to the population density of the residential use within the service areas of recreation can be considered a sign of equity (Oh and Jeong 2007)

Nicholls and Shafer (2001) combined the accessibility and equity in one analysis. To measure the accessibility, they conducted a comparative study between the centroid radii analysis and the network analysis to show the areas served by local parks. On the other hand, in order to assess the degree of equity of their distribution, they based their study upon a comparison of the demographic characteristics of people inside and outside the service area. They used a basic, two-sample non-parametric test called the Mann-Whitney U. This was performed by comparing the median values of nine variables that are measured inside the neighborhood parks service areas as well as outside of them. The variables that the study was based upon included percentage of people from non-white races, percentage of black population, percentage of occupied rented housing, average contractual rental value, percentage of Hispanic population, average housing value, density of population, percentage of population under the age of 18, and percentage of population over the age of 64. According to the equity definition adopted by Nicholls and Shafer, inequitable distribution is found when there's no difference between the proportion of the need-based population inside and outside the service areas. On the other hand, distribution is considered equitable when the percentage of the population in need is higher within the service areas than they are outside of them.

In Besler's study (2011), equity was studied in terms of certain categories of population in need. The population in need included were chosen according to the socio-economic properties of the population, their population density and race. In order for her to measure the equity of Kansas

City population in terms of neighborhood parks, she measured three components of accessibility: gravity potential, minimum distance and travel cost. She applied a spatial autocorrelation where she used a two dimensional version of the time series problems and traditional autocorrelation illustrated by Comer and Skraastad-Jurney (2008). This spatial autocorrelation illustrates spatial relationships where the relationship is considered high – or highly correlated – when the values are close, on the other hand the relation is poor – or independent – if the values are irrelevant to each other. Besler's study concluded that most of the high need population experienced equity in terms of neighborhood parks, however, there were block groups who did not have access to those parks.

3.4 Identified Indicators and Methods

Scope of the study is defined according to the definition of recreation in Egypt. As recreation in Egypt is defined as active recreation (GOPP 2004), the study focuses on facilities that offer outdoor active recreation to the public. And since not all of the facilities are available for everyone to access, the study took into consideration the established public and semi-private *(please refer to section 4.2)* recreational facilities. Youth centers may or may not include indoor gyms and indoor sports (e.g. Ping Pong); and they are typically included within the youth centers' total areas. Youth centers within the city vary according to quality of service and condition, but since it is not the scope of the study, all the recreational facilities are considered in the calculations.

The study focuses on measuring the levels of accessibility and equity of recreational facilities as indicators on the quality of recreational facilities using GIS. These two parameters were chosen due to their importance as crucial components of assessing the quality of recreational facilities and thus the quality of life people are experiencing. (Nicholls and Shafer 2001), in order to improve people's quality of life. The study covers the geographical aspect in measuring the accessibility in addition to equity as the other aspects like capacity and gravity/potential would require more time, data and resources. Equity is measured in terms of the socioeconomic characteristics of population inside and outside serviceability areas of recreational facilities. Due to the lack of demographic information at small scale (residential clusters), social and economic characteristics of population in the city are resembled by the classes of the residential buildings. Percentage of each residential class area is calculated inside and outside serviceability areas of recreational facilities. Knowing the residential classes within the different serviceability areas of recreational facilities of the city could give indications on the level of equity received by the city's inhabitants. The low and average residential classes resemble the population with the lowest income who cannot afford to buy private vehicles and mainly depend on walking to facilities or using the means of public mass transportation in order to reach far places or in the situations where the climate gets hot and inconvenient for pedestrians. Hence, it is important that the low residential class buildings to be highly concentrated in the areas within walking distance or within the service areas of public mass transportation.

Although the built up residential buildings might not be fully occupied, the residential units within these buildings are owned by people. Since these building already exist and will be occupied by their owners at a certain time, all the residential units established are taken into account in the calculations of equity.

4. Methodology:

Developing the Assessment Model:

The purpose of the study is to use GIS in assessing recreational facilities with a model that is simple and as accurate as possible to be able to measure the sufficiency as well as accessibility and equity of recreational facilities in new urban settlements. This would give the opportunity to answer questions about the distribution or the locations of recreational facilities, as well as questions about who has access to these facilities and if there are areas that are in need of recreational facilities.

The focus of the methodology section is integrating the identified indicators of recreational facilities efficiency into a GIS model that is able to measure these indicators. In order to measure the levels of accessibility and equity of the recreational facilities which are considered as indicators on the efficiency of recreational facilities; three GIS models are applied. The first is the ratio model, which is used to calculate the number of facilities per population. The second is the LCPA (least cost path analysis), which is used to measure the accessibility of recreational facilities where the areas with high accessibility are elaborated. And the third model is the equity analysis model, which measures the socioeconomic characteristics of the population serviced by the recreational facilities.

4.1 Structure of Study

A detailed structure of the study is illustrated in figure10. A flow chart of the steps taken throughout the study starting from the literature review, the GIS part of the study and the conclusion is shown in the figure.

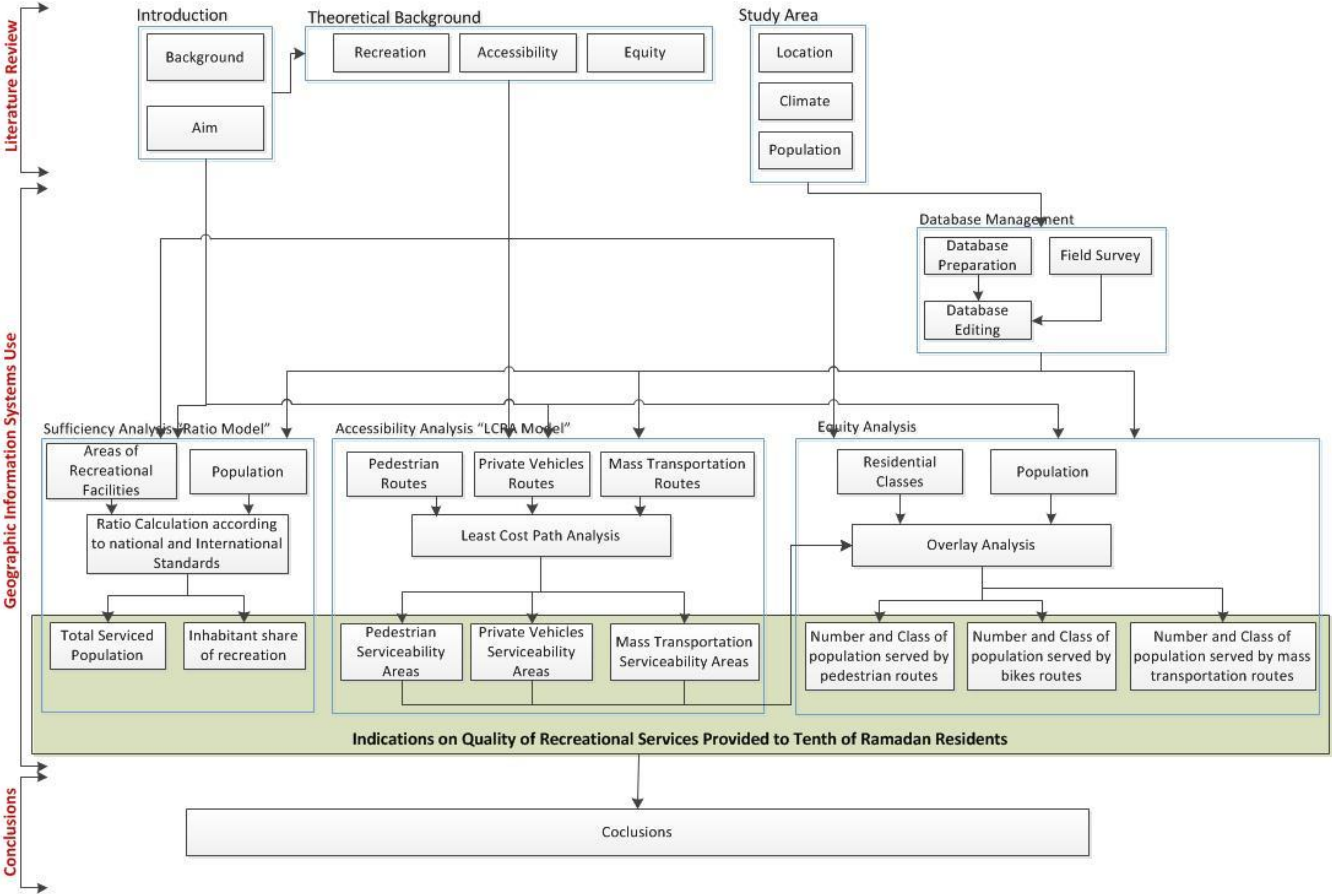

Figure 10 Framework of the study

There are three successive stages that the GIS model goes through in order to perform the analysis. Data management stage where the inputs of the model are entered, edited and checked. Data analysis stage, which is divided into three sub-stages, the first is measuring the sufficiency of recreational facilities areas for the population with respect to the national and international standards. The second is measuring the levels of accessibility to recreational facilities. And the third is the assessment of degree of equity based upon the accessibility levels deduced from the second stage analysis. The last stage of the model is representing the outputs in the forms of maps and graphs *(figure 11)*.

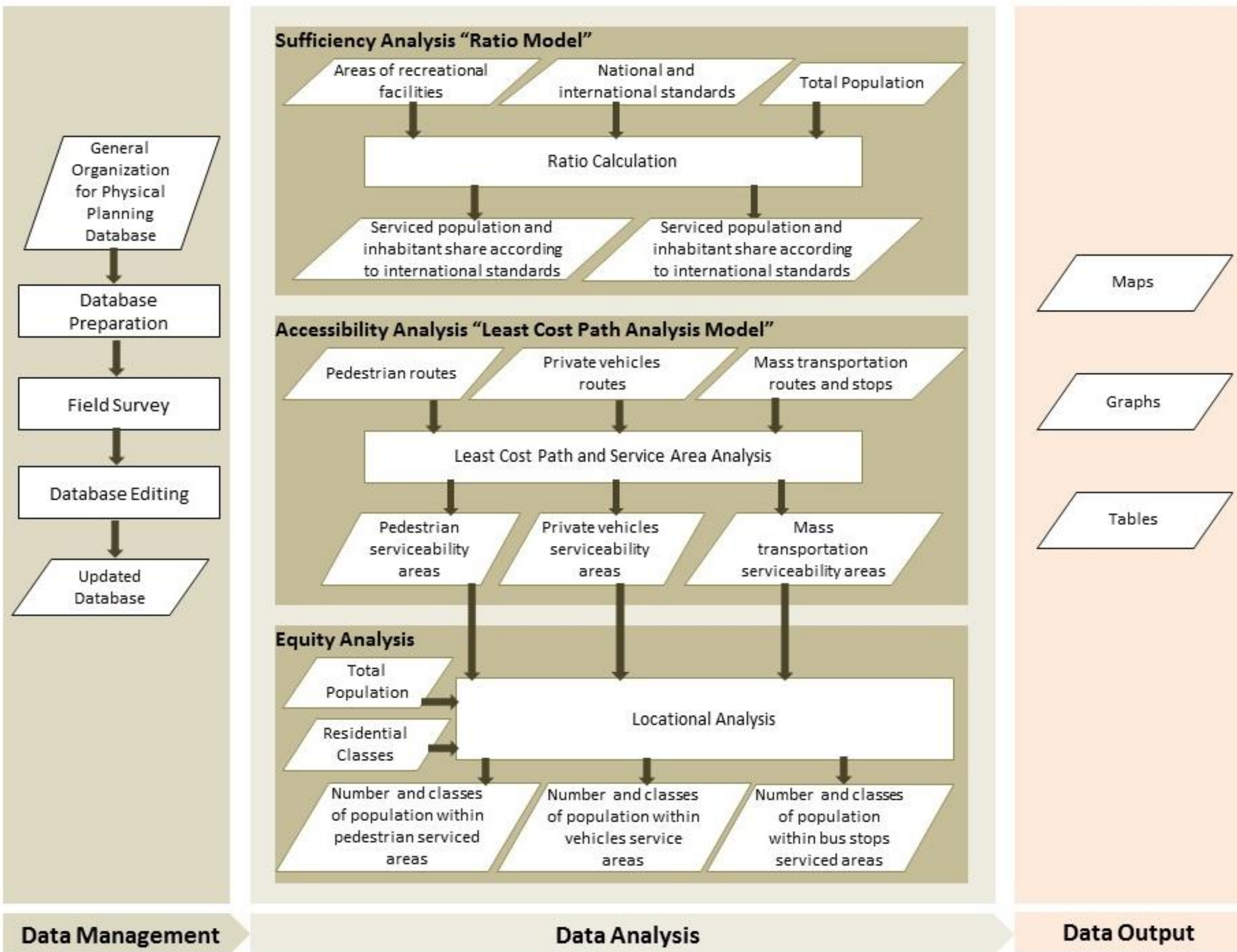

Figure 11 Stages of the GIS Model

4.2 Data Management/Inputs

Data management is the first and most important stage of a GIS model. The high accuracy of the data inputs enhances the results of the analysis process. Data management involves data acquisition, preparation and editing. Data acquisition involves gathering accurate data and information required for the analysis process. Data usually comes from different sources. It might come in different forms, digital or analogue. Digital data might come in different formats and different spatial references. Also, data acquired might not be up to date or missing information. Data preparation and editing is then required to prepare the data acquired for the GIS use. This involves unifying the formats of data by importing the digital data into a geodatabase, unifying the spatial references of the different layers, adding missing attributes and features, updating data, drawing essential layers needed for the analysis, unifying the attributes language and preparation of geometric networks.

Observations on new cities in Egypt revealed four types of recreational facilities: private, semi-private, special and public. Private facilities require relatively high initial and annual fees in order to be a member of these facilities and have the ability to access, the fees of the private facilities (clubs) vary according to the name and location of the club. Special facilities do not allow people of other professions to enter except with higher entry fees. Semi-private facilities (named in Egypt as Youth Centers) can be referred to as "Playgrounds" or "Neighborhood Parks" depending on whether they serve a neighborhood or a district. This can be known by Semi-private facilities require low annual and entry fees. They are named semi-private as they are not fully public, but still, their fees are low – around 500 Egyptian pounds (55 US Dollars/year) for the whole family – that makes them affordable for most people. Public facilities allow public access with very low – 5 to 10 Egyptian pounds (0.5 to 1 US Dollars for an entrance ticket) – or without fees.

To perform such a study, a geodatabase is needed with the feature classes (layers) illustrated in table 2. The spatial reference of the feature classes are unified to the global projected coordinate system (UTM) Universal Traverse Mercator, zone 36 north. It is defined on the ArcGIS software with the name "WGS 1984 UTM Zone 36N".

Digital data of new cities are provided by the GOPP. Updates are performed by the researcher through field surveys, satellite images imbedded in GIS software as base maps or Google earth and minor interviews with the city's residents. Missing information and updates are performed manually after acquiring the needed updated data.

Table 2 Feature Classes of the geodatabase required for the study

Feature Class	Attributes	Source
Land Parcels	Use, Name, Construction_Type, No_of_Floors, Condition	GOPP
Buildings	Use, Name, Construction_Type, No_of_Stories, Condition, Residential_Class, Landuse_Pattern	GOPP
City Border	----	GOPP
City Cordon	----	GOPP
Districts	Name	GOPP
Neighbourhoods	Ditsrict_number, Neighborhood_number	GOPP
Roads	Name, Condition, Width	GOPP
Paths of mass trasportation	Paths, No_of_local_buses	GOPP
Bus stops		Researcher
Pedestrian Network		Researcher
Recreation	Name, Type	GOPP
Recreational facilities entrances	Name, Type	Researcher

In order to perform the ratio and equity analysis illustrated later in sections 4.3.1 and 4.3.3 respectively, data acquisition is required for the national planning standards, the percentage of recreational services from the total area of the city and population estimations based on the average number of units (flats) in a floor for each residential class and the average number of family members. This kind of data are retrieved from the GOPP reports and databases.

4.3 Methods/Analysis

The GIS analysis stage is the stage where the assessment process takes place. It is divided into three main sub-stages. The first is ratio analysis, where the areas of recreational facilities are analyzed to conclude if these areas are sufficient to the population number or not. The second is the accessibility analysis (LCPA), where levels of accessibility to recreational facilities are measured. And the third is the assessment of degree of equity based upon the accessibility levels that will be deducted from the accessibility analysis.

The total population number that will be used throughout the study will be estimated by calculating the number of residential units (flats), thus number of families that the city can accommodate (population capacity).

*Number of flats in each residential class = Number of floors * average flats per floor in that class*

*Total number of population = Number of flats * average family members*

4.3.1 Ratio Model

To measure the sufficiency of recreational facilities for the population in a new city or to measure if there are enough recreational facilities for the population in the city, a ratio model is developed taking into consideration the national and international standards of recreational areas *(please refer to figures 12 and 13)*.

First: Comparing with National Standards

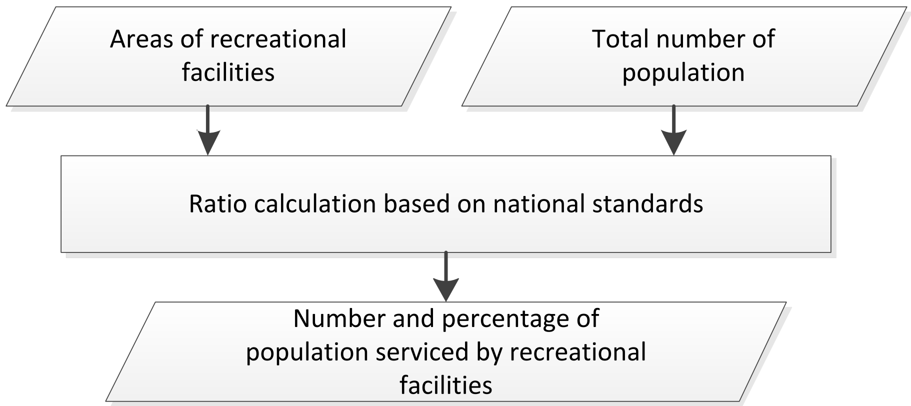

Figure 12 Flow chart of the ratio model based on national standards

The actual inhabitant share of recreational services offered to the public is calculated through this model and thus compared with the national standards set by the GOPP for new cities, and also the process is reversed where calculations are made to show the actual number of population served if we take into account the standard inhabitant share of recreation. In addition, the actual percentage of recreational services in the new city is calculated from the total area and compared with the national standards.

Percentage of recreational areas *(A_p) in (m^2)* from the total area of the city is deduced using the following formula:

$\boldsymbol{A_p = A_f * 100 / A_c}$
Where, A_f = Total area of recreational facilities (m^2)
A_c = Total area of the city (m^2)

The ***actual inhabitant share*** *(I) in (m^2)* is calculated using the following formula:
$\boldsymbol{I = A_f / P_t}$
Where, A_f = Total area of recreational facilities (m^2)
P_t = Total population of the new city (inhabitants)

The ***population*** served by the recreational facilities *(P_s) (inhabitants)* in terms of the standard inhabitant share *(I_s) in (m^2)* is calculated using the following formula:
$\boldsymbol{P_s = A_f / I_s}$
Where A_f = Total area of recreational facilities (m^2)

Second: Comparing with International Standards

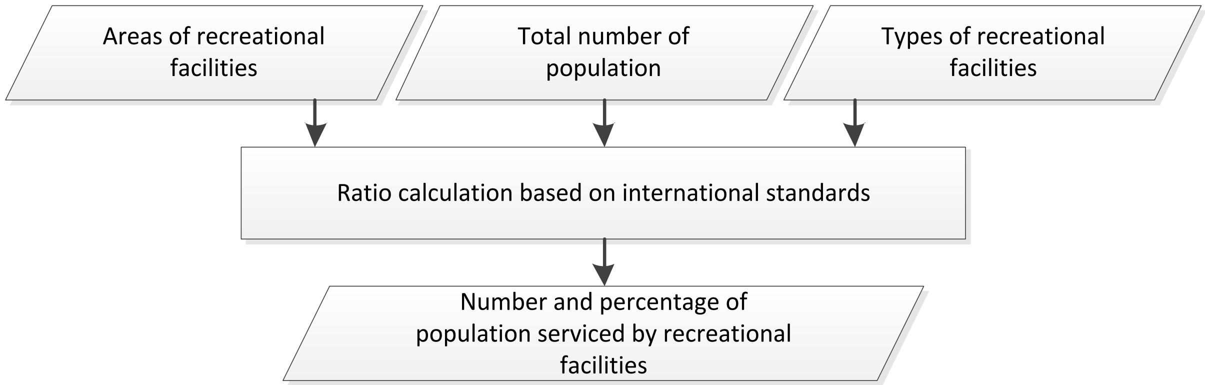

Figure 13 Flow chart of the ratio model based on international standards

Based on the classification illustrated by DeChiara and Koppelman (1982) to the recreational facilities; the recreational and sports facilities in the study area are classified to illustrate which category each facility falls in: playgrounds, neighborhood parks, playfields, community parks, district parks, or regional parks *(Please refer to Table 1 illustrated in section 3.1)*. DeChiara and Koppelman (1982) set a standard area for each type of recreational facility per 1000 inhabitants. To deduce the actual population served by the recreational facilities the following formulas are used for each recreational facility:

$\boldsymbol{I_f = A_s / 1000}$

Where I_f = the international standard inhabitant share (m^2)

A_s = area of the recreational facility for each 1000 inhabitant referred to in Table 1 (m^2)

$\boldsymbol{P_f = A_r / I_f}$

Where P_f = Actual population served by the recreational facility (inhabitants)

A_r = area of the recreational facility (m^2)

I_f = the international standard inhabitant share (m^2)

The previous formulas are repeated for each recreational facility where A_s varies according to its type. The population served is then summed up to deduce the total number of population served by the recreational facilities within the study area.

4.3.2 Accessibility Analysis, LCPA “Least Cost Path Analysis”

This section of the study aims at measuring the levels of accessibility of public and semi-private recreational facilities in new cities using the capabilities of GIS. Service areas and accessibility can be easily measured using the simple radii method where a circle is drawn around the facility with the desired radius to determine its serviceability area. However, this method is not accurate for many reasons as it does not take into consideration the actual distance travelled by the user to reach this facility, doesn’t take barriers into account like rivers and railroads and it measures the distance from the centroid of the facility not the boundaries (access points) (Nicholls and Shafer 2001). Network analysis in GIS takes into account these inaccuracies by measuring the distance travelled by users on actual routes from the recreational facilities points of access towards the residences. The appropriate distance, depending upon the type of facility can be measured to or from each of the access points to each of the facilities and then combined to form one aggregate service area. The “Network Analyst” software extension of the ArcGIS software is used to perform the network analysis.

In most zones of the country, whether to walk to a facility or deciding on taking other transportation service may highly depend on the weather conditions as walking in the hot days of summer gets inconvenient. Not only the weather conditions determine the mean of transportation, other factors could contribute to one’s choice to go by car, bus or on foot such as health issues or any other reason. Thus, to measure accessibility, the study took into consideration not only the pedestrian routes to the recreational facilities, but also two means of transportation were considered (private vehicles and mass transportation routes).

A point to be taken into consideration is the percentages of buildings uses within the different types of serviceability areas. Sometimes other uses like the industrial or utilities exist significantly inside the serviceability areas where the residential use should be more concentrated. Such an issue has to be highlighted in order to evaluate the efficiency of the recreational facilities distribution.

Service Areas of the Recreational Facilities in New Cities

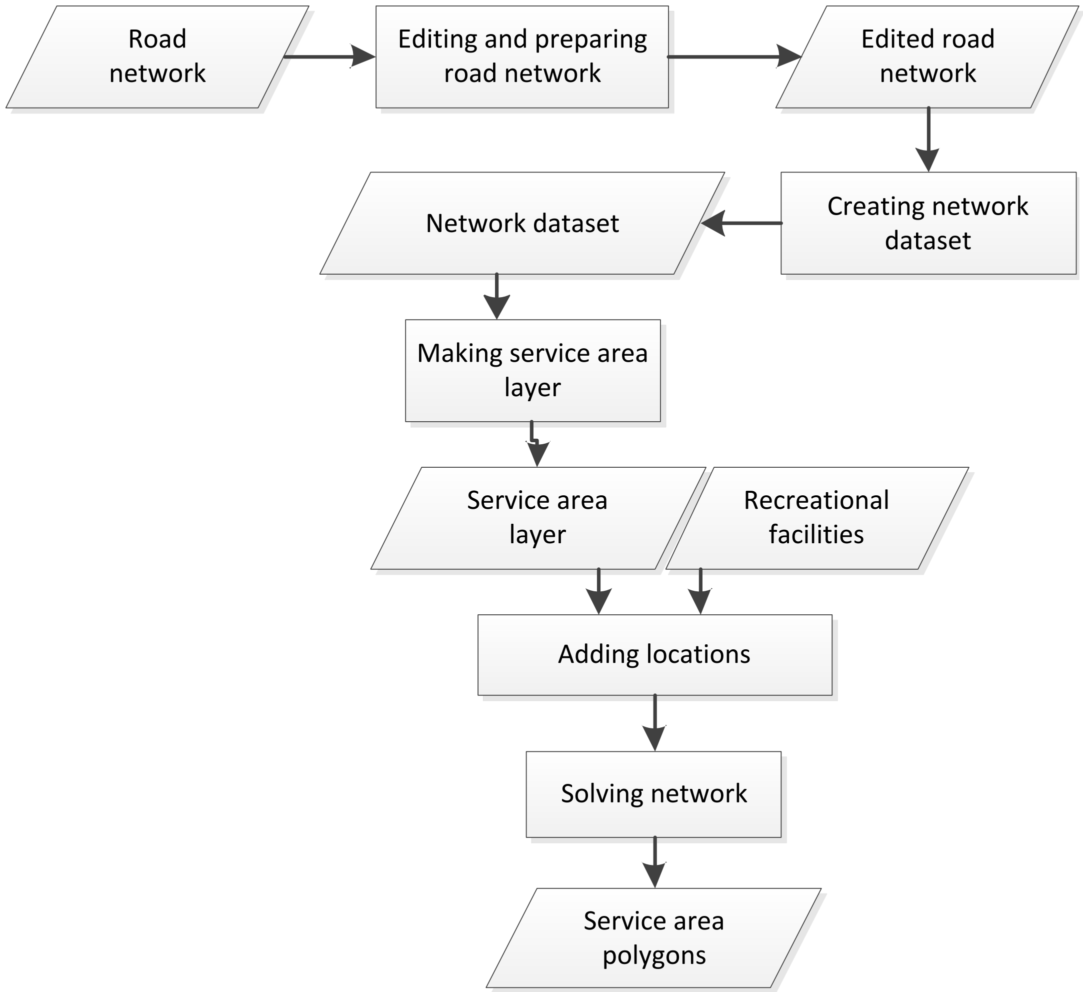

Figure 14 Flow chart of the accessibility model – deducing service areas of recreational facilities

Not all the recreational facilities have the same radius of service areas. Service areas differ according to the type or category of the recreational facility *(Please refer to Table 1)*.

Figure 14 illustrates the work flow for the process of deducing the service areas of recreational facilities using the network analyst, extension of the software ArcGIS. Service areas are conducted for the recreational facilities depending on the facility category; each category has a service area with corresponding service area radius. 800 meters service areas are conducted for playgrounds and neighborhood parks, 2414 meters for playfields, 3220 meters for community parks, 4828 meters for district parks *(please refer to Table 1)*.

Pedestrian Service Areas of the Recreational Facilities in New Cities

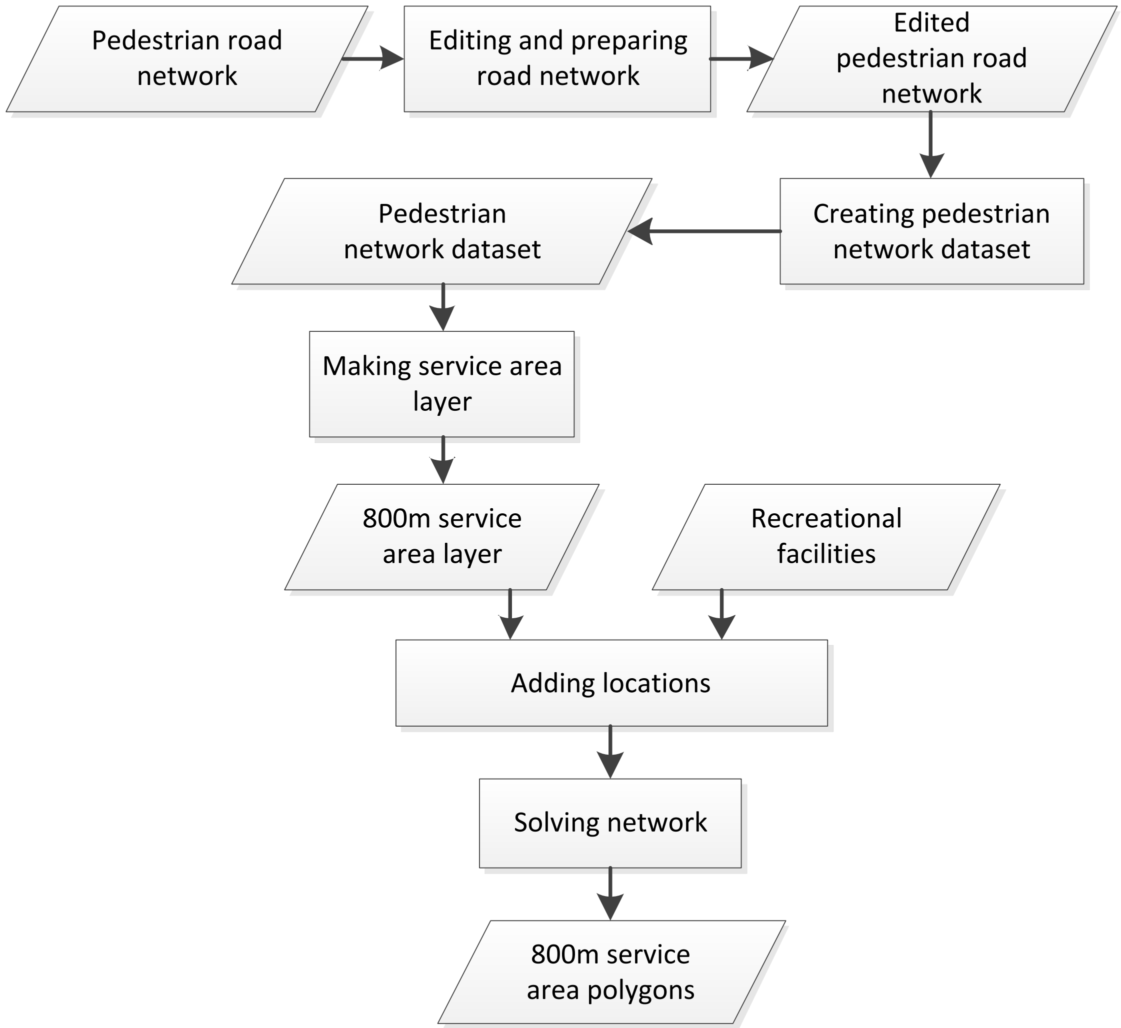

Figure 15 Flow chart of the accessibility model – deducing pedestrian service areas of recreational facilities

Figure 15 illustrates the work flow for the process of deducing the pedestrian service areas of recreational facilities using the network analyst, extension of the software ArcGIS. As the neighborhood parks act as the most basic unit of the local park system serving as a recreational and social destination to the neighborhood (Nicholls and Shafer 2001), their locations should not be more than one half mile i.e. approximately 800 meters in distance from users, "uninterrupted" by non-residential roads or other physical barriers (Mertes et al. 1995). This lines with the service areas illustrated by DeChiara and Koppelman (1982) for the playgrounds and neighborhood parks. Other categories of recreational facilities serve larger radii; however, the analysis at this stage involves all the established public and semi-private recreational facilities in the study area in order to deduce all the areas served by pedestrian routes for all the categories of recreational facilities.

Public Mass Transportation Routes

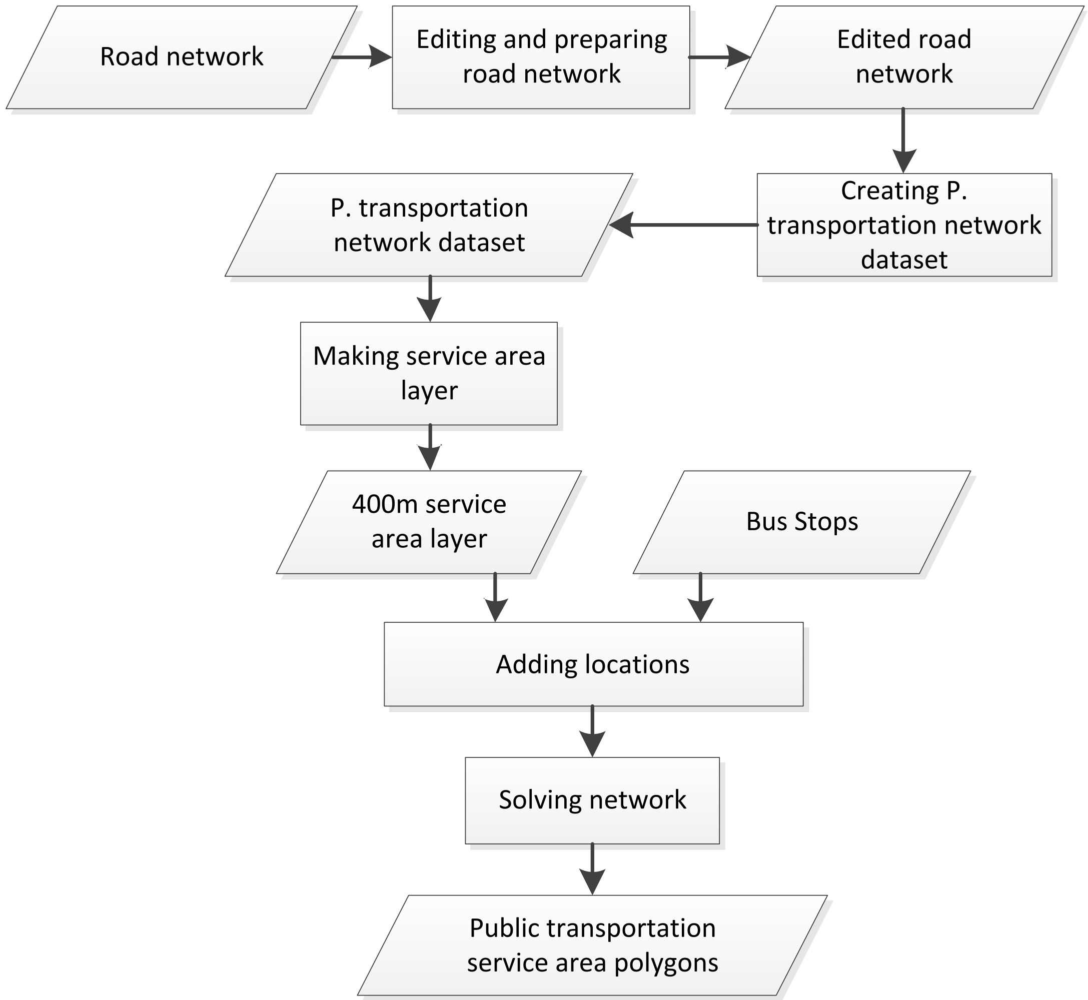

Figure 16 Flow chart of the accessibility model – deducing public mass transportation service areas

Figure 16 illustrates the work flow for the process of deducing the public transportation service areas of recreational facilities using the network analyst, extension of the software ArcGIS. Paths of mass transportation are required at this stage in the analysis where bus stops are allocated. Each recreational facility is checked if it is crossed by one or more paths. Bus stops are drawn where they are distributed along the paths approximately every 400 or 450 meters. Since the bus stops are the actual locations where users access the mass transportation (Mavoa et al. 2012), they were taken as the locations in the network analysis. To compute the service areas of the mass transportation routes, a 400 meters walking distance from the bus stops to homes and similarly to recreational facilities were considered regardless of the length of the bus ride (Niyonsenga and Zuidgeest 2014). Unlike the pedestrian service areas, the bus stops are chosen as locations in the network analysis in order to compute the mass transportation service areas. The whole recreational facility is considered accessible if one or more of its entrances falls into the buffer of the mass transportation service areas.

Private Vehicles Service Areas of the Recreational Facilities in New Cities

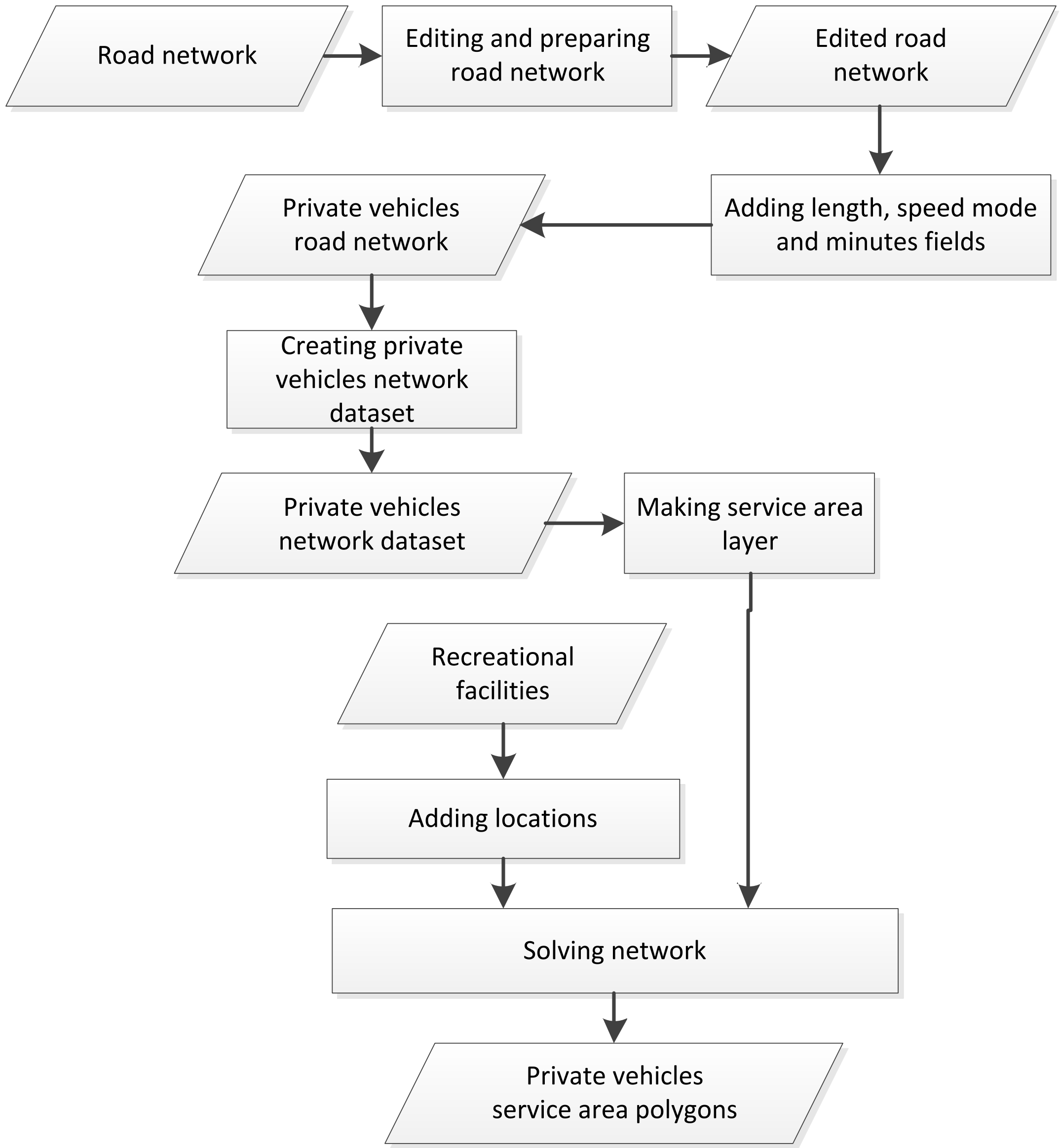

Figure 17 Flow chart of the accessibility model – deducing private vehicles service areas

Figure 17 illustrates the work flow for the process of deducing the private vehicles service areas of recreational facilities using the network analyst. To determine the service areas of private vehicles, ArcGIS network analyst was used. The previous network analysis performed to deduce the pedestrian and mass transportation service areas of recreational facilities was distance based as walking requires physical effort that is directly proportional to the distance covered. Unlike the distance covered by vehicles, the network analysis for the private vehicles was time based. Time needed to travel a certain road was taken as impedance and three service polygons were produced: polygons within three minutes, six minutes and nine minutes' drive. The three thresholds are chosen with regard to the distance travelled from the recreational facilities to the furthest point in the city, the speed limits of the roads and thus the time taken to travel from a facility to any point in the city.

4.3.3 Equity Analysis Model

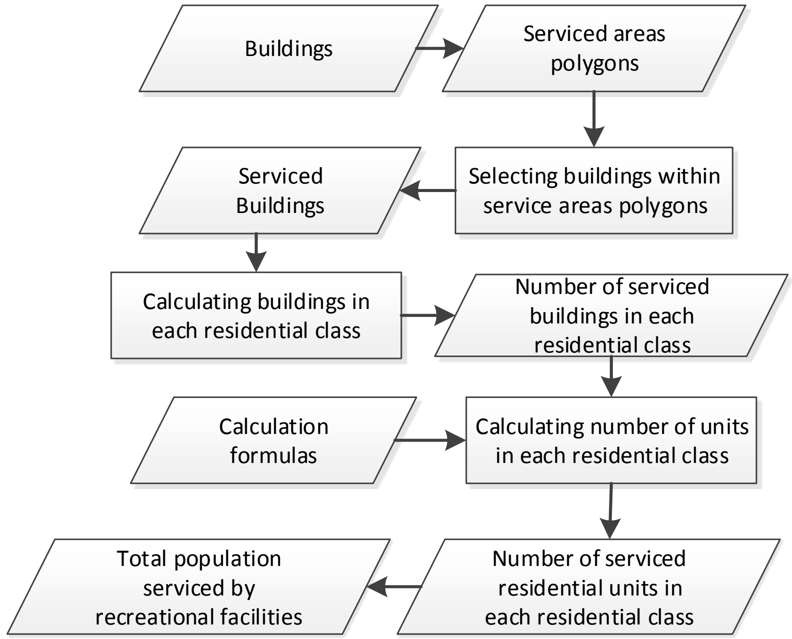

Figure 18 Flow chart of the equity model

Figure 18 illustrates the work flow for the process of deducing the characteristics of the population within the serviceability areas of recreational facilities. Due to the lack of demographic data on the neighborhood scale, concluding the number and type of residential buildings within each of the recreational facilities serviceability areas is done using locational analysis and thus, the number of floors in each residential class can be deducted. Residential classes are used in the calculations to reflect the residents' income level. The class of the residential unit was assumed to be an indicator on the economic level of the population as the price of the residential square meter varies according to the residential class. Residential classes are mapped showing the total number of floors in each class. Thus, total number of population capacity and their classes are estimated taking into consideration the average number of residential units (flats) in each residential class.

Population capacity of the current residential buildings is estimated based on the estimation of number of residential units (flats) in each class depending on the data available which is the number of floors in each residential class and the average number of residential units (flats) in each residential class in the study area.

The average number of residential units per floor *(A)* is known for each residential class through an interview with the staff of the study area's authority during the field visit.

Number of residential units (flats) for each residential class inside the serviceability areas *(N_i)* is calculated using the following formula where it is repeated for each residential class:

$$\boldsymbol{N_i = N_s * A}$$

Where, N_s = number of floors inside the serviceability layer

A = the average number of residential units per floor

The average number of population for each residential class within the serviceability areas *(P)* is calculated using the following formula:

$$\boldsymbol{P = N_i * F}$$

Where, N_i = Number of residential units inside the serviceability area

F = average number of family members in this region of the country

Number of residential units (flats) for each residential class outside the serviceability areas *(N_o)* is calculated using the following formula where it is repeated for each residential class:

$$\boldsymbol{N_o = N_t * A}$$

where, N_t = number of floors outside the serviceability layer

The average number of population for each residential class outside the serviceability areas *(P_o)* is calculated using the following formula:

$$\boldsymbol{P_o = N_o * F}$$

Where, N_o = Number of residential units outside the serviceability area

F = average number of family members in this region of the country

The calculations in the equity model are performed taking into consideration the population capacity of the buildings established in the study area at the time the research is performed. This is because these buildings are already established and owned by people, thus they can be fully accommodated at a time.

There would be indications on equity if the percentages of flats of the low and average residential classes are higher inside the pedestrian and public transportation serviceability areas of recreational facilities than they are outside of them. The opposite will indicate inequity as these two classes accommodate population where the majority do not own private vehicles and mainly depend on public transportation and walking.

4.4 Outputs

The outputs of the models applied through the study vary between maps and graphs. Type of output is chosen to better present the results of the model so they can be easily analyzed and discussed.

The results of the ratio model are represented by graphs and tables. Graphs in the ratio model show the percentage of population serviced by recreational and sports facilities from the current population in the study area based on national and international standards. They also show the difference in the inhabitant shares of recreational facilities according to national and international standards as well as the population served by recreational and sports facilities in the study area. Tables show the types of recreational facilities in the study area and the population served by these facilities.

The accessibility model results are best represented by maps which give visualization of the areas of serviceability of the different kinds of recreational facilities. Maps show the pedestrian, public transportation and private vehicles serviceability areas relative to the whole study area. Graphs in this model show the percentages of the service areas of recreational facilities from the total built up land in the study area. Tables also hold the information about the percentages of the building uses within the serviceability areas where they're represented afterwards in graphs for better visualization.

The equity model gives an idea on who gets a better access to the recreational facilities. Classification of residential use (residential classes) inside the serviceability areas is presented in maps. Results of the equity model formulas are represented in tables and graphs.

5. Results: Assessment of Recreational Facilities in 10RC

This section focuses on the implementation of the methodology deduced for the measurement of the recreational facilities efficiency. This will give the opportunity to test the deduced methodology and reviewing the outputs of the GIS models introduced.

5.1 GIS Software

The software used in the study is ArcGIS 10.1 Desktop and the network analyst extension that is embedded inside the software.

5.2 Data Management

5.2.1 Data Acquisition

Digital data was provided by the GOPP in the form of a Personal Geodatabase as a part of a full report performed in the year 2011. The spatial reference of the feature classes in the GOPP geodatabase was defined as the global projected coordinate system (UTM) Universal Traverse Mercator, zone 36 north and it is defined on the software (ArcGIS Desktop) with the name “WGS 1984 UTM Zone 36N”. The Geodatabase contained the following feature classes illustrated in Table 3:

Table 3 Feature Classes of the 10RC database (GOPP, 2011)

Feature Class	Attributes
Land_Parcels	Use, Name, Construction_Type, No_of_Stories, Condition
Buildings	Use, Name, Construction_Type, No_of_Stories, Condition, Residential_Class, Landuse_Pattern
City Border	----
City Cordon	----
Districts	Name
Neighborhoods	Ditsrict_number, Neighborhood_number
Lithology	Lithology
Roads	Name, Condition, Width
Paths_mass_trasportation	Paths, No_of_local_buses

5.2.2 Data Preparation and Editing

The database was generated in the year 2010 and was updated and edited by the researcher using institutional data and field surveys in June 2014. The updates and edits included:

- Translating the attributes from the Arabic language to the English language.
- Updates on the Housing (number of buildings implemented and types of residential classes). New Buildings were digitized using Google Base Map embedded inside the GIS application (ArcGIS Desktop) and the attributes were edited manually after field visits.
- Preparing a geometric network as a basis for the network analysis (vehicles routes) by validating the roads connections.
- Creating a feature class for the pedestrian routes. Vehicles routes were used as a base and appended with pedestrians paths observed. Pedestrians use narrow paths that are not suitable for vehicles in addition to the paths through the urban spaces between residential buildings.
- Creating a “bus stops” point layer. Bus stops were drawn along the routes of Mass Transportation. Bus stops were drawn according to their location every 400-450 meters.
- Creating a point feature class for the facilities entrances.

Non-spatial data are collected in the field such as the established buildings and the average residential units (and thus families) in each residential class. This helps in concluding the number of flats existing in each class and thus the population can be estimated.

5.3 Implementation of Methodology (Analysis) and Results

As discussed in section 4.2, there are four types of recreational facilities in new cities, private, semi-private, special and public facilities. 10RC contains the four types of recreational facilities. Since not all of the facilities are available for everyone to access, the study took into consideration the established public and semi-private recreational facilities.

Tenth of Ramadan city contains 14 recreational facilities, 8 youth centers (semi-private), 3 clubs in addition to the engineers and police officers clubs and Al Kafrawy garden. 13 facilities are established leaving only the police officers club non-established *(please refer to figure 19).*There are four types of recreational facilities in 10RC: private, semi-private, special and public *(please refer to table 4)*. Since not all of the facilities are available for everyone to access, the study took into consideration only the established public and semi-private recreational facilities which removes from the calculations the Engineers special club and AlRowad private club.

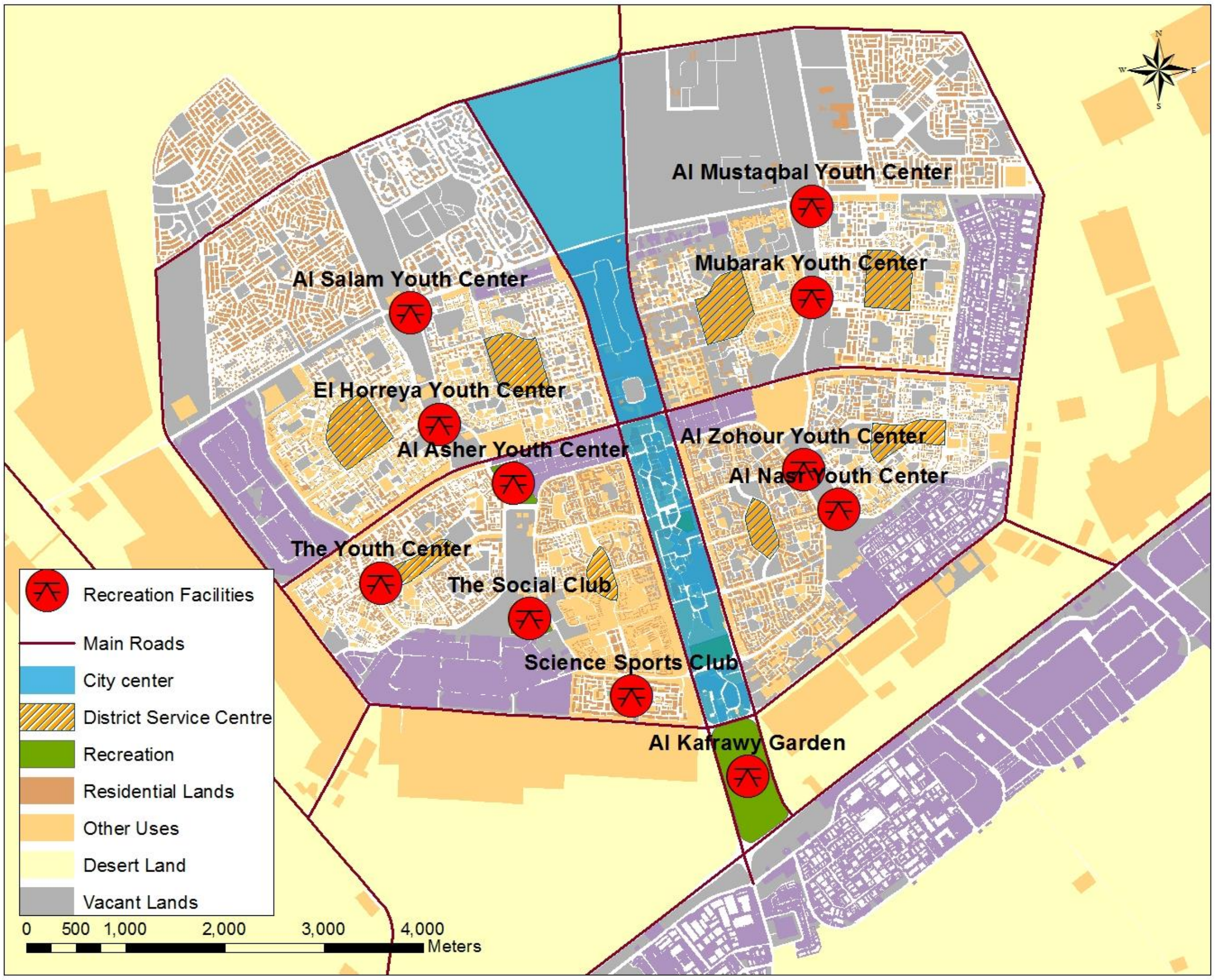

Figure 19 The recreational facilities and the city centres of 10RC

Table 4 Recreational facilities in 10 RC

Recreational Facilities	Type	Area (m^2)	Status
The Social Club	Semi-private	97,871	Operating
The Youth Center	Semi-private	13,126	Operating
Al Zohour youth Center	Semi-private	3,732	Operating
Al Nasr youth center	Semi-private	3,673	Operating
Al Salam youth center	Semi-private	3,525	Operating
Mubarak youth center	Semi-private	3,701	Operating
Al Horreya youth center	Semi-private	3,565	Operating
Al Asher youth center	Semi-private	102,987	Operating
Al Mustaqbal youth center	Semi-private	3,692	Operating
The Science sports club	Semi-private	8,368	Operating
Al Kafrawy Garden	Public	548,850	Operating

Figure 20 Al Nasr youth centre

Figure 21 Al Zohour youth centre

Figure 22 The Social Club (Al-Safwa)

Figure 23 The Engineers Club

As figures 20 and 21 show, the youth centers – playgrounds – in 10RC are identical in their design. They differ in their locations and might differ in the types of their indoor activities. The Social Club and Al Asher Club – neighborhood parks – are bigger in size and contain various playgrounds and activities. The Engineers club shown in figure 23 is exclusive to the members of the Egyptian Engineers Syndicate, thus it is not included in the analysis.

The residential use in 10RC is divided into three classes, low, average and above average class. The number of flats in the above average class ranges from 2 to 3 flats per floor. The number of flats in the average class ranges from 3 to 4 flats per floor. The number of flats in the low class ranges from 4 to 6 flats per floor. Number of flats resembles number of families. To deduce the total number of population that the city can accommodate, total number of flats is multiplied by the average number of family members. At 10RC, the average number of family members for the whole city is 4.23 (GOPP 2011).

Table 5 Average number of flats per floor in each residential class in 10RC

Residential Class	Number of floors	Average number of flats per floor	Number of flats
Above average	10,238	2.5	25,595
Average	70,691	3.5	247,419
Low	2,752	5	13,760

Total number of flats in each residential class is illustrated in Table 5. Total number of flats (families) is estimated to be 286,774. Based on the average family members' number set by the GOPP, the total number of population that the city can accommodate currently is estimated to be 1,213,054 including the vacant residential units. Comparing with the city's current population, this means that nearly 65% of the city is not inhabited. By comparing the planned residential classes' percentages with the current ones, the average residential class is found to be the highest growing class and it exceeded the planned percentage, unlike the above average and the low residential classes where the percentage has fallen.

5.3.1 Ratio Model

According to the GOPP detailed report on the 10RC (2011), the area of recreational facilities represent 1.8% (1.008 km2) of the total area of the city. Total area of public and semi-private facilities is 0.793 km^2 representing 1.4% of the city's area.

First: Comparing According to National Standards

National planning standards of this region are used according to the GOPP *(please refer to section 3.1)*. Excluding private, special and non-established facilities from the calculations, there are 11 recreational facilities that serve 550,000 inhabitants where each recreational facility serves 50,000 inhabitant (GOPP 2011). The total area of the 11 recreational facilities is 793,089 m^2, with an inhabitant share – for the current population – of 1.844 m^2. Here, the number of recreational facilities may show that they are sufficient to the current population which is 430,000 inhabitant (NUCA 2015a), but the areas of these facilities do not cover the population needs in terms of the inhabitants' shares. Taking the inhabitant share standard into consideration, then the recreational facilities serve only 393,397 inhabitants (i.e. 91.5%) of the current population.

If we take into consideration the population size that the city could accommodate if all currently vacant residential buildings were to be inhabited, then we find that the current recreational facilities serve only 32.4% of that population with inhabitant share of 0.65 m^2.

Second: Comparing According to International Standards

According to the classification illustrated by Dechiara and Koppelman (1982) to the recreational facilities, the recreational facilities in 10RC fall into three categories: playgrounds, neighborhood parks and one Community Park *(Table 6)*.

Based on the international standards, the recreational facilities in 10RC serve only 70,712 out of 430,000 total inhabitants which represent 16.4% of the current population, and only 6% of the population potentially accommodated by the currently vacant residential buildings established in the city *(Figure 24)*.

Table 6 Population served by recreational facilities in 10 RC based on international standards

Recreational and Sports Facilities	Type	Area (m^2)	Population Served
The Social Club	Neighborhood Park	97,871	12,092
The Youth Center	Playground	13,126	2,162
Al Zohour youth Center	Playground	3,732	615
Al Nasr youth center	Playground	3,673	605
Al Salam youth center	Playground	3,525	581
Mubarak youth center	Playground	3,700	610
Al Horreya youth center	Playground	3,565	587
Al Asher youth center	Neighborhood Park	102,987	12,724
Al-Mustaqbal youth center	Playground	3,692	608
The Science sports club	Playground	8,368	1,378
Al Kafrawy Garden	Community Park	548,850	38,750

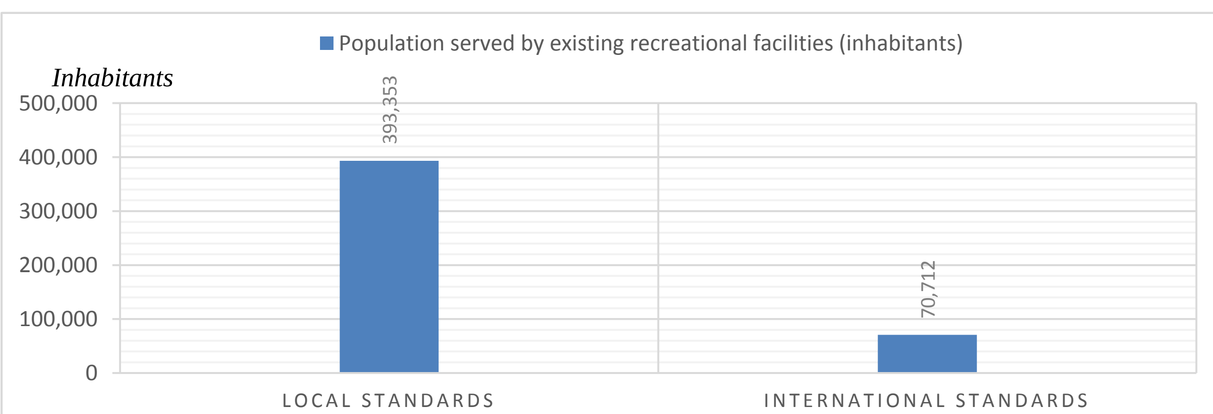

Figure 24 Population served by recreational facilities in 10RC

As for the standards related to the inhabitant share from recreational facilities, according to international standards, each inhabitant should have a share of approximately 9 m^2, while according to local standards that share is 2 m^2. The data shows that the actual share of inhabitants of 10RC from the recreational facilities is 1.84 m^2, as illustrated in Figure 25 below. The figure illustrates the high difference between the national standards regarding the inhabitant share from recreational facilities and the inhabitant share if international standards were to be considered, compared with the actual inhabitant share in the current population residing in the city.

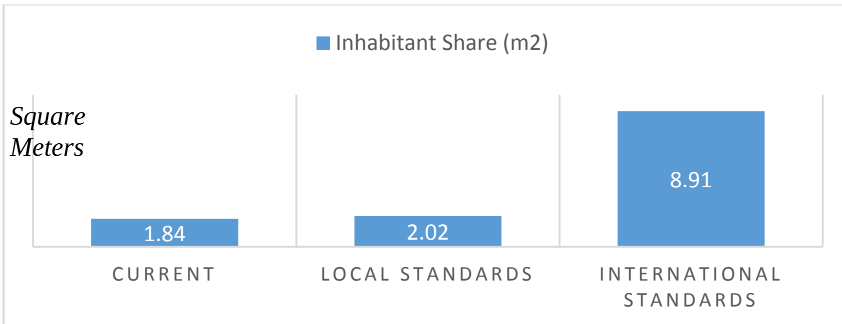

Figure 25 The inhabitant share of recreational and facilities in 10RC

5.3.2 Accessibility Model (LCPA)

In this zone of the country – where 10RC is located – the climate may control the means of transportation that the inhabitant decides to take especially in the hot days of summer. Thus, to measure accessibility, the study took into consideration not only the pedestrian routes to the recreational facilities, but also two means of transportation (private vehicles and mass transportation routes). But first of all, the service areas – the service zones – suggested by DeChiara and Koppelman (1982) *(Table 1)* were deduced to determine the deprived zones of the city that lack recreational services.

Service Areas of the Recreational Facilities in 10RC

Two service areas were conducted for the recreational facilities categories, one for the playgrounds and neighborhood parks as they have the same service area radius (800 meters), and one for the community park (3,220 meters).

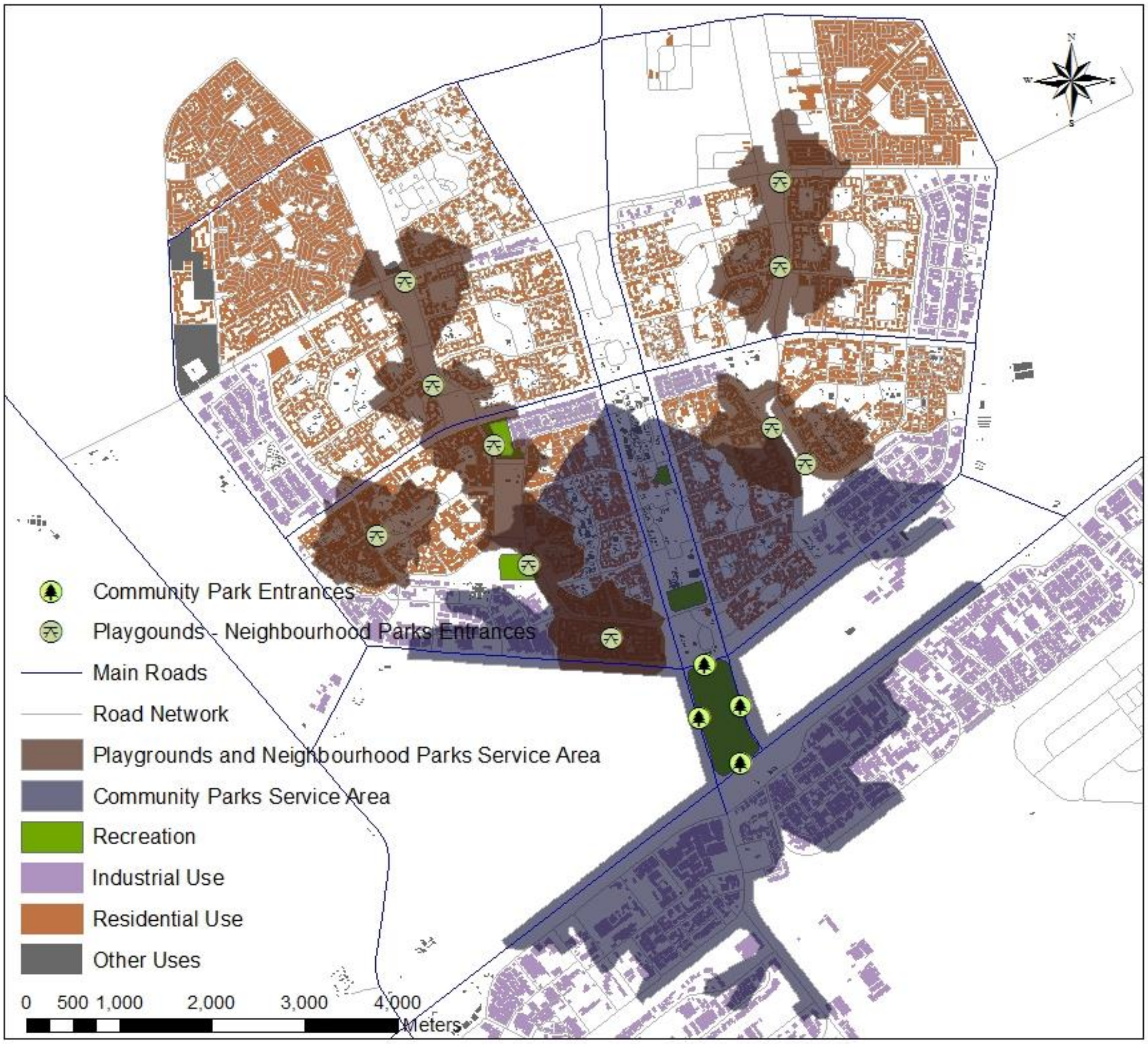

Figure 26 The service areas of recreational facilities in 10RC

Figure 26 illustrates the service areas of recreational facilities in 10RC, the serviced area in the city is 23.5 km^2 – of which 4.5 km^2 area of buildings – representing only 31% of the city's area. Table 7 illustrates the areas of the residential and industrial uses within the serviceability areas in addition to the other uses: administrative, commercial, cultural, educational, entertainment, hospitals, religious, utilities, security and social uses. The residential use area is 2.1 km^2 representing only 48% of the total area of the buildings within the service area of the recreational facilities. 67.7% of the residential buildings area are outside the service areas of recreational facilities.

Table 7 Areas of different building uses within the service areas of recreational facilities in 10 RC

Building Use	**Area (km^2)**
Total Residential Use	2.1
Industrial	1.9
Other Uses	0.35

Pedestrian Service Areas

The service areas of the recreational facilities in 10RC were concluded using the ArcGIS network analyst taking into account 800 meters as the walking distance along the pedestrian routes. The 800 meters distance is mapped from the entrances of the recreational facilities in the city. *(Figure 27)*.

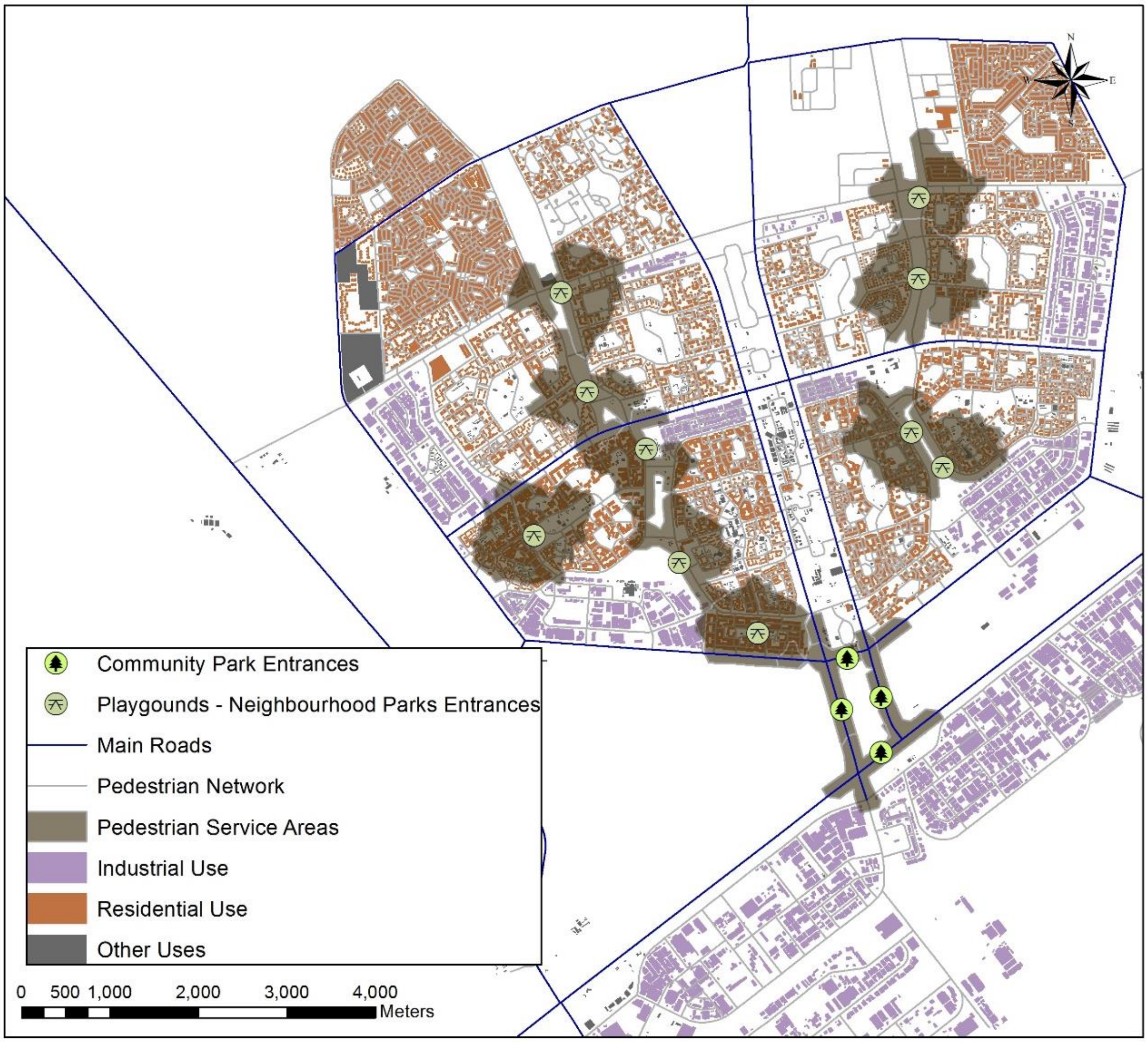

Figure 27 The pedestrian service areas of recreational facilities in 10RC

Levels of accessibility can be seen in Figure 27 where the shaded areas are the areas within 800 meters walking distance from recreational facilities. The pedestrian service areas of recreational facilities is 11.2 km^2 – of which 1.7 km^2 area are buildings – representing only 14.7% of the city's area. Table 8 illustrates the building uses within the pedestrian service areas of recreational facilities in 10RC; uses include residential and industrial uses in addition to the other uses: administrative, commercial, educational, entertainment, hospitals, industrial, utilities and religious uses. The residential use area is 1.3 km^2 representing 88% of the total area of the buildings within the pedestrian service area of the recreational facilities. 80% of the total area of residential buildings is outside the pedestrian service area.

Table 8 Areas of different building uses within the pedestrian service areas of recreational facilities in 10 RC

Building Use	Area (km^2)
Total Residential Use	1.3
Industrial Buildings	0.08
Other Uses	0.12

Public Mass Transportation Routes

There are nine paths for mass transportation (buses) in 10RC. Each recreational facility is crossed by one or more path except for two facilities (Al Mustaqbal and Al Salam youth centers). Bus stops are distributed along the paths approximately every 400 or 450 meters. To compute the service areas of the mass transportation routes, a 400 meters walking distance from the bus stops was considered (Niyonsenga and Zuidgeest 2014).

Figure 28 The areas serviced by mass transportation "bus" stops of paths crossing recreational facilities in 10RC

Private Vehicles Service Areas

To determine the service areas of private vehicles, ArcGIS network analyst was used. Time needed to travel a certain road was taken as impedance and three service polygons were produced: polygons within three minutes, six minutes and nine minutes' drive. As shown in figure 29, the whole city is within a nine minute ride to a recreational facility.

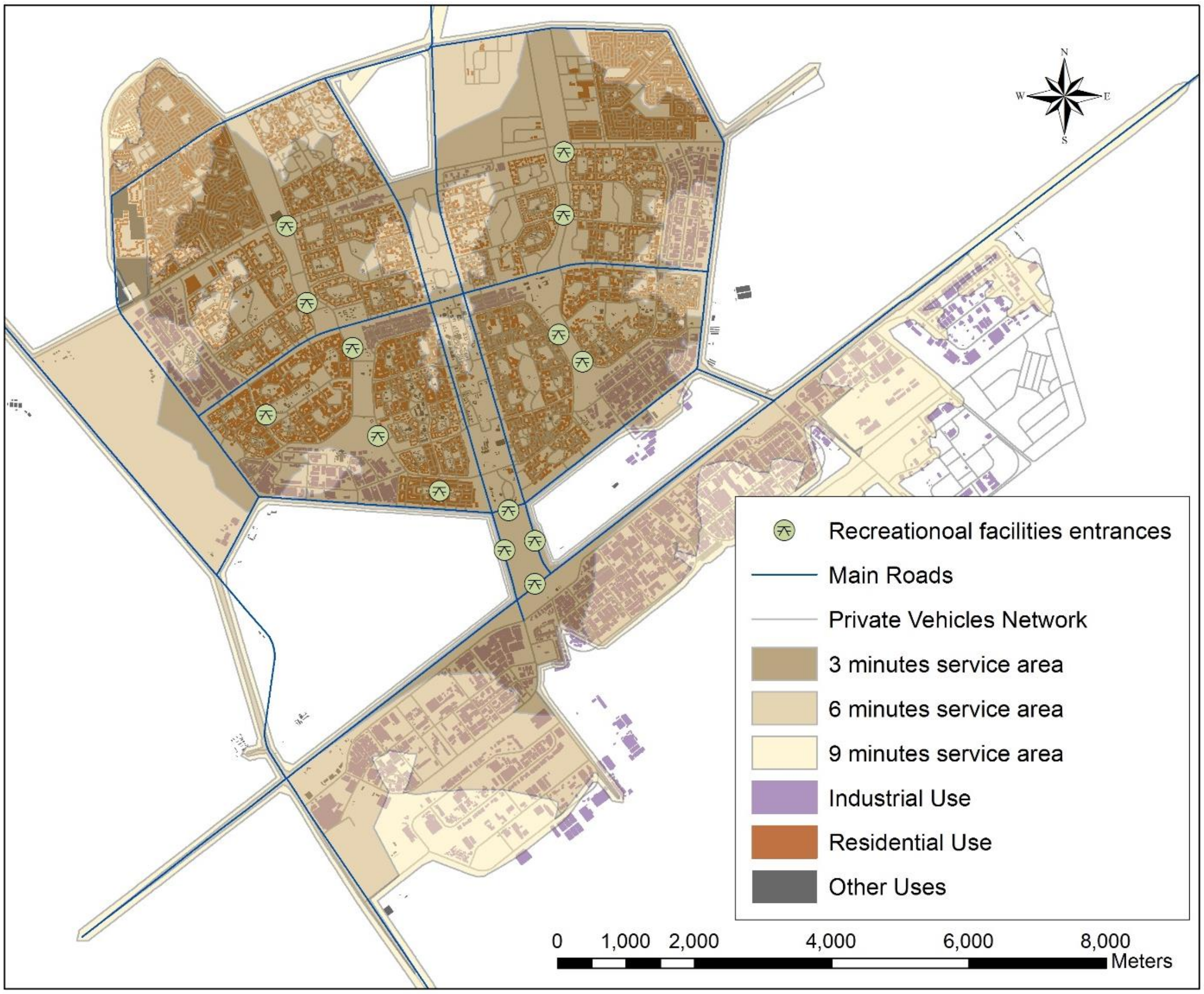

Figure 29 Private vehicles service areas of recreational facilities in 10RC

Figure 30 illustrates the percentage of the areas of service of the different means of transportation from the total built up land of 10RC. This gives a comparative view of the different areas served by recreational facilities. According to the standards of recreational services radii, only 30% of the city is serviced by recreation. As for the means of transportation, the one where its service area covers the whole city is the private vehicles followed by the mass transportation but with a much less percentage (approx. 29%). Only 15% of the city could reach the recreational facilities on foot when taking into consideration the walking distance.

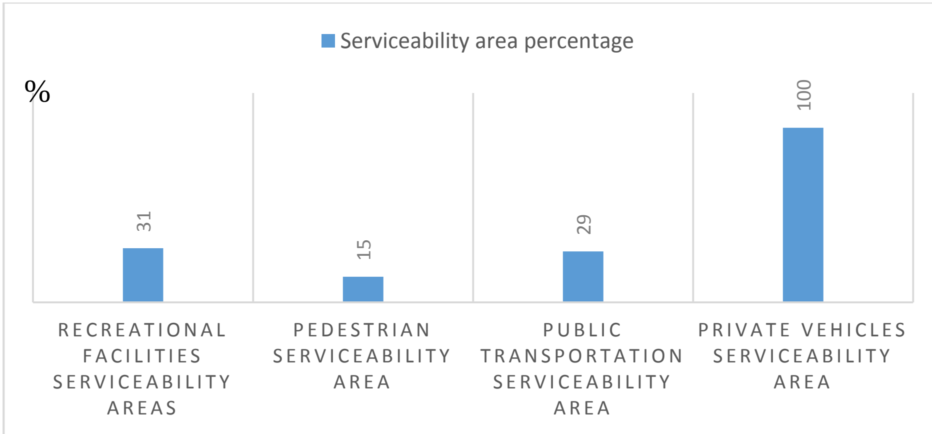

Figure 30 Percentages of service areas of recreational facilities from the city's area in 10RC

Total area of land allocated for the residential use represents 6.5 km^2 which is around 45% in 10RC. Only 32.3% of the residential area are serviced by recreational areas, 20% within pedestrian service areas, 46% within public trasportation service areas and 100% serviced by private vehicles.

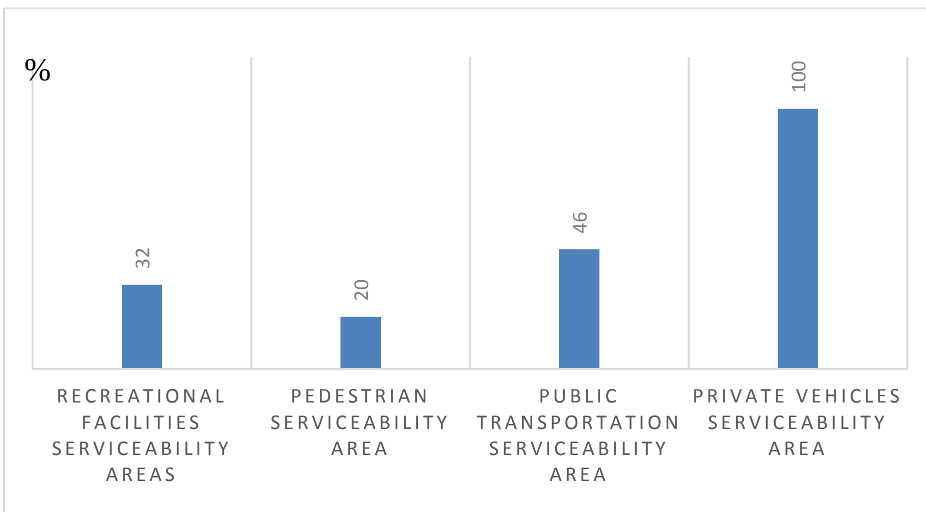

Figure 31 Percentages of residential area inside the serviceability areas in 10RC

5.3.3 Equity Analysis Model

Calculations of equity analysis are performed on all the residential classes except for the "build your own house" project. As illustrated in section 5.3 Table5, the average numbers of residential units (flats) per floor *(A)* for the above average, average and low residential classes are 2.5, 3.5 and 5 units respectively.

Figure 32 illustrates the types of residential buildings and their classes within the service areas of recreational facilities in 10RC in addition to the other uses: administrative, commercial, cultural, educational, entertainment, hospitals, industrial, religious, utilities, security and social uses. The residential use area is 2.1 km^2 representing only 48% of the total area of the buildings within the service area of the recreational facilities.

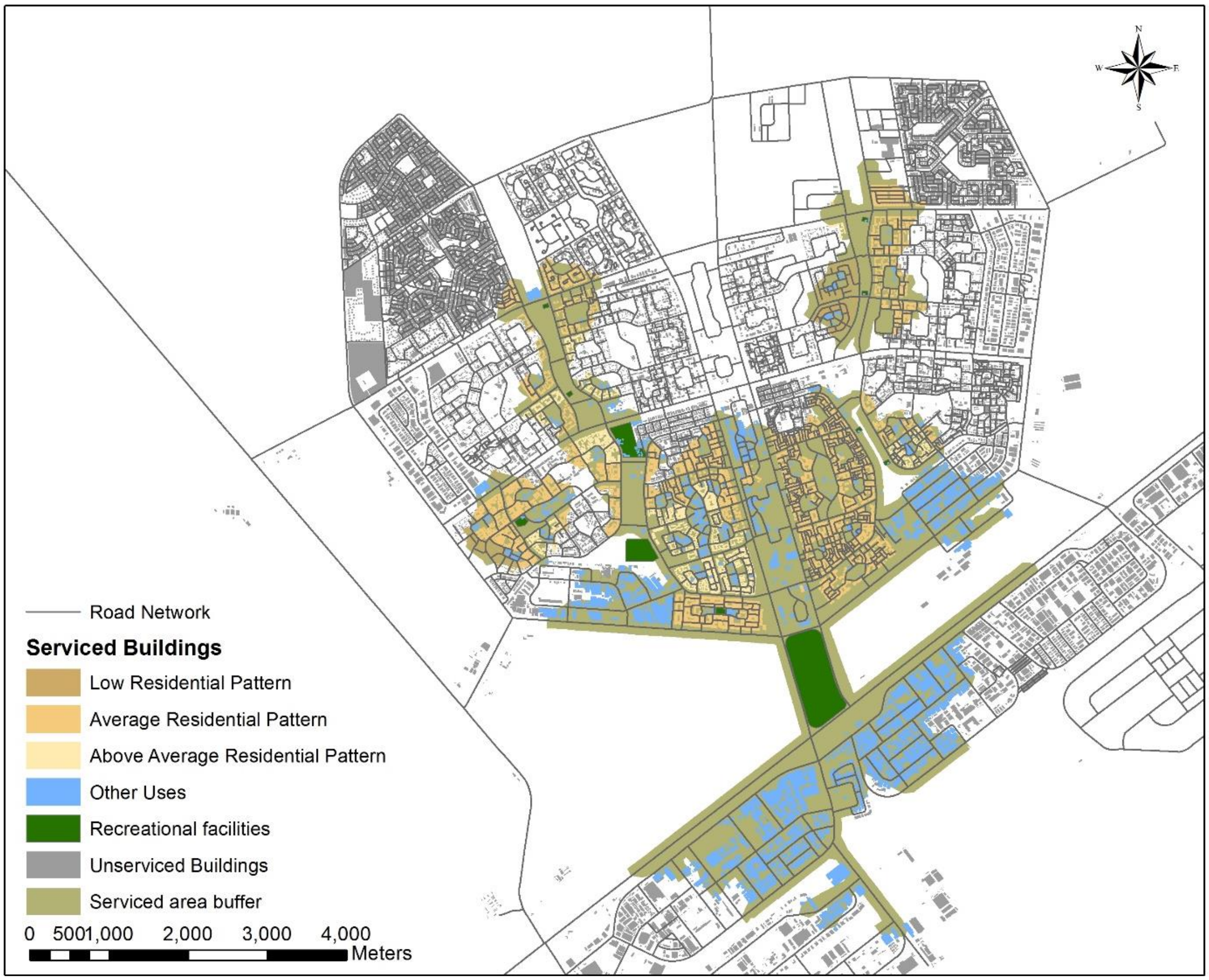

Figure 32 The residential classes within the service areas of recreational facilities in 10RC

Table 10 illustrates the areas and number of floors of the residential buildings within the service areas of recreational facilities. The table also illustrates the number of residential units and total number of population deduced based on the calculation formulas of the equity model. In addition, Table 10 illustrates the share of each residential class from the serviced residential buildings were the low residential class is the least existing.

Table 9 Details of residential buildings within the service areas of recreational facilities in 10 RC

Building Use	Number of Floors	Number of units	Total population	Percentage (%)
Above Average Residential Class	6,313	15,783	66,760	19
Average Residential Class	17,229	60,302	255,075	74
Low Residential Class	1,170	5,850	24,746	7
Total Residential Use	**24,712**	**81,934**	**316,581**	**100**

Figure 33 illustrates the difference between the percentage of residential units (flats) in each residential class inside and outside the serviceability areas of recreational facilities.

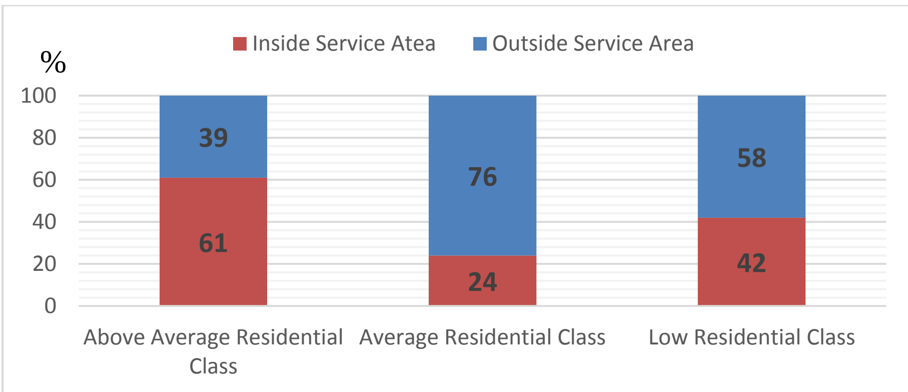

Figure 33 Percentage of residential units (flats) in each residential class inside and outside the serviceability areas of recreational facilities

Figure 34 illustrates the types of residential buildings and their classes within the pedestrian service areas of recreational facilities in 10RC in addition to the other uses: administrative, commercial, educational, entertainment, hospitals, industrial, utilities and religious uses. The residential use area is 1.3 km^2 representing 88% of the total area of the buildings within the pedestrian service area of the recreational facilities.

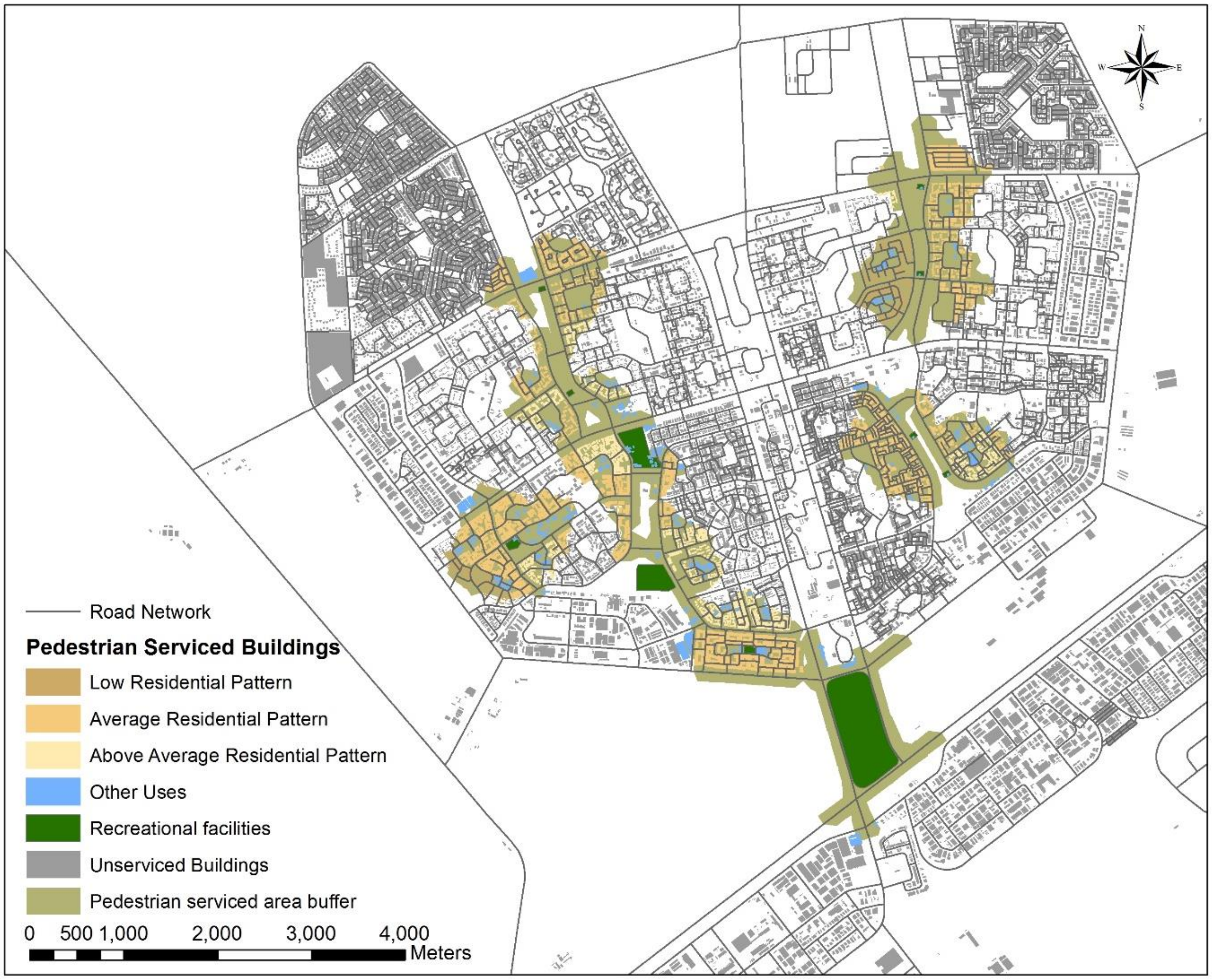

Figure 34 Residential classes within the pedestrian service areas of recreational facilities in 10RC

Table 11 illustrates the areas and number of floors of the residential buildings within the pedestrian service areas of recreational facilities. The table also illustrates the number of residential units and total number of population deduced based on the calculation formulas of the equity model. In addition, Table 11 also illustrates the share of each residential class from the residential buildings within the pedestrian service area where the low residential class is the least existing.

Table 10 Details of residential buildings within the pedestrian service areas of recreational facilities in 10RC

Building Use	Number of Stories	Number of Flats	Total Population	Percentage (%)
Above Average Residential Class	4,720	11,800	49,914	21
Average Residential Class	10,960	38,360	162,263	69
Low Residential Class	1,170	5,850	24,746	10
Total Residential Use	**16,850**	**56,010**	**212,177**	**100**

Figure 35 illustrates the difference between the percentage of residential units (flats) in each residential class inside and outside the pedestrian serviceability areas of recreational facilities. The figure shows that nearly half of the above average class is inside the service areas while half of the low residential class is outside.

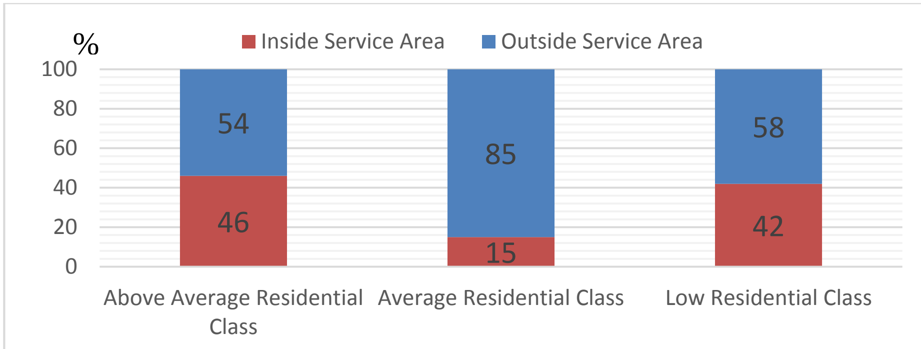

Figure 35 Percentage of residential units (flats) in each residential class inside and outside the pedestrian serviceability areas of recreational facilities

Figure 36 illustrates the types of residential buildings and their classes within the public transportation service areas of recreational facilities in 10RC in addition to the other uses: administrative, commercial, cultural, educational, entertainment, hospitals, industrial, religious, utilities, and social uses. The residential use area is 2.98 km^2 representing 75% of the total area of the buildings within the public transportation service area of the recreational facilities.

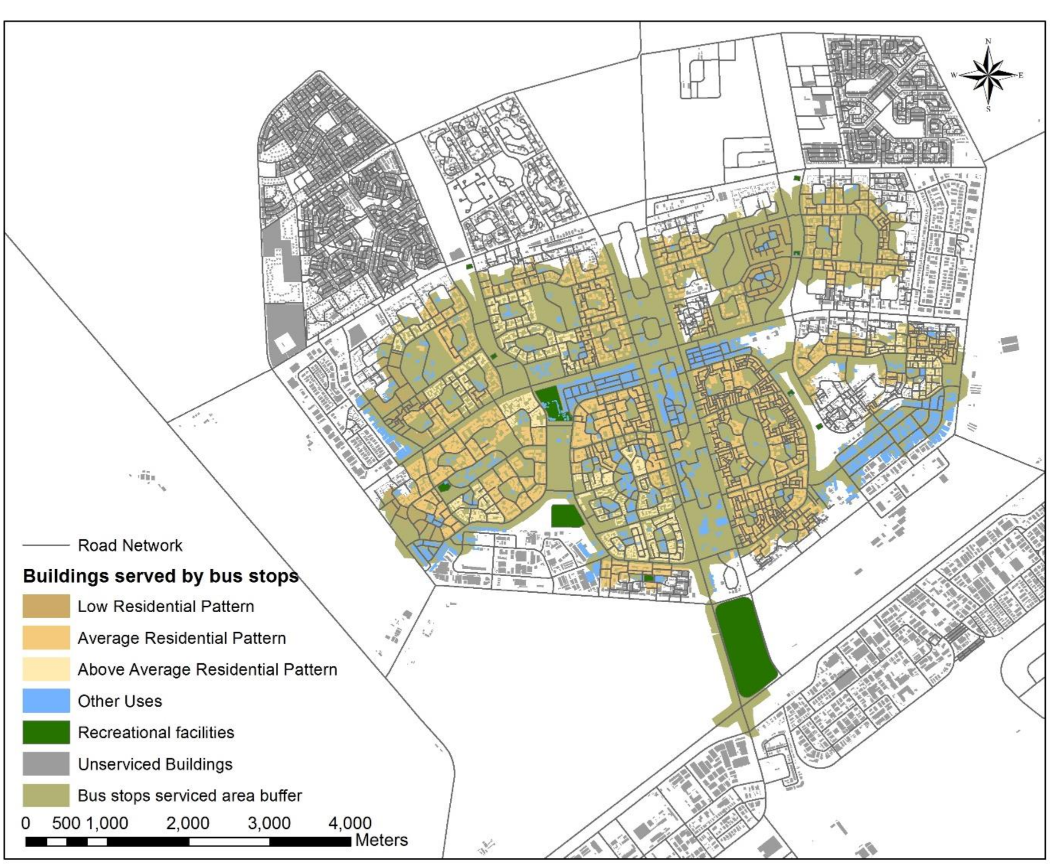

Figure 36 Residential classes within the public transportation "bus" stops service areas of paths crossing recreational facilities in 10RC

Table 12 illustrates the areas and number of floors of the residential buildings within the mass transportation service areas of recreational facilities. The table also illustrates the number of residential units and total number of population deduced based on the calculation formulas of the equity model. In addition, the table illustrates the share of each residential class from the residential buildings within the public transportation "bus" stops service area where the percentage of the low residential class is still the least existing.

Table 11 Details of residential buildings within the public transportation service areas of recreational facilities in 10 RC

Building Use	Number of Stories	Number of Flats	Total Population	Percentage (%)
Above Average Residential Class	9,073	22,683	95,947	18
Average Residential Class	25,664	89,824	379,956	73
Low Residential Class	2,242	11,210	47,418	9
Total Residential Use	**36,979**	**123,717**	**523,321**	**100**

Figure 37 illustrates the difference between the percentage of residential units (flats) in each residential class inside and outside the public transportation serviceability areas of recreational facilities. The majority of the above average residential class is within the service areas of mass transportation, the percentage of the average class decreased, and 19% of the low residential class are not serviced.

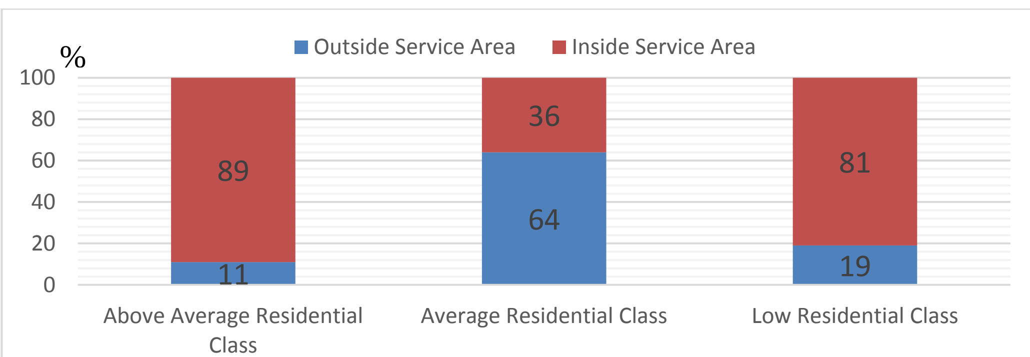

Figure 37 Percentage of residential units (flats) in each residential class inside and outside the public transportation "bus" stops serviceability areas of recreational facilities

6. Discussion

The planning of new cities started in the seventies where the plans tried to avoid the problems of the existing crowded city while absorbing the vast increase in the country's population. The plans were based on certain planning criteria that included population densities and population based services standards. However, population numbers in new cities have not reached their targets which was clear throughout the study. Although 10RC is one of the oldest and most developed new cities in Egypt, its current population according to NUCA is around one third of the population that the city could accomodate. Hence, the study attempts to assess the recreational services introduced to the population of new cities in Egypt as part of the big picture where the assessment of the quality of life people experience becomes crucial.

The planning standards mainly concentrated on the inhabitant share from each service (GOPP 2011), the distribution of the locations of the services came as later phase during the design of the master plan of the city. Thus, it was logic to start the assessment process from the sufficiency perspective. The first question raised in the study was whether the recreational service areas sufficient to the population as per the new cities planning standards or not. The first point of analysis, which is the ratio model, was generated in order to answer that question. The Ratio Model highlighted a number of key problematic issues. The ratio model concluded through the study introduces the number of population that should theoretically be covered by the recreational facilities based on the national standards (i.e. as planned) and also based on the international standards illustrated by DeChiara and Koppelman (1982). The calculations showed that the difference in the standards leads to very variant results. Based on national standards (GOPP 2011), it seemed that the recreational facilities in the city are almost sufficient to the population size; however, all figures become drastically lower if we use international standards where the calculations show that they are only sufficient to about one sixth of the current population. This underscores the inadequacy of the national standards compared to their international counterparts. There is also an issue with the duality within the national standards stated in the GOPP report (2011) which state that the inhabitant share should be $2m^2$, but also states that there should be 1 facility for every 50,000 residents regardless of its size. Thus, the study recommends the necessity of a full revision of the national planning standards for recreational facilities that firstly takes into account international standards, and secondly streamlines the various numeric criteria to reflect one coherent standard, rather than the potentially confusing duality that exists now.

Calculating the number of population served by recreational facilities might give an indication on quality of living in the city, but the question raised at this point is whether the sufficiency alone could be an indicator to the quality of the recreational services introduced to the new cities population. Thus, another question was raised, could the population easily access the recreational facilities in their new city or are they at least living within their areas of serviceability. This question led to the second point of analysis reflecting the accessibility of recreational facilities. Similar to what was introduced by Lovett, Haynes, Sunnenberg and Gale (2000), Nicholls and Shafer (2001) and Oh and Jeong (2007), this entry point relies on adding the physical – geographical – component to the analysis as an indicator of the quality of the recreational services, accessibility model generated through the study, and introducing the visual tools to spot the actual areas being served with recreational facilities. To perform this kind of analysis, international service area radii were used due to the lack of this kind of standards for the recreational services on the national level. Thus, the study recommends adding the service radius component to the planning standards of the recreational services in Egypt in addition to the inhabitant share. The accessibility model generated through the study tried to put answers to the questions mentioned above taking into consideration the actual paths that people take to travel from one place to another (Nicholls and Shafer 2001). Drawing buffer circles with constant radii around the recreational facilities might give wrong indication about the areas of service(Nicholls and Shafer 2001). Therefore, network analysis was suggested to deduce the service areas of recreational facilities in new cities. By running the LCPA model on 10RC as a case study, using the service radii of international standards, some interesting outputs were found. The city center divides the city in two halves where the recreational facilities are distributed along the mid axis of each half, leaving the one community park right at the entrance of the city. This might give an idea that they are logically distributed, but when adding the service areas, other outputs were found. The two neighborhood parks are on the west side of the city leaving the east side of the city with only playgrounds that are the smallest in size. Although the playgrounds and neighborhood parks share the same service area radius (800 meters), they differ in their size and thus, servicing different numbers of population. The east side of the city is serviced by less areas of recreation than the west side – in fact 90% less serviced population – while they are nearly evenly populated. The one community park existing in the city is located at the edge with almost half of its service area covering the industrial zone of the city. The total service areas of recreational services in the city represent around only one third of the built up land while only less than half of these serviced areas is residential. This means that two thirds of the city are not serviced with recreational facilities and are in need of locating new ones in the zones of deprivation.

People use different means of transportation to reach recreational facilities, walking is the first mean to be considered. About one eighth of the city's area is within the walking distance from the recreational facilities which means that most of the city has no access to recreation via walking. When taking a further look at the map of the pedestrian service areas *(figure 27)*, one could see that the community park – which is the biggest and the only public facility in the city – is inaccessible through walking.

As the weather in this part of the country gets hotter in summer, walking is not always the best mean of transportation. Public mass transportation routes were taken into consideration in the analysis to emphasize the areas that have accessibility to recreation. It was found out that around one third is within the public mass transportation service. While all of the recreational facilities are crossed by one or more of the mass transportation paths or their buffers, people living on two thirds of the city's area have no access to them through these mass transportation paths.

Another mean of transportation was considered: private vehicles. Accessibility by private vehicles appears to be the highest due primarily to the small size of the city in general, as all recreational facilities are within a maximum 9 minute driving distance. This shows that 10RC's recreational facilities are more accessible by private vehicles than by mass transportation or via walking. There is also a significant percentage of the built-up land – 36% – that is not serviced by recreational facility within walking distance, a nearby bus stop or even covered by the standard service areas. This raises serious concerns in regards to the accessibility of the city's recreational facilities, and highlights the need for a revision of the spatial distribution of the facilities. The ratio model showed that there is a need for additional facilities, and this study recommends that when constructing these new facilities, planners take into consideration the accessibility of each via walking and mass transit as outlined above.

An interesting output was deduced when analyzing the total areas of land allocated to the residential use, it was found out that around 67% of the area is not within the recreational facilities service areas, instead, half of the service areas are dedicated to industrial uses. Also, 80% of the residential use are not accessible through walking, and nearly half of it is not even accessible through means of public mass transportation.

Another important indicator of the quality of recreational services was analyzed in the study where more questions were raised about who is having the access to the recreation in new cities (Laswell 1958; Nicholls and Shafer 2001). A closer look to the deduced service areas – through the accessibility model – was essential to assess the equity of the recreational facilities distribution.

Equity model was generated to know who actually has the access to the recreational facilities. This analysis is done using calculations of socio-economic characteristics of population in the residential use located within the service areas of recreational facilities. Due to the lack of demographic data on the neighborhood level or less, some assumptions were made based upon the number of flats in each residential class in addition to the average family size in that zone of the country according to the GOPP. The class of the residential unit was assumed to be an indicator on the economic level of the population as the residential unit price per meter varies according to class. Thus, to perform the equity analysis, percentages of the different residential classes (low, average and above-average) within the service areas of recreational facilities were calculated.

To ensure equitable access to recreational facilities, the low residential class should constitute the majority inside the service area, while the above average should constitute the minority, since the low residential class represents the population with the lowest income which suggests that they use public mass transportation and walking as means of transportation; while the above average are most likely to own private vehicles. What is happening in reality is the complete opposite. The majority of the above average residential class (61%) is inside the service area, while only less than half of the low residential class is inside the service area.

Similarly, regarding units within walking distance, nearly half of above average units, as well as half of the low residential class units, are within walking distance. Nevertheless, the low residential class is the least existing class within the service areas, as it only represents 10% of the residential units within the walking distance from recreational facilities.

As for units that can access facilities via mass transportation, 89% of above average residential class can access facilities via bus, and 81% of the low residential class can access via bus. This shows that the above average residential class consistently has the highest share of its units that can access recreational facilities, for both means of access (i.e. walking, bus). And again the low residential class is found to be the least existing within the mass transportation service areas with a percentage of only 9%. Furthermore, 36% of the total built-up land is not serviced at all by any means of accessing recreational facilities, thus, inhabitants from this 36% must rely on private vehicles.

Residential classes are assumed to be an indicator for the socio-economic characteristics of the population. However, this can be considered a point of weakness in the study as there are no restrictions that prohibit the residential units to be owned by people from higher or lower income categories.

The findings of the study raise serious concerns regarding recreational facilities, namely that they are insufficient compared to the population size, and inadequately distributed in regards to both accessibility and equity.

While the study attempts to give a comprehensive model and as accurate as possible to assess the plans of the new cities established in Egypt, it does not give complete image on the quality of recreational services. The accuracy of the model can be increased by including more accurate demographic data on the cluster scale in addition to integrating other demographic characteristics like the age groups, levels of education and unemployment rates as introduced by previous researches (Besler 2011; Meng and Malczewski 2015; Nicholls and Shafer 2001). Other aspects beyond the physical accessibility can be considered like the quality of the facilities themselves in terms of types of sports introduced, levels of maintenance and safety, green spaces, levels of developments, financial affordability, opening hours and other parameters that might contribute in measuring the "attractiveness" of a recreational facility (Brabyn and Sutton 2013; Huisman and Forer 1998; Maroko et al. 2009; Talen 1998). In addition, the previous parameters can be integrated with social surveys on the satisfactions, motivations and expectations of users. These can all be valuable contributions of future research on this topic. However, for this particular study, the findings highlight a serious need to consider aspects of sufficiency, accessibility, and equity in the planning of future recreational facilities in Egypt's new cities.

7. Conclusions

The study is performed in an attempt to use GIS to provide a framework to assess the recreational facilities in new cities in Egypt. This assessment process gives indications on the quality of recreational services introduced to the people by measuring three main components: sufficiency, accessibility and equity. Visual maps and graphs provided by the GIS can enhance further understanding of the new cities services current problems regarding recreational services. This could open the way for a better planning and management of the services in new cities and communities in Egypt not only in the existing but also the future plans.

The ratio model implied that the city is in a high need of increasing the number as well as the areas of recreational facilities in 10RC. The accessibility model implied that the number and distribution of recreational facilities in 10RC is inconvenient for users in addition to the high concentration of uses other than the residential use within the service areas of recreational facilities. The equity model implied that there is inequity in the distribution of the recreational facilities and that the low residential class buildings are in high need of new mass transportation routes in order to access the recreational facilities. By integrating the three models generated through the study, Tenth of Ramadan city is need of new recreational facilities with bigger areas to accommodate the high population of the city, convenient distribution of the new recreational facilities where the residential areas are concentrated within the facilities’ service areas especially the low and average residential classes’ buildings.

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Department of Physical Geography and Ecosystem Science

Master Thesis in Geographical Information Science

1. *Anthony Lawther:* The application of GIS-based binary logistic regression for slope failure susceptibility mapping in the Western Grampian Mountains, Scotland (2008).
2. *Rickard Hansen:* Daily mobility in Grenoble Metropolitan Region, France. Applied GIS methods in time geographical research (2008).
3. *Emil Bayramov:* Environmental monitoring of bio-restoration activities using GIS and Remote Sensing (2009).
4. *Rafael Villarreal Pacheco:* Applications of Geographic Information Systems as an analytical and visualization tool for mass real estate valuation: a case study of Fontibon District, Bogota, Columbia (2009).
5. *Siri Oestreich Waage:* a case study of route solving for oversized transport: The use of GIS functionalities in transport of transformers, as part of maintaining a reliable power infrastructure (2010).
6. *Edgar Pimiento:* Shallow landslide susceptibility – Modelling and validation (2010).
7. *Martina Schäfer:* Near real-time mapping of floodwater mosquito breeding sites using aerial photographs (2010).
8. *August Pieter van Waarden-Nagel:* Land use evaluation to assess the outcome of the programme of rehabilitation measures for the river Rhine in the Netherlands (2010).
9. *Samira Muhammad:* Development and implementation of air quality data mart for Ontario, Canada: A case study of air quality in Ontario using OLAP tool. (2010).
10. *Fredros Oketch Okumu*: Using remotely sensed data to explore spatial and temporal relationships between photosynthetic productivity of vegetation and malaria transmission intensities in selected parts of Africa (2011).
11. *Svajunas Plunge:* Advanced decision support methods for solving diffuse water pollution problems (2011).
12. *Jonathan Higgins:* Monitoring urban growth in greater Lagos: A case study using GIS to monitor the urban growth of Lagos 1990 - 2008 and produce future growth prospects for the city (2011).
13. *Mårten Karlberg:* Mobile Map Client API: Design and Implementation for Android (2011).
14. *Jeanette McBride:* Mapping Chicago area urban tree canopy using color infrared imagery (2011).
15. *Andrew Farina:* Exploring the relationship between land surface temperature and vegetation abundance for urban heat island mitigation in Seville, Spain (2011).
16. *David Kanyari*: Nairobi City Journey Planner: An online and a Mobile Application (2011).
17. *Laura V. Drews:* Multi-criteria GIS analysis for siting of small wind power plants - A case study from Berlin (2012).

18. *Qaisar Nadeem:* Best living neighborhood in the city - A GIS based multi criteria evaluation of ArRiyadh City (2012).
19. *Ahmed Mohamed El Saeid Mustafa:* Development of a photo voltaic building rooftop integration analysis tool for GIS for Dokki District, Cairo, Egypt (2012).
20. *Daniel Patrick Taylor*: Eastern Oyster Aquaculture: Estuarine Remediation via Site Suitability and Spatially Explicit Carrying Capacity Modeling in Virginia's Chesapeake Bay (2013).
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30. *Oleksandr Nekrasov:* Processing of MODIS Vegetation Indices for analysis of agricultural droughts in the southern Ukraine between the years 2000-2012 (2014).
31. *Sarah Tressel:* Recommendations for a polar Earth science portal in the context of Arctic Spatial Data Infrastructure (2014).
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