

Prediction of Torrents Risk in Urban Sprawl Areas in Egypt

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PREDICTION OF TORRENTS RISK IN URBAN SPRAWL AREAS IN EGYPT

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In Partial Fulfilment of the Requirement
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“Doctor of Philosophy”
In Urban Design, Planning and Disaster Management

by

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Abstract

Natural hazards are a naturally occurring event that might have a negative effect on people or the environment, which are caused because of natural phenomena. Examples of natural hazards are cyclones, tsunamis, earthquake, volcanic, Landslides, floods. Torrents are one of the most important natural disasters that threaten with destruction of urban areas, especially those which are located directly in the areas of storm water drains, where the rush of water is very large and the concentrated amounts makes huge destruction for the buildings, streets, and infrastructure of the region.

Using ArcGIS - Hydrology Tools that can gives fast tool to identify the risk area but still it has primary estimation because depends on single source of data , also it doesn't take into account the land use maps and soil maps when study or identify the risk area. The second part was the safe area with buildings located outside the hazard zone. To make this classification, we used the GSSHA model by WMS software to simulate rainfall and surface water runoff in the case study area.

The world has witnessed a frightening increase in the frequency and harshness of disasters, with 240 million people on average being pretentious by natural disasters universal each year between 2000 and 2005. In 2007 alone, 414 natural disasters were informed, killing 16847 persons, harming or displacing more than 211 million others, and affecting damage estimated at over 74.9 US\$ billion.

Urban sprawl, a serious problem for many rapidly developing countries, refers to the uncontrolled growth of an urban area resulting from poorly or totally unplanned urbanization. The encroachment of urban land uses on non-urban land has become a common phenomenon throughout

developing countries. Particularly, the urban sprawl will discontinuously expand around old urban cores, and continue surround major road networks. The findings proved that the desired urban sustainable development in Aswan will not be assured in 2037, proving that the historical growth trends is not a proper scenario to achieve the urban development sustainability goals of GOPP, 2005.

The purpose of this research can be describe as trial to achievement the following specific objectives. To determine different methods can help in identified the risk area which it was prone to torrents these methods can gives fast tool to identify the risk area from natural environmental disasters as a very important step in disasters risk management. To identify torrents simulation uses free and easy access data in can generate primary results close to real live situations. It is necessary to perform simulations of the potential site to avert the threat of natural disasters. To describe simple and plain methodology to determine the approximate periods for buildings that have been where construction by using manual photo-interpretation from satellite imagery. This methodology will be very useful in determine the urban sprawl. To extract the driving factors that can led the urban sprawl to try understanding the expansion of urban area, and helping the decision-makers and planners to expect the urban growth in future. To estimate the future urban area situation by identify fast and easy method to expecting the future urban sprawl that will help the government officials in estimate the expanding of urban area in risk area porn to natural disasters.

In the following point the research will give a brief description about the chapters:

Chapter 1: This part describes the background of three main definitions, first the natural environmental disasters in the world specifically

shows the impact of torrents and flooding, the second one is some definitions about risk and disaster risk management especially the mean of flood disasters managements in Arab Region, further this chapter describes the importance of this study and what is the research objectives which the methodology have to achieve it, In the end of chapter there is the skeleton of the research thesis.

Chapter 2: This chapter suggest uses two method to identify the risk area comes from the natural disaster (Torrents), first one using ArcGIS - Hydrology Tools to delineate the watersheds and stream drain, the second method that the research uses GSSHA model to simulate the torrents in study case area. Those methods has many benefits especially for planners and decision makers in development countries, the first one those methods are very easy access and common use by very famous software such as ArcGIS, Second benefit is all data which used in this part is free data.

Chapter 3: This section analyses the past urban growth based on the study of the region in different time periods and identifies urban growth by a visual analysis of high-resolution aerial historical images of the city in Google Earth. Furthermore extract the driving factors that can led the urban sprawl using Land Change Modeler in IDRISI@Selva software, this method is very useful to try understanding the expansion of urban area. Moreover this chapter try to estimate the future urban sprawl by using method depend on the Logistic regression and Markov Chain Model.

Chapter 4: This chapter aims to identify the risk areas affected by torrents in the case study area and to investigate the relationship between the risk areas and urban sprawl. Using the WMS software, the collected data would be used to simulate the torrent and runoff water so that risk areas could be identified. Moreover the simulation method using WMS software was the

more accurate method because the take in account many kind of data source such as soil type map, land use map and the rain precipitation so that in this chapter will use this method to identify the risk area in case study.

Chapter 5: This is the last chapter in this thesis that contain the two important parts, first part summaries all results of this research and explain the ability of this results to achieve the objectives of the research such as the ability of research method could identify the risk area from the natural disasters also the situation of urban sprawl in past and future, the second part suggests some of ideas to how could this research be useful for the future work moreover suggests process to develop the research method be helpful to decision makers and planners in non-development countries.

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CHAPTER ONE INTRODUCTION

Chapter 1

Introduction

1.1 Background and Statement of the Problem

We are recognizing that “Many Arab cities and towns are located in high risk areas, including coasts and highly seismic zones as well as volcanic areas making them exposed to disaster risks from earthquakes, flooding, flash flooding and storms leading to losses in lives, assets and livelihoods.”[1].

This is one of the most important sentences expression of the natural environmental disasters situation in Middle East and their impact on urban areas, especially when we know who said that. They were the Mayors and Local Government representatives together with National Government Officials in 1st Arab Conference for Disaster Risk Reduction, 19-21 March 2013 in Aqaba, Jordan.

1.1.1 Natural Environmental Disaster

Natural hazards are a naturally happening event that might have a harmful effect on people or the environment, which are initiated because of natural phenomena. Examples of natural hazards are typhoons, tsunamis, earthquake, volcanic, Landslides, floods [2]. Natural hazards is natural progression or phenomenon that may cause loss of life, harm or other health effects, property injury, loss of livings and services, social and economic trouble, or environmental damage [3]. While the Disasters are regularly defined as a result from the mixture of hazard, vulnerability and insufficient volume or measures to reduce the probable chances of risk. A disaster happens when a hazard influences on the vulnerable population and reasons damage, casualties and disruption [4].

In brief we can consider that when the natural hazard caused loss of life, injury, disease and other negative effects on human physical, together with damage to property, destruction of assets, loss of services, and environmental degradation in that case it is called Natural Environmental Disasters.

The world has witnessed a frightening increase in the frequency and harshness of disasters, with 240 million people on average being pretentious by natural disasters universal each year between 2000 and 2005. In 2007 alone, 414 natural disasters were informed, killing 16847 persons, harming or displacing more than 211 million others, and affecting damage estimated at over 74.9 US\$ billion [5]. In 2014, the number of stated disasters confirmed the worldwide upward trend in natural disaster incidence. This trend is mostly driven by the increase in the amount of reported hydro-meteorological disasters. Hydrological (essentially floods) and meteorological (storms) disasters are the main contributors to this pattern. In

latest decades, the amount of reported hydrological disasters had been growing by 7.4% annually on average [5].

The amount of people that have been affected by natural disasters from 1975 to 2000 by income and disaster category as observed in Figure 1-1 [6]. Further than 95% of all deaths as a consequence of natural disasters are in the slightest developed nations, and these same countries have the greatest number of persons affected by natural disasters. Flooding is the single utmost destructive category of natural disaster that attacks humans and their livelihoods in all world [6].

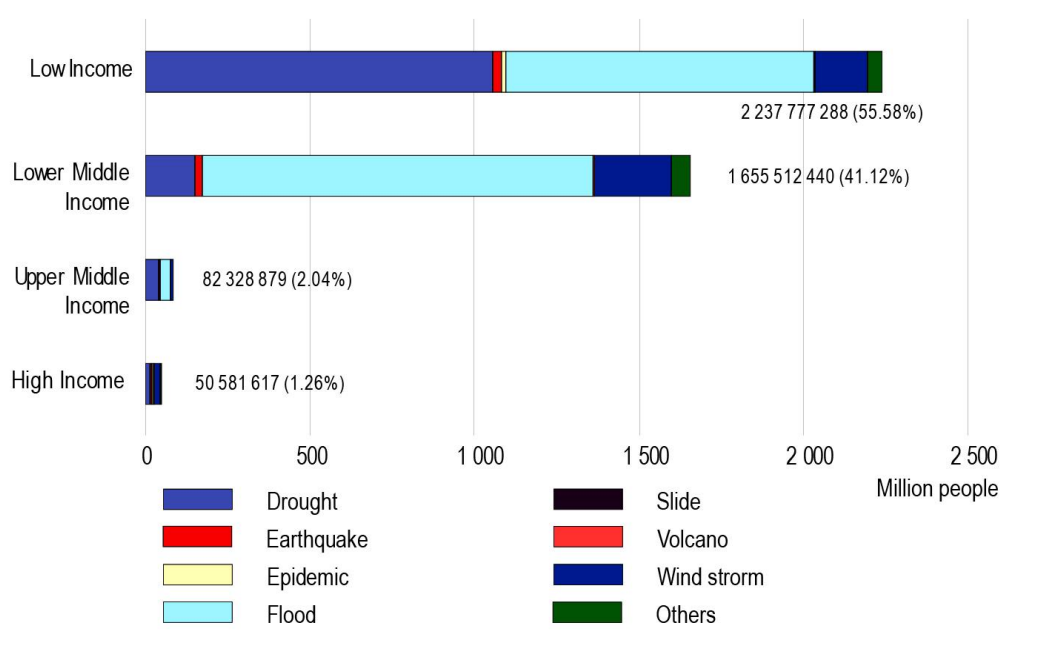


Figure 1-1 World overview from 1975-2000 of number of people affected categorized by income class and disaster type.

A flash flood is, in brief, a sudden local flood of great volume and short period which follows within a few (generally less than six) hours of heavy or moderate rainfall [4]. Flash floods are regularly characterized by raging torrents afterward heavy rains that rip through river beds, urban roads,

or mountain valleys, sweeping all things before them [7]. The phenomenon of the flash flood is one of the furthestmost difficult natural disasters to predict in relations of time and place of occurrence [4].

During a flash flood there is a sudden increase in the water level in rivers and drains, and flow speed can be very high; the power of the water can be so countless as to tear away boulders, displace trees, and destroy bridges and constructions that stand in its way. Hence, flash floods present a thoughtful threat to lives and property [4]. As an outcome, it is challenging for the concerned authorities and groups to respond appropriately; active response plans are indispensable tools to lessen the danger of flash floods.

Between 1980 and 2008, further than 37 million persons were affected by lack, earthquakes, flash and other floods and storms and the losses to Arab economy were estimated at around US\$ 20 billion [8]; Flood risk is cumulative in towns across the region (Arab Countries) because of real surfaces that do not engross water, inadequate or clogging of stream systems and the increased structure in lowland areas in floodplains [9].

Egypt is subject to a crowd of different types of crises/ disasters such as those: subsequent from natural disasters, environment pollution and neglect in areas such as transport accidents (cars, ships, aircrafts and trains). These disasters can be divided into two kinds: Natural Disasters and Man-made Disasters. Figure 1-2 shows the classification of the furthestmost important disasters that Egypt expression (actual and potential). It covers together natural and man-made disasters [10].

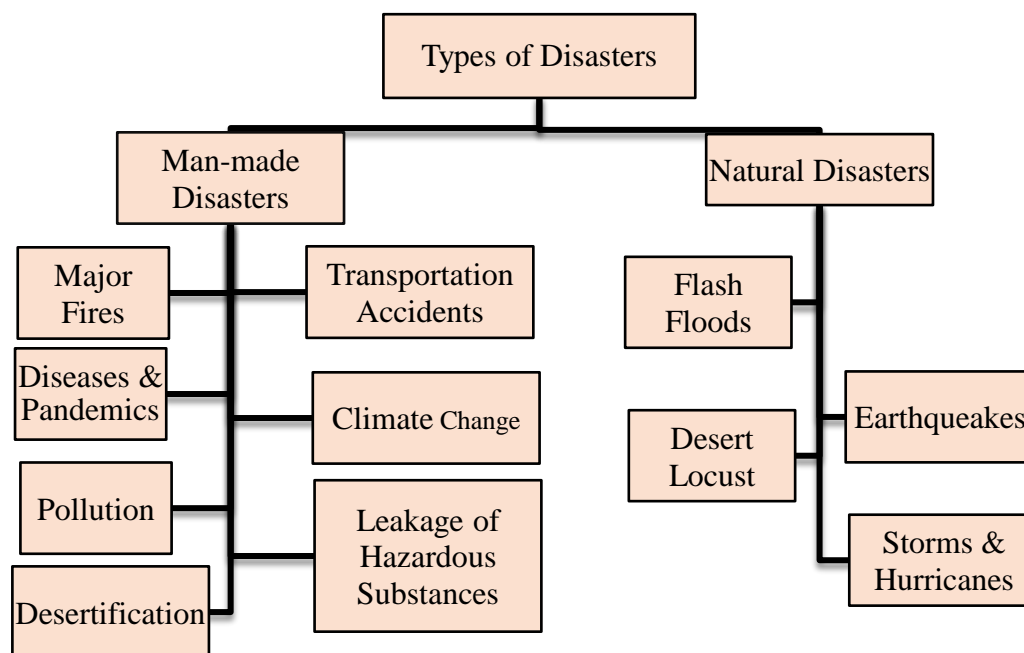


Figure 1-2 The most common types of man-made and natural disasters occurred in Egypt.

Egypt is subject to so many natural disasters initiating main human and financial losses. The following table (Table 1-1) introduces a number of statistics on losses resulting from natural disasters which Egypt experienced during the period 1987-2008 [10].

Table 1-1 Losses occurred due to natural disasters in Egypt in (1987-2008).

Number of disasters	20
Number of deaths	1469
Annual average deaths	67
Number of victims	259,324 persons
Annual average of victims	11,787 persons
Financial losses	US\$ 1,342,000
Annual average financial losses	US\$ 61 million

Egypt is positioned in the global belt of hot dry desert land with scarce rains. The Eastern desert has a network of intertwined olden valleys. When water exceeds the level of fullness in these deserts, it concentrates in the valleys and decants either into the Red Sea or the Nile Valley. Geographic topographies assist in giving water a drive to destroy anything in its way [10, 11]. Occasionally, heavy rains regularly result in flash floods in Egypt. Rain-made floods wash away property, claim exists and displace people. Flooding on January 18, 2010, for instance, affected over 3500 persons and claimed 12 lives, while a similar flood in 1994 affected over 160,000 persons as shown in Table 1-2 [11, 12].

Table 1-2 Number of people affected by natural hazards in Egypt.

	1979	1992	1993	1994	1995	1996	2002	2008	2010
Earthquake	-----	92,649	-----	-----	69	-----	250	-----	-----
Flood	66,000	-----	-----	160,660	3000	260	800	-----	3500
Landslide	-----	-----	-----	-----	-----	-----	-----	697	-----
Storm	15,000	-----	-----	-----	-----	-----	-----	-----	-----

Egypt has also suffered after periodic flash floods in the Sinai Peninsula, and the districts of the Red-Sea port of Hurghada and Aswan [13]. Torrential rains as high as 20 mm/ day over Sainte Catherine on October 18, 1997 and comparable amounts in Al Qusseir, Ras Benas, Ras El Naqb and Aswan on the same time, led to very severe floods [11]. Table 1-3 shows the impact of the natural disasters in different cities [14].

Table 1-3 Distribution of disasters, damages and losses in Egypt by province.

Governorate	Number of events	Deaths	Houses destroyed	Houses damaged
Bani Suef	7	30	0	379
Giza	4	11	0	0
South Sinai	29	8	135	405
Aswan	9	4	1194	1101
New Valley	4	0	0	0
Suez	7	0	0	0
Total	60	53	1329	1885

1.1.2 Risk Management

Risk is defined as the probable losses (of lives, peoples injured, property injured, and disruption of financial activities) due to a particular danger for a given area and reference period [15].

Disaster risk management is worried with putting the institutional and organization mechanisms in place to evade, lessen or transfer the adverse effects of dangers through activities and procedures for prevention, mitigation and preparedness [16].

A change to active management of natural disasters needs an identification of the risk, the improvement of strategies to reduce that risk, and the making of policies and programs to set these strategies into effect. Risk management is a major activity geared to the evaluation of systems for reducing but not essentially eliminating the total risk, as in many cases risk cannot be completely eliminated [6].

Flood disaster management is an end-to-end process for distinguishing and effectively combating the risk connected with floods through a suite of planned activities. The process includes a number of activities that occur throughout the cycle: [6].

- Pre-disaster - preventative measures and preparedness;
- During the flood - disaster relief, response and mitigate actions; and
- Post disaster - rehabilitation, reconstruction, economic recovery, and efforts to assess and fine-tune preventative measures.

This research focuses in the first activity which how to prepare the Pre-disaster step about preventative measures and preparedness, by simulate the natural disaster and identify the risk area before it acted .

Arab Region synthesis report denote to the weakness management of disaster risk by reference that Several Arab countries face institutional and management challenges, These management challenges include lack of technical skills, relevant experience, and human, logistical and financial funds to plan and implement disaster risk reduction measures [9].

Also the previews report denote to the lack of data, information, and mapping tools on susceptibility, danger exposure and risk add to the challenges facing effective disaster risk management is central factor that weaken effective application of DRR plans and activities [9].

The Sendai Framework for Disaster Risk Reduction 2015-2030 recommend in his final report that. To achieve Understanding disaster risk it is important: [17].

- To develop, occasionally update and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the common public and communities at risk of exposure to disaster in an appropriate format by using, as applicable, geospatial information technology.
- To promote real time access to dependable data, make use of space and in situ information, including geographic information systems (GIS), and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data.

1.1.3 Risky Urban Area Sprawl

City landscapes have been rapidly changing in the last few years in response to faster population growth and the transition from rural to urban areas [18]. According to United Nations reports, urban population will rise by 1.35 billion by 2030, at which period the population in urban areas in the world will be around 5 billion. It is prediction that worldwide urban land will increase by 1.2 million km² by 2030, which will be closely triple the global urban land area circa 2000 [19].

Urban sprawl, a serious problem for many quickly developing countries, refers to the uncontrolled sprawl of an urban area resulting from poorly or totally unplanned urbanization [20]. The encroachment of urban land uses on non-urban land has become a common phenomenon throughout developing countries [21].

By the 1970s, urban sprawl was not only gotten as an incompetent pattern of urbanization but also as a phenomenon that injured inner cities, and consequently it had to be brought under stricter control [22]. The beginning of the 21st century saw urban population attainment a milestone when census showed that half of the world's population exist in in cities [19].

Furthermore, urban areas have a natural extension in multiple directions, sometimes with growth even heading towards places prone to natural disasters. Hence, decision-makers and planners should mitigate this problem through risk management and by providing different replacements. Additionally, high risk locations include urban areas, from pavement to tops where there is a concentration of rainfall runoff [23].

Cities are gradually more exposed to a variety of natural and manmade hazards including lacks, floods, earthquakes, storms and Torrents. The potential for a hazard to become a disaster depends on the grade of exposure of a population and its physical or financial assets. Urbanization, immigration, population growth and economic increase are all factors that increase the attentiveness of people and assets in high risk areas. The higher grade of exposure and vulnerability of both people and infrastructure inside towns is a powerful cause behind why natural hazards tend to have larger social and economic impact in urban areas than in rustic areas.

Therefore, it is very important to manage the Risk of Natural Disasters such as Earthquakes and Torrents in sprawl of urban areas and make classification for main affective factors to try to control and direct the growth of cities to save it from the Risk of Natural Disasters.

Urban risk is a main concern in the region as big urban middles and mega cities are loaded by extreme poverty, slums, poor districts, joblessness,

and lack of basic services. Several urban areas, and not only the poor ones, are located in regions of high risk and are vulnerable to destruction from floods, earthquakes, landslides and snowstorms [9].

Urban planning and design has a key part to play in defining the pliability of a city or urban area. While the planning procedure and design requires vision, participation, suitable knowledge and information on present and future risks, the implementation and capacities to provide for safe area and main services to all urban residents requires political leadership backed up by solid policy decisions and investments. This is one of today's foremost challenges in rapid urban sprawling contexts such as in Africa, Asia and Latin America [24].

Land use control will decrease danger of life and property when waters overwhelm the floodplains and the coastal areas. The number of casualties is connected to the population in the area at risk. In areas where people already have constructed their settlements, actions should be taken to relocate to better sites so as to decrease vulnerability. No main development should be allowable in the areas which are subjected to high flooding. Important services like hospitals, schools should be constructed in safe areas. In urban areas, water holding areas can be created like ponds, lakes or lowland areas.

Egypt has to contend with the problems caused by urban sprawl. For the earlier five decades, there has been an unprecedented sprawl process despite the government's efforts to slow it down. While only fewer than 10% of the current total population lived in cities at the opening of the 20th century, the urban population rose by 45 % by the finish of the century.

1.2 Purpose and Importance of the Study

Based on the recommendations from two of most important meeting has been holed in Middle East for National Government Officials about Disaster Risk Reduction, the first one is the 1st Arab Conference for Disaster Risk Reduction, 19-21 March 2013 in Aqaba, Jordan, the second one is 2nd Arab Conference on Disaster Risk Reduction, 14-16 September 2014 in Sharm El Sheikh, Egypt. We can observed many of important points that give impression about the orientation of Government Officials in Middle East about the disaster risk management, it can be mentioned in the following points:

- The importance of the absence of database and information in disaster risk management, they mentioned that “Disaster losses are compounded due to the lack of a database and updated information on risk exposure in the Arab region” [8].
 - It is very needed to build or restore at least two infrastructure facilities to reduce disaster risks such as a dam or a flood drainage system.
 - They were referring to the urban sprawl in Arab country and its affect in risk management for natural disasters “Rapid urbanization in the Arab region constitute challenges that have negatively impact the capacity of Arab States to reduce and manage disaster risk.” [8].
 - Until the end of 2017, they attempt to prepare at least one disasters risk assessment report of the city to lead urban development plans and decisions, and ensure that this information and the plans for city’s resilience are readily available to the public [1].
 - Focus on scientific research and the promotion of technical means to assess risk, monitor and develop hazard maps, analyses vulnerability
-

using GIS and remote sensing tools, and enhance national risk assessment capacities [8].

This research takes advantage of the recommendations and observations of the 1st and 2nd Arab Conference for Disaster Risk Reduction about three points have big value in risk management of natural disasters. First one is the importance of identifying the area of risk exposure by monitor and develop hazard maps, especially studying the flooding as a one of most hazardous natural hazards. The second point is the value of Urban Sprawl when manage the risk of natural disaster, how we can protect the urban area from expands to risks prone areas. The last point is the importance of the database and how much is the lack of data will be negatively impact on manage disaster risk process also the database and disaster information have to be available to the public and easy access

1.3 Research Objectives and Questions

The purpose of this research study will be to find easy and free access sources method to identify the risk prone areas from the torrents as a one of most effective natural environmental disasters, Moreover understanding of urban area expanding for this risk area by analysis the driving forces of urban sprawl in Aswan. This issue try to help the decision makers and planners in non-development countries which do not have enough data to complete the risk management procedures and plans.

In order to realize this, the specific objectives are:

- To determine different methods can help in identifying the risk area which it was prone by torrents these methods can gives easy and fast tool to identify the risk area from natural

environmental disasters as a very important step in disasters risk management.

- To identify torrents simulation model uses free and easy access data in generate primary results close to real live situations. It is necessary to perform simulations of the potential site to avert the threat of natural disasters.
- To describe simple and plain methodology to determine the approximate periods for buildings that have been where construction by using manual photo-interpretation from satellite imagery. This methodology will be very useful in determine the urban sprawl.
- To extract the driving factors that can led the urban sprawl to try understanding the expansion of urban area, and helping the decision-makers and planners to expect the urban growth in future.
- To estimate the future urban area situation by identify fast and easy method to expecting the future urban sprawl that will help the government officials in estimate the expanding of urban area in risk area porn to natural disasters.

Based on the above objectives, there are four major emerging research questions the ability of implementation of the research aims about management the risk came from the natural disasters on urban areas, A key requirement to understand and achievement the research objectives by answering the following questions:

- 1- What is the convenient and easy method that can identify the risk area was prone to natural environmental disaster such as Torrents?

- 2- What is the proper way to simulate the torrents by using free and reachable data in the same time can generate primary results close to real live situations?
- 3- Is it possible to get simple methodology can gives approximate periods for buildings that have been where construction by using manual photo-interpretation from satellite imagery?
- 4- How can the research method extract the driving factors that can led the urban sprawl to expand in risk area porn to natural disasters and how we can estimate and expect the future urban area situation?

1.4 Framework of the Research

The thesis structure consists of five chapters describe the sequence of steps to achievement of the research objectives. Starting with the introduction which draw the statement of the research problem and the overview about the thesis logical processes, the second step was the body of research which include three parts describe in first one the method of identifying the risk areas from the Natural Disaster (Torrents), then shows how it can be study the growth of urban area from past to future, the last part contain to the analyses and predict the urban sprawl in torrents risk areas especially in case study area (Aswan City), In final of structure the thesis conclude the results of the research steps and give small issue about the future work.

In the following point the research will give a brief description about the chapters:

Chapter 1: This part describes the background of three main definitions, first the natural environmental disasters in the world specifically

shows the impact of torrents and flooding, the second one is some definitions about risk and disaster risk management especially the mean of flood disasters managements in Arab Region, further this chapter describes the importance of this study and what is the research objectives which the methodology have to achieve it, In the end of chapter there is the skeleton of the research thesis.

Chapter 2: This chapter suggest uses two method to identify the risk area comes from the natural disaster (Torrents), first one using ArcGIS - Hydrology Tools to delineate the watersheds and stream drain, the second method that the research uses GSSHA model to simulate the torrents in study case area. Those methods has many benefits especially for planners and decision makers in development countries, the first one those methods are very easy access and common use by very famous software such as ArcGIS, Second benefit is all data which used in this part is free data.

Chapter 3: This section analyses the past urban growth based on the study of the region in different time periods and identifies urban growth by a visual analysis of high-resolution aerial historical images of the city in Google Earth. Furthermore extract the driving factors that can led the urban sprawl using Land Change Modeler in IDRISI@Selva software, this method is very useful to try understanding the expansion of urban area. Moreover this chapter try to estimate the future urban sprawl by using method depend on the Logistic regression and Markov Chain Model.

Chapter 4: This chapter aims to identify the risk areas affected by torrents in the case study area and to investigate the relationship between the risk areas and urban sprawl. Using the WMS software, the collected data would be used to simulate the torrent and runoff water so that risk areas could be identified. Moreover the simulation method using WMS software was the

more accurate method because the take in account many kind of data source such as soil type map, land use map and the rain precipitation so that in this chapter will use this method to identify the risk area in case study.

Chapter 5: This is the last chapter in this thesis that contain the two important parts, first part summaries all results of this research and explain the ability of this results to achieve the objectives of the research such as the ability of research method could identify the risk area from the natural disasters also the situation of urban sprawl in past and future, the second part suggests some of ideas to how could this research be useful for the future work moreover suggests process to develop the research method be helpful to decision makers and planners in non-development countries.

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**CHAPTER TWO
IDENTIFY THE RISK AREAS
FROM THE NATURAL
DISASTER (TORRENTS)**

Chapter 2

Identify the Risk Areas from the Natural Disaster (Torrents)

2.1 Introduction

Torrents are one of the most important natural disasters that threaten with destruction of urban areas, especially those which are located directly in the areas of storm water drains, where the rush of water is very large and the concentrated amounts makes huge destruction for the buildings, streets, and infrastructure of the region. The hazard degree is depending on torrents' power and the layout readiness of the city or village to face and manage that risk. It is found that many academics focused on using indicators to measure urban sprawl by founding multi-dimensional indicators by GIS analysis or descriptive statistical analysis [1].

Risk is defined as the probable losses (of lives, peoples injured, property injured, and disruption of financial activities) due to a particular

danger for a given area and reference period [2]. A strong current of water at a depth of only 60 cm can move off most passenger vehicles [3]. Through a flash flood there is a sudden increase in the water level in rivers and streams, and flow speed can be very high; the power of the water can be so great as to tear away rocks, uproot trees, and destroy bridges and constructions that stand in its path.

Research needs to be focused on vulnerability analysis and impact of disaster risk associated with climate change and natural hazards. There is a necessity to develop scientific research and technical tools for climate observing, hazards mapping, use of GIS and remote sensing tools, connecting gaps in national capacity construction focusing on risk assessment and vulnerability assessment [4].

Simulate the torrents is one of the most important way to study and analyses this phenomenon, by using simulation we can identify the many effective torrents data such as the depth of runoff water in each area from the start to end of flooding, there are many models can simulate the rain and flooding of torrents such as MIKE FLOOD, CCHE, FLO-2D, TUFLOW or GSSHA.

This research uses two method to identify the risk area, first one using ArcGIS - Hydrology Tools to delineate the watersheds and stream drain, the second method that the research uses GSSHA model to simulate the study case area for many reasons it can be clear in the flowing point.

2.1.1 ArcGIS - Hydrology Tools

Nowadays, the water related disasters (floods, droughts, and tropical storms) are already a main challenge for sustainable human development [5-7]. Floods and/or flash floods are amongst the most catastrophic natural

hazards in the world causing the biggest amount of deaths and property damage [8]. Recently, problems related to flooding have been greatly increased [9].

A flash flood can be defined as a flood that threatens damage at a critical location in the watershed, where the time for the growth of the flood from the upstream catchment is less than the time wanted to activate warning, flood protection or mitigation measures downstream of the dangerous location [10]. Floods can influence several aspects of human life due to their destructive effects and make significant expenses on mitigation efforts. Heavy rains, land-use change in basin areas and many engineering applications contribute to the size and frequency of flood events [11]. Urban flash floods are flood events which cause damages in small catchment areas of less than 100 km² (and even fewer than 10 km²) and are initiated by small scale rain events with volumes far above design rainfall for the concerned hydrological constructions [12].

Flash floods, especially in urban areas, may contain dangerous materials, broken electrical lines, sewage, etc. Explosions and fires during flash floods are not rare [13]. In urban areas, the impacts caused by floods can be very high because the areas affected are thickly populated and contain vital infrastructure [14]. Growing urban environments result in a larger risk of flash floods because urbanization usually increasing flood risk when compared to rural environments [13].

Human activities such as unplanned fast settlement development, unrestrained construction of buildings in general, and main land use changes can effect the spatial and temporal pattern of hazards [9]. The probability of a flood event (i.e. the flood hazard) is consequently growing in those watersheds that are prone to or focus to anthropogenic disturbances [15]. The

impact of urban sprawl on the natural watershed procedures is resulting in a big increase in flash flood occurrences [13].

The houses of poor people in these furthestmost vulnerable informal settlement areas are characteristically constructed with materials and techniques that cannot resist risky weather or natural disasters [16]. Rapid urbanization in low-income and middle-income countries tends to take place in similar relatively high-risk areas, thus placing an increasing proportion of the economies and populations of those countries at risk [17, 18].

A watershed is defined as natural Hydrologic object that covers a particular area of land surface from which rainfall runoff flows to a defined stream, channel, drain or river at any point [19]. A watershed is a natural or disturbed system that purposes in a manner to collect, store, and releases water from a common outlet, such as a greater stream and lakes [20]. Watershed: is an extent, or an area of land, wherever surface water from rain and melting snow, or ice, converges to a single point [18].

Watershed delineation can be prepared manually or automatically. But manual watershed delineation method for large basin is very time intense and required good quality topographic maps. Afterward the development of reliable DEM, automatic watershed delineation has become very common and has proved advantageous above manual method when study area are large and numerous [21]. Automated extraction approaches are the most efficient approach when DEM cell size is significantly smaller than the watershed sizes [11].

Identification of drainage networks within basins or sub-basins can be achieved using outdated methods such as field observations and topographic maps or alternatively with advanced methods using remote sensing and DEMs [22-24].

Digital elevation models (DEM for short) are a significant source of information in GIS applications. It has been widely used for modelling surface hydrology counting the automatic delineation of catchment areas, corrosion modelling or automatic drainage network extraction [25]. Delineation of drainage network for catchments is very significant for partitioning sub-basin and the application of a spread hydrologic model. Several available algorithms automatically extract river network parts and associated sub-basins from a digital elevation model (DEM). DEM is a kind of spatial data set, which mirrors topography of a river basin [26].

A digital elevation model of Shuttle Radar Topography Mission (SRTM) & a geospatial tool HEC-GeoHMS (Hydrologic Engineering Center Geospatial Hydrologic Modeling Extension), extension of ArcView 3.2 of ESRI, have been used to delineate the sub-basins to excerpt the hydrographical network, to calculate the physical characteristics and some hydrological parameters and to found the watershed schematic appropriated with a hydrologic model [27].

Alike with the hydrologic tool in ArcGIS, the Pre-processing Program has several functions for example determination of flow accumulation calculation, flow direction, drainage extraction and so on [26]. By the development of computer and information technology, distributed hydrologic models become research focus, in which watershed delineation based on DEM (Digital Elevation Model) is the key step and priority. Successful and accurate watershed delineation is the precondition of the following runoff, sediment and water quality modelling and credible results [28].

ArcGIS Spatial Analyst contains particular tools for working with and deriving new info from hydrologic and landscape data. The hydrologic modelling functions assistance planners to model where water will flow, create watersheds and drains networks, and derive other hydrologic features.

The ArcGIS Spatial Analyst extension offers a rich set of spatial analysis and modeling tools for both raster (cell-based) and feature (vector) data. The abilities of Spatial Analyst are broken down into categories or groups of related functionality. Knowing the classes will help you identify which specific tool to use. There are numerous ways to access Spatial Analyst functionality. By geoprocessing, operations in the Spatial Analyst toolbox can be achieved through a Tool dialog box, Python (either at an interactive command line interface or with a script), or a Model. Traditional operations and workflows spending Map Algebra can also be performed in the Python environment. There is also a Raster Calculator available for entering simple Map Algebra expressions that generate an output raster [29].

The Hydrology tools are used to model the flow of water through a surface. Information about the shape of the earth's surface is beneficial for several fields, such as regional planning, forestry and agriculture. These fields require an understanding of how water flows across an area and how variations in that area may affect that flow. When modeling the flow of water, users may want to know where the water came from and where it is going. The following matters explain how to use the hydrologic analysis functions to help model the movement of water across a surface, the concepts and key terms regarding streams systems and surface processes, how the tools can be used to extract hydrologic information from a digital elevation model (DEM), and sample hydrologic analysis applications [29].

Watershed modeling is one important component of the project. A crucial stage in data preparation for modeling is delineating correct watershed boundaries for the study watersheds [30]. Watersheds can be delineated in Arc GIS by keeping track of flow direction and amount of upstream points for each grid point in a DEM. When the watershed is delineated it can then be used to crop out data from other layers (e.g. land cover, area, etc.), that are useful in hydrology [31].

Watershed boundaries were resulting from the DEMs using automated processes with the Watershed Delineator (written by ESRI and the Texas Natural Resource Conservation Commission), an ArcGIS Extension that needs the Spatial Analyst extension to be installed as well. The GIS technique for watershed delineation contains of the following steps. First, the “Fill” tool was used to fill sinks in the elevation grid; this removed small imperfections in the data and enabled the “Flow Direction” tool (the second step) to run properly and create a grid of flow direction from each cell in the elevation grid to its steepest down slope neighbor. Then, the “Flow Accumulation” tool was used to create a grid of accumulated flow to each cell from all other cells in the flow direction grid. The next step was to identify the watershed outlet grid, ensuring that was located directly over a grid cell from the drainage network. Finally, the “Watershed” tool was used to delineate the watershed for the specified outlet. Boundaries (in grid format) were defined. Using Spatial Analyst, the watershed boundary and the stream grids were then converted to vector files to produce polygon and polyline themes, respectively, for further analysis and comparison [30].

2.1.2 GSSHA Hydrological Models

The Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model is a distributed, gridded, and physically based hydrologic model [32]. It uses explicit finite-volume solutions of the diffusive wave formulation of the St. Venant equations of motion in two dimensions on a structured grid to simulate overland flow and channel flow in one dimension [33]. The model simulates the hydrologic response of a watershed subject to given hydro meteorological inputs [34]. GSSHA is used because the model explicitly includes the spatial variability of land-surface and hydrodynamic parameters, including subsurface storm drains. Results have indicated that increases in drainage density, particularly increases in density from low values, produce significant increases in flood peaks [35].

GSSHA is a spatially-distributed, physics-based, continuous simulation hydrologic model. Computations in GSSHA are performed on a uniform raster grid which is used to represent the modelled watershed system. Numerous hydrologic processes – such as rainfall distribution, evapotranspiration (ET), infiltration, surface water retention, overland flow runoff, and snowmelt / accumulation – are numerically simulated within each grid cell of the model at a user-defined time step. Although these hydrologic processes are simulated within each individual cell, they are connected through two-dimensional (2-D) overland flow, 2-D groundwater flow, and a 1-D stream network, resulting in simulations of the overall watershed response [36, 37].

GSSHA and the Watershed Modelling System (WMS), which is a graphical user interface (GUI) that provides pre and post processing for the GSSHA model, were the two major components of this project. Both of these programs are continuously being worked on and improved by the U.S. Army Corps of Engineers Engineer Research and Development Centre (ERDC) and Aquaveo, LLC [36]. WMS has a GIS-based user interface and is capable of both pre- and post-processing the digital spatial data necessary for hydrologic modelling and visualization [37].

The aim of this part is to address for urban growth management, namely how it can identification of urban areas located in regions that will be affected by simulated flash floods in the case study area. This section uses the free data source to achieve the above mentioned aim. The findings would be useful to urban planners and decision makers from developing countries where there is generally a dearth of official and high resolution data.

2.2 Method

2.2.1 Identifying the Risk Areas by ArcGIS - Hydrology Tools

Digital elevation models (DEM) as shown in Figure 2-1 are an important source of information in GIS applications. They have been commonly used for modeling surface hydrology, including the automatic delineation of catchment areas [38]. The two most widely applied satellite-derived DEM datasets (SRTM and GDEM) were used in this study. SRTM provides near-global topographic coverage of the Earth's surface with a horizontal grid size of 3-arc-seconds (~90 m). Recently, 1-s (30 m) data for the whole world except the Middle East region were released [39]. Risk assessments and inundation modelling of coastal zones rely heavily on both the accuracy and resolution of digital elevation models (DEMs) [40].

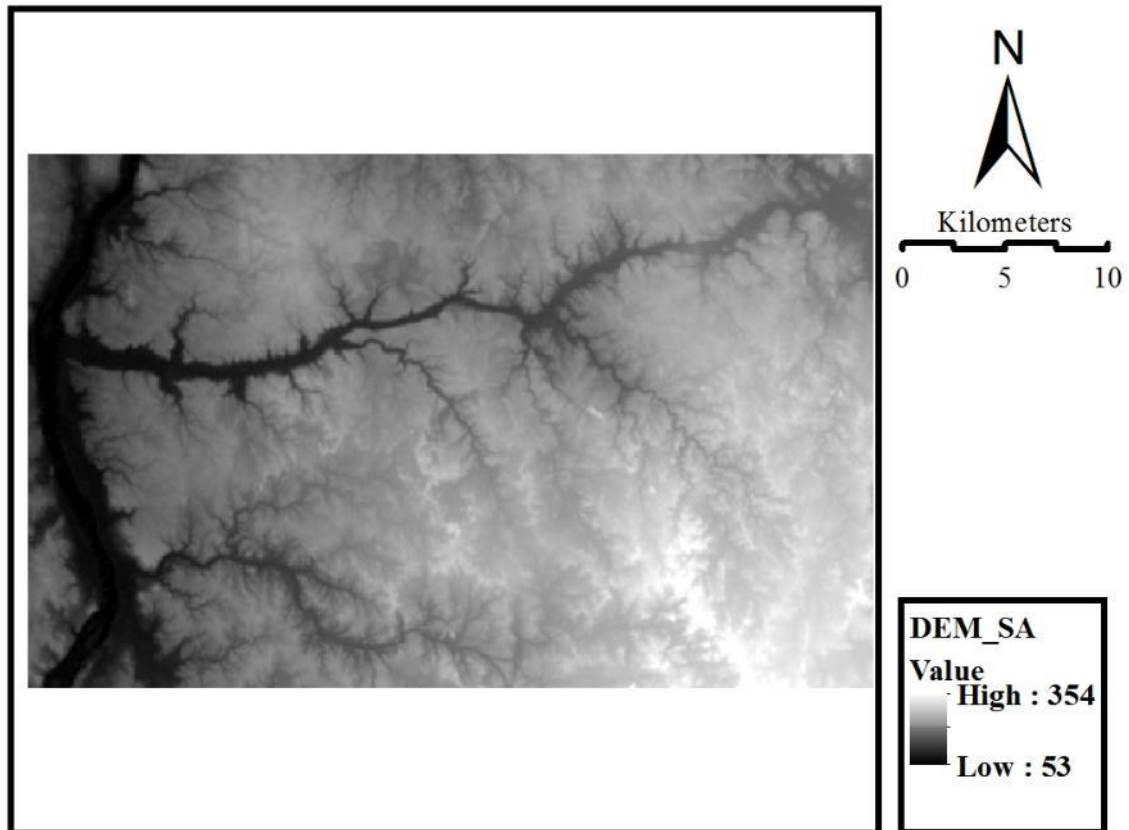


Figure 2-1 Digital Elevation Model File for the case study area.

2.2.1.1 Contour Map Delineation

This method is very quick to identifying the risky areas also it is need only one type of data, mainly to identify the contour map we need DEM file only to through locating the storm water drains from the official bodies of government in addition to using the Digital Elevation Model (DEM), and converting it into a contour map using GIS to get the lowest possible elevations which affected by torrents water.

The software converts scanned maps or images to vector formats for mapping, geographic information systems (GIS), CAD, and technical computing applications. The data in vector format are required for providing elevation values to the contours as depicted in the topographical maps. For

generation of the contour map, each contour line is selected one by one and the elevation value is assigned.

The Construction Contouring toolbar contains a suite of tools that allows to work with digital elevation models (DEMs), automate contour creation by letting us to create contours on multiple raster at the same time, and find the uppermost and lowest points on a map. Before creating contours, we often need to prepare the DEMs that we will use when generating the contours. The Set Consistent DEMs Symbology tool allows us to set the minimum and maximum heights to be rendered so the DEMs are all displayed with the same height values. The Merge and Filter DEMs tool merges individual DEMs into a single new DEM and optionally allows us to apply a filter to smooth the z-values throughout the DEM files. The Create Contours tool creates a contour line feature class. Before creating the contours, we can set options to configure the granularity of the contours to be created and their frequency.

There are several ways to create contours in ArcGIS depending on the version. The Contour tool available on the 3D Analyst toolbar. There is also a geoprocessing version of the tool (for scripting, building models, or single executions) available in Arc Toolbox > 3D Analyst tools > Raster Surface > Contour. If we don't have 3D, we have to have the Spatial Analyst extension. Pre 10, the Contour tool is available on the Spatial Analyst toolbar (similar place as the 3d toolbar) and also in Arc Toolbox. In ArcGIS 10, Contour is only available from the Geoprocessing Environment. For Spatial go to Arc Toolbox > Spatial Analyst tools > Surface > Contour. For access to Contour from 3D Analyst, the location in Arc Toolbox is unchanged from 9.3 to 10.

In this part of methodology we create the contour line every 1 m and chose the lowest level in each individual urban area to identify the maximum area will affected by water surface.

2.2.1.2 Watershed Delineation.

GIS is generally used to support water quantity and quality studies. GIS and digital elevation models (DEM) can be used to make watershed delineation to a point, a reach, or an area of attention, which is usually one of the first steps in such studies. This part presents the methodology that preprocesses the DEM in order to facilitate interactive watershed delineation. Consequently, watersheds can be delineated quickly and with consistent time response, regardless of the DEM size, or the size of the resulting watershed. This methodology used as a basis for interactive basin development in GIS tools for HMS model support [41].

Research methodology tried to determine the risky areas and analyze the urban growth towards this direction depend on the satellite data, it was conducted in several steps. First, we were identifying risky areas through locating the storm water drains using the Digital Elevation Model (DEM) and made different analysis with hydrology toolbox in Arc GIS to get the storm drains and watershed which affected by torrents' water(Figure 2-2). We will use the Spatial Analyst extension in ArcGIS as following steps (Table 2-1).

Table 2-1 The steps to get watershed and water streams from DEM file.

Tool / Step	Description
Fill	This occupation fills the sinks in a grid. If cells with upper elevation surround a cell, the water is trapped in that cell and cannot flow. The Fill function modifies the elevation value to eliminate these problems.
Flow Direction	This function computes the flow direction for a given grid. The values in the cells of the flow direction grid indicate the direction of the steepest descent from that cell.
Flow Accumulation	This function computes the flow accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid.
Stream Link	This tool assigns a unique number to each link (or segment) in the stream raster
Stream Order	Assigns a numeric order to segments of a raster representing branches of a linear network.
Stream to Feature	Converts a raster representing a linear network to features representing the linear network.
Flow Length	This tool uses the flow direction to compute the flow distance or length from each cell to the most downstream or upstream cell in the DEM
Basin	This tool uses the flow direction grid to find all sets of connected cells that belong to the same drainage basin, and assigns the number of cells that belong to a basin to all the cells within that basin
Snap Pour Point	Snaps pour points to the cell of highest flow accumulation within a specified distance.
Watershed	Determines the contributing area above a set of cells in a raster.
Raster to Polygon	convert the watershed raster to a polygon shape file for area calculations or to clip other data sets to the watershed boundary [42].

After made the analyses with hydrology toolbox, we obtained the watershed boundaries and water streams network that affect on the case study area. The watershed is the risky area when the rain is coming; the urban area was included in watershed boundaries it will be at risk from raining water.

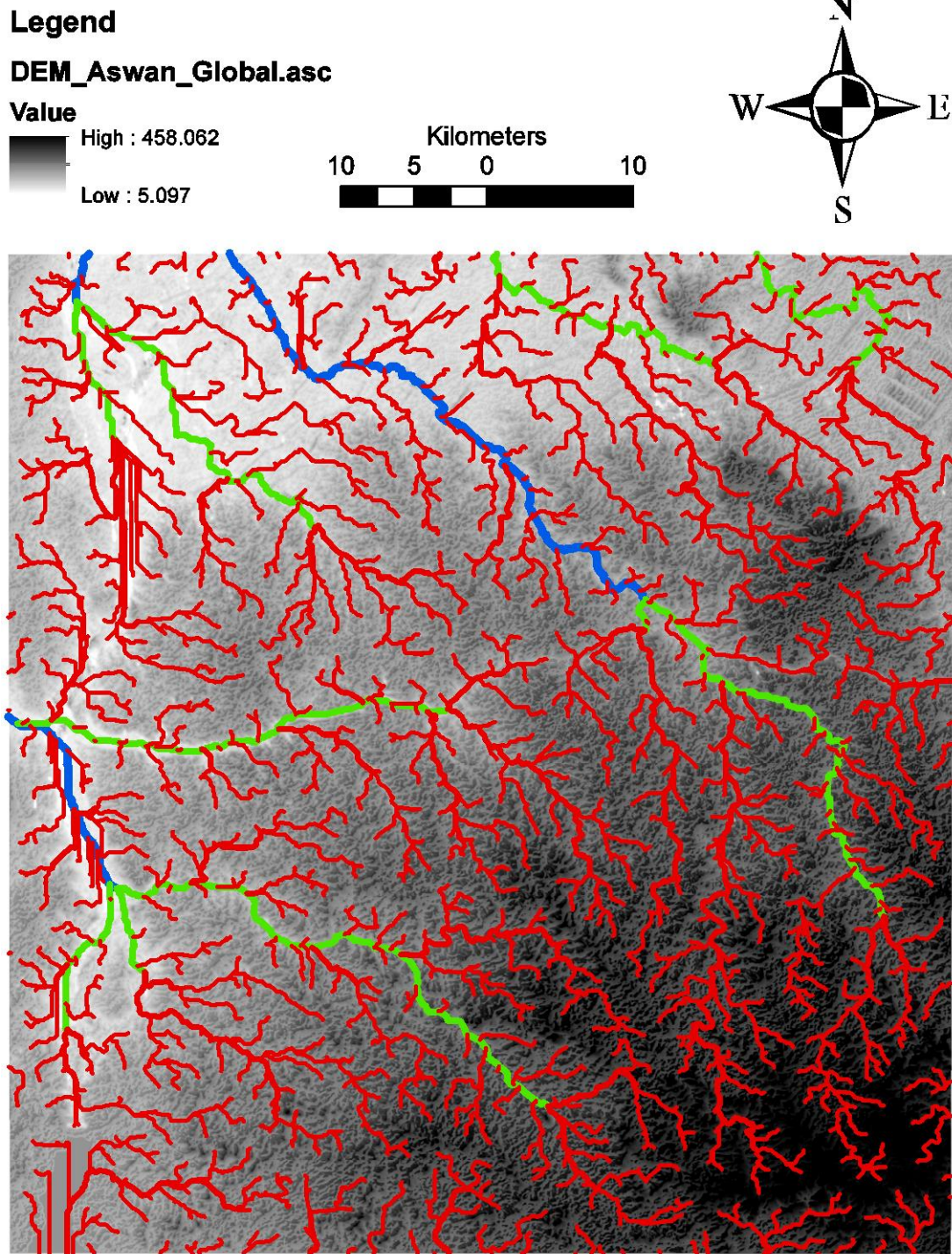


Figure 2-2 DEM file and water streams.

2.2.2 Identifying the Risk Areas by GSSHA Model

The methodology in this section describes how the hazard areas were identified. We had to determine which parts in the case study area would experience flash floods in relation to its distance from the hazard area. To achieve this objective, we used the GSSHA model by WMS software to simulate rainfall and surface water runoff in the case study area. The main output from simulation was the depth map that showed the depth of the runoff. This map could be converted to Arc GIS format to generate a polygon layer for each depth area. In order to make the map simply understandable, a reclassification was performed to define five flood hazard intensity levels/categories—very low, low, medium, high and very high [43].

We used the Arc GIS software to analyses the data from WMS simulation. A detailed plan for case study area was drawn, with an overlay of the urban area which was divided into two sections. One was the risk area where buildings were located in an area subjected to simulated floods of varying degrees, and runoff water at different depths. The second part was the safe area with buildings located outside the hazard zone.

The risk areas were further divided into five parts based on the range of water depth. There were 5 levels of flood hazards: Very Low Hazard with < 0.07 m depth of flood, Low Hazard with 0.07 m to 0.24 m depth of flood, Moderate Hazard with 0.24 m to 0.58 m depth of flood, High Hazard with 0.58 m to 1.09 m depth of flood, and Very High Hazard with > 1.09 m depth of flood [44].

Ogden, Downer, and Meselhe highlight the varied range of hydrologic scenarios that can be accurately simulated using the GSSHA program. GSSHA also allows for individual models to be changed much more readily than other approaches [36]. Besides GSSHA, several more existing numerical models are existing for simulating flood events such as

MIKE FLOOD, CCHE, FLO-2D or TUFLOW. None of the flood models above has been integrated with a GIS such that a user could quickly modify boundary conditions, run and archive a flood simulation for different levee breach scenarios into a geodatabase. In fact, one purpose of this research was to develop such a system [45].

WMS is completely capable of dealing with all kinds of GIS data for hydrologic and hydraulic modelling. WMS provides a commanding set of tools which allows the user to create, import, and manipulate GIS vector and raster data. Numerous hydrologic parameters such as area, mean elevation, slope, maximum flow distance and several more can be auto-computed using WMS. Furthermore, using WMS is the most efficient way to build a GSSHA model. It is a very suitable way to quickly set up the files needed for a GSSHA model. Much of the initial procedure for creating a GSSHA model using WMS can be easily performed using the Hydrologic Modelling Wizard which guides users step by step to create an initial GSSHA model. GSSHA developers have strongly recommended the use of WMS for pre and post processing. . It also makes the visualization of a project extra user-friendly, therefore greatly facilitating the setup of a GSSHA model. For these reasons, WMS was used to create and analyses the model in this study [36, 45].

GSSHA modelling starts with the watershed delineation and characterization which describes the problem domain. Performing distributed hydrologic modelling with GSSHA basically involved the following sequential steps as shown in Figure 2-3. First, the TOPAZ tool was used. This step involved collecting digital elevation data for the watershed of the study area, and computing flow direction and accumulation. Second, watershed model Infiltration was examined.

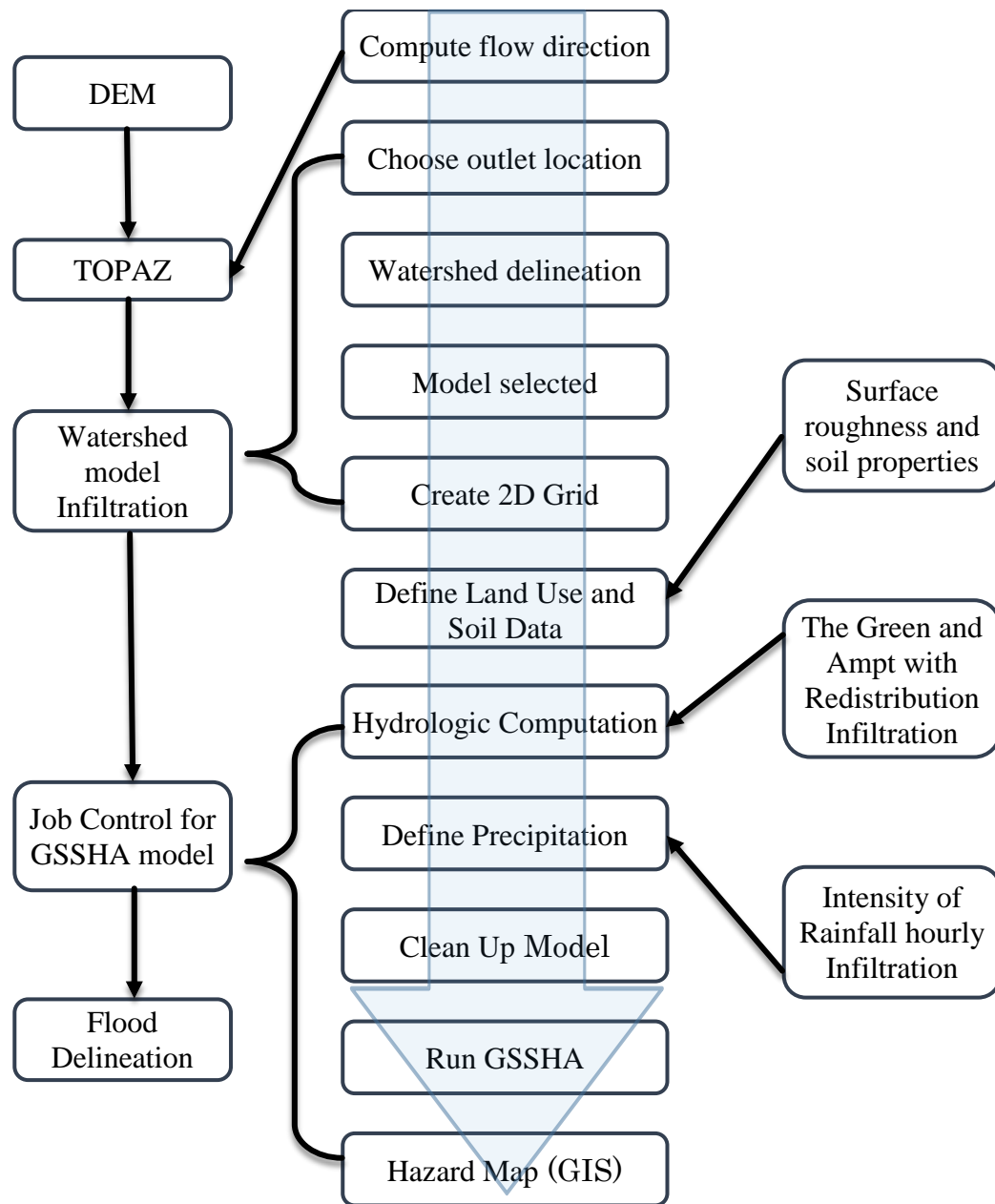


Figure 2-3 Simulation steps.

There were four processes were in this step: (i) selecting an outlet location, (ii) delineating the watershed, (iii) initializing the Model, and (iv) creating a 2D grid. The third step was defining job control parameters for GSSHA. There were three parameters for each of the respective functions, namely creating index maps from land use and soil data, establishing initial parameter values for the index maps, and defining precipitation. After undergoing all these processes, the model was cleaned up before running model. The final step was creating the hazard contour map in Arc GIS using the WMS data based on the depth of water [46].

2.2.2.1 Collecting DEM for the Watershed of Interest Area

This tool lets the user to specify the extent of the area of interest and the resolution of data, previously downloading the data straight from the USGS through web services. Furthermore the DEM, land use, and soil type data were necessary to classify runoff and infiltration parameters. Soil type data were collected from Soil Data Mart at soildatamart.nrcs.usda.gov [47]. Table 2-2 shows all data sources which used in simulation.

Table 2-2 Data used in flood simulation

	Data Source
Detailed plan	General Organization for Physical Planning - Aswan
DEM file	U.S. Geological Survey (USGS) Website
Land Use map	USGS Land Cover Institute
Soil Type map	Food and Agriculture Organization of the United Nations(FAO) Digital Soil Map of the World (DSMW)
Precipitation	Master Thesis http://www.cpas-egypt.com/ [48]

2.2.2.2 Land Use and Soil Data

Land cover data were determined by the USGS Land Cover Institute database and soil type was defined by the FAO classification. Using these two sets of data we were able to build coverage and index maps. The main goal of creating index map table was to deal with the different hydrological parameters of land cover and soil in the watershed. So each grid cell was assigned different parameters depending on its land cover and soil type [49]. Figure 2-4 and Figure 2-5 shows the land use and soil type maps.

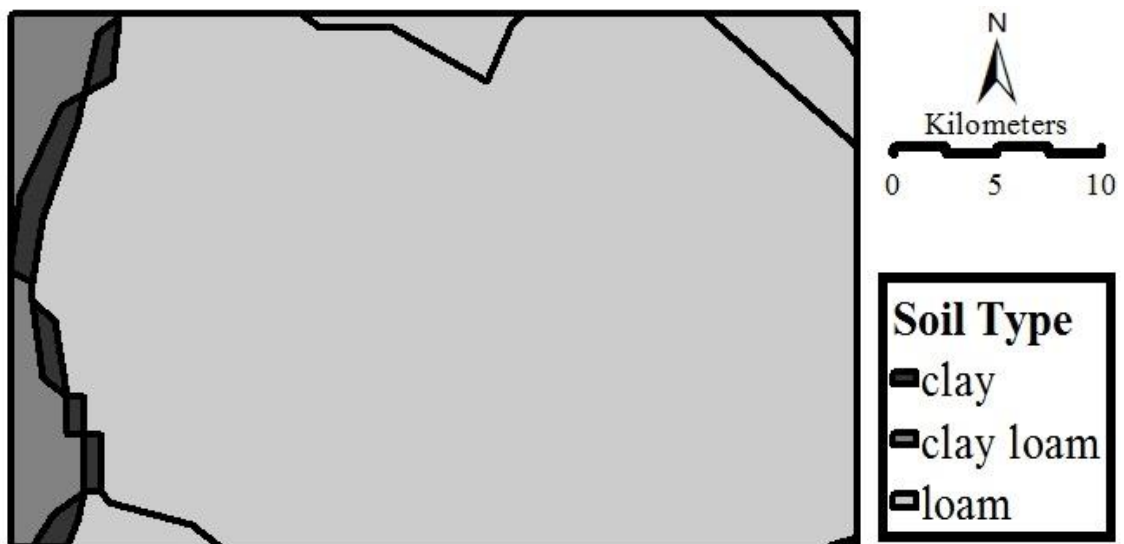


Figure 2-4 Map showing soil type.

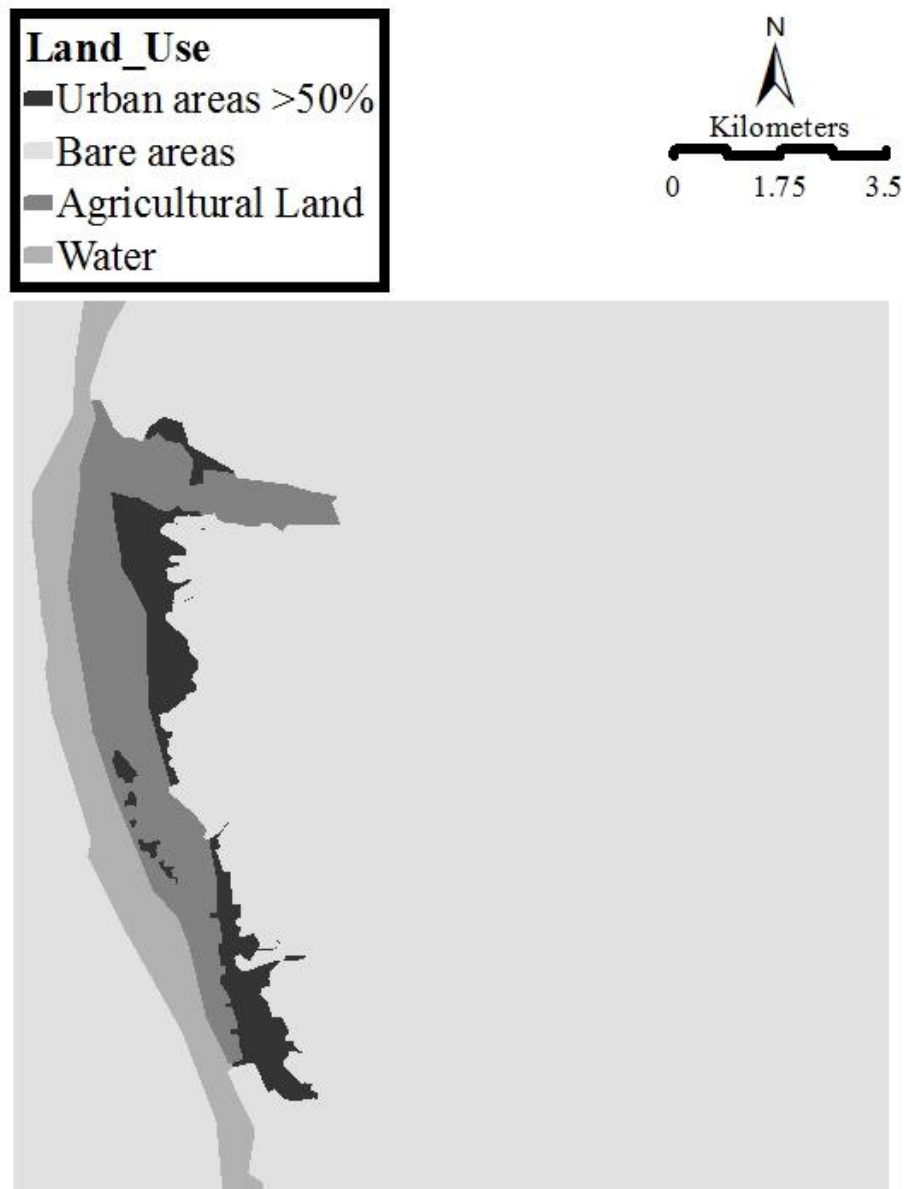


Figure 2-5 Map showing land use.

2.2.2.3 Hydrologic Computation

Assigning Map tables will allow the user to provide to each grid cell hydrological value parameters using the two index maps created before (Soil Type and Land Use). The hydrological properties for this study of long term simulation are: surface roughness, initial moisture, infiltration, and evapotranspiration. All processes are described below.

2.2.2.4 Surface Roughness

The different values given concerning the roughness Manning coefficient of the basin is defined according to the GSSHA wiki. A Manning roughness coefficient is given to each different land cover present in the watershed area. The GSSHA wiki is an excellent source for many of these values and it is where they were found for this project. The first mapping table to fill in is the roughness mapping table [36]. Figure 2-6 shows the values of surface roughness for study area.

Roughness				
ID	11	190	200	210
Description1	Post-floodin...	Associated ...	Bare areas	Water Bodies
Description2				
Surface roughness	0.200000	0.500000	0.010000	0.100000

Figure 2-6 Surface Roughness Values.

2.2.2.5 Infiltration

As definition infiltration is the process of water penetrating from the ground surface into the soil. The factors that affect infiltration are: soil texture, initial soil moisture, soil layering, vegetation, macro-pores and location of the water table as shown in Figure 2-7.

Infiltration	
ID	1
Description 1	Infiltration ID
Description 2	
Hydraulic conductivity (cm/hr)	0.606576
Capillary head (cm)	8.890000
Porosity (m^3/m^3)	0.463000
Pore distribution index (cm/cm)	0.252000
Residual saturation (m^3/m^3)	0.027000
Field capacity (m^3/m^3)	0.270000
Wilting point (m^3/m^3)	0.120000

Figure 2-7 Infiltration values.

2.2.2.6 Initial Moisture

Initial moisture refers to the percentage of water volume already contained in the soil. Initial moisture values vary according to dissimilar parameters. Since the two main factors were the type of soil and seasonality, the values differed over time. One rule for selecting the value of the initial moisture is that it would not be larger than the porosity of the soil, as shown in Figure 2-8.

Initial Moisture	
ID	1
Description 1	Soil moisture...
Description 2	
Initial moisture	0.310000

Figure 2-8 Initial moisture values.

2.2.2.7 Rainfall Values

Assigning uniform rainfall values over the whole watershed was maintained mostly as a trouble-shooting feature and was regularly used in initial model development. For spatially and temporally constant rainfall, the input parameters were: 1- Rainfall Intensity (mm/hr.), 2- Rainfall Duration (minutes). For the first parameter, this section completed the simulation in the worst case scenario during which the rainfall intensity equaled 25 mm/hr. [50]. While rainfall duration in Egypt can be from one to four days, the minimum duration of one day (1440 minutes) was selected for the second parameter to obtain the smallest area that would be of risk [47].

2.3 Results

In this chapter the research tried to find different methods to identify the risk area, those methods has many benefits especially for planners and decision makers in development countries, the first one those methods are very easy access and common use by very famous software such as ArcGIS, Second benefit is all data which used in this part is free data.

We used three methods in this part, one of them is using the simulation software and GSSHA model to simulate the flash flooding and surface runoff water, the others two methods depend on analyses the Digital elevation model (DEM) files to determine the risk area by using Arc GIS Tools, in the following points will show this results.

2.3.1 Identifying the Risk Areas by ArcGIS - Hydrology Tools

As a result of DEM analyses the research could be able to identify the lowest level of elevation it can be more risk than others to receive the surface run off water Subsequently this area will be the most urban area has chance to be risk area threaten by torrents.

2.3.1.1 Contour Map Delineation

Urban areas in the case study were divided into two groups, depending on the location from low level contour boundary prone to flash floods. The first group was located in a safe area about 126.71 ha, free from flash flood water as the expected elevation level was high; the second group was about 57.96 ha, and was located in an area at risk of being inundated at different levels. All the risk area was located in area has lost elevation area, it was less than 85 m contour level from the sea level which is the lower level contour areas. Figure 2-9 shows the lower level contour area it has more ability to be under risk.

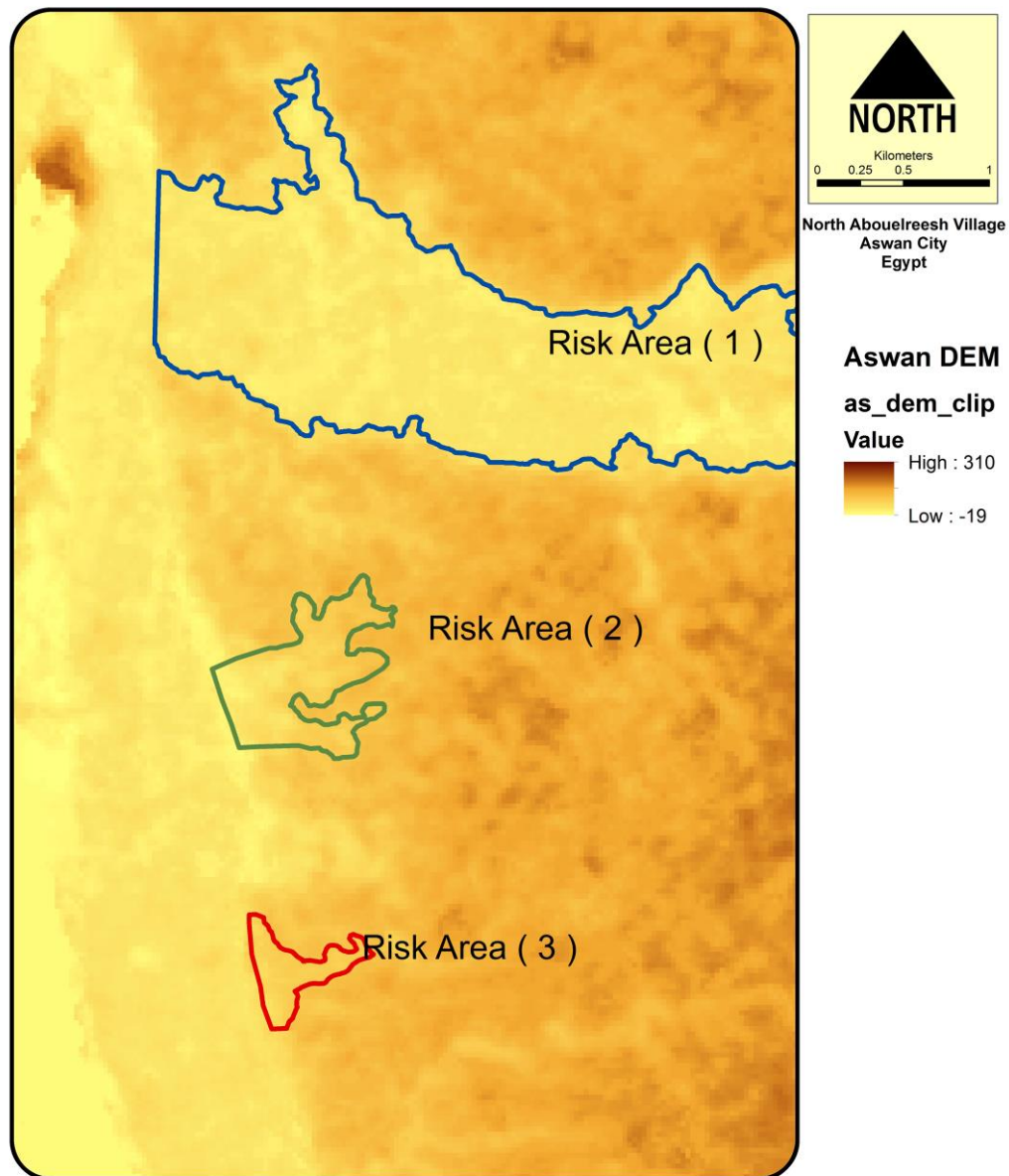


Figure 2-9 low level contour under risk of torrents

Urban areas in the risk area was distributed according to three categories as shown in Figure 2-10. In the risk area, land allocated in first Risk Zone was the biggest category, occupying 26.71 ha or about 46.08 % of the total risk area, the second category was the urban area which located in Second Risk Zone it occupied 20.88 ha or about 36.02 %, while Urban areas in third Risk Zone was the smallest category (17.90 %) in the risk area all these results it can be observed in Table 2-3.

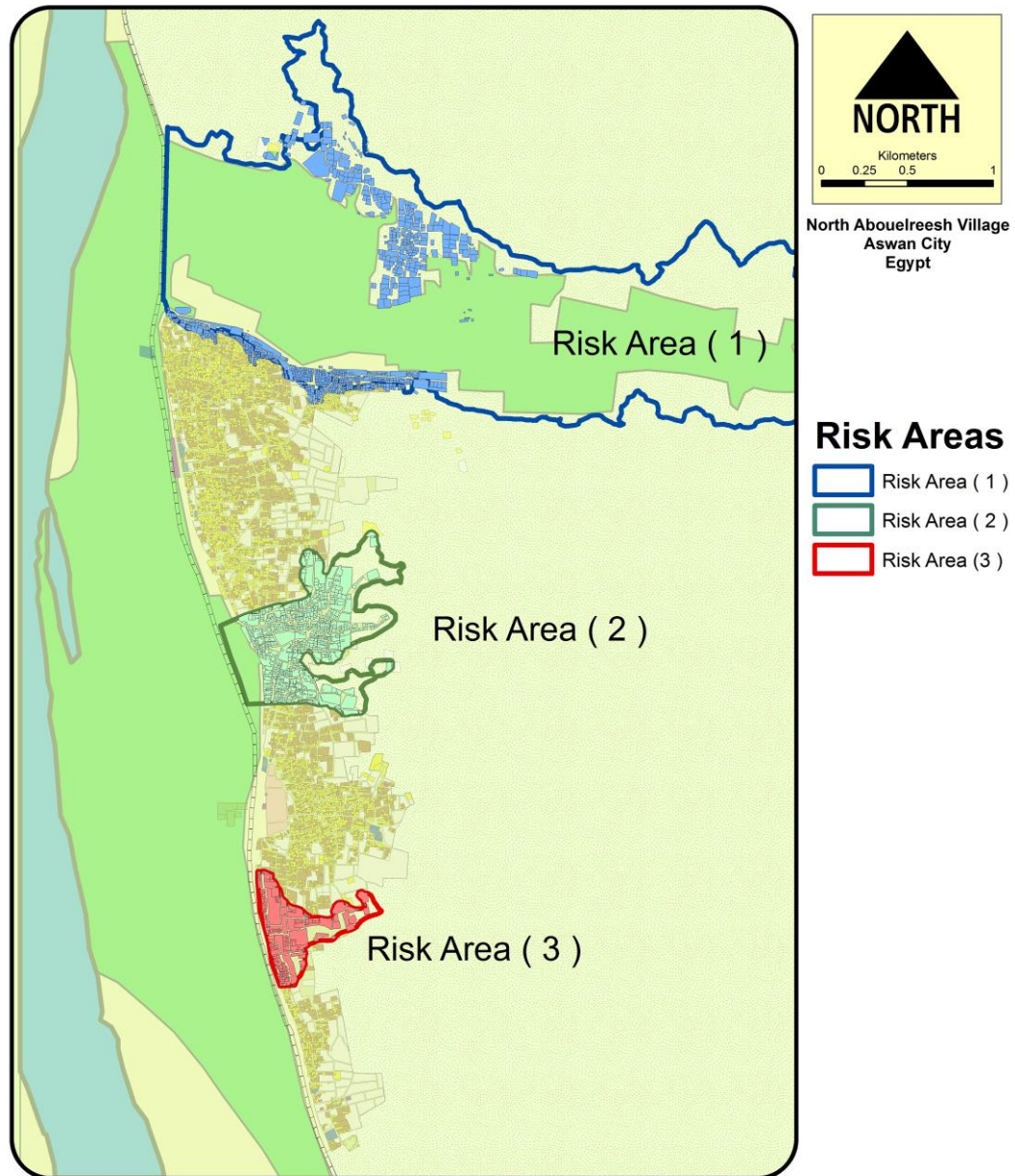


Figure 2-10 Three parts from the Urban area located in risk area

These statistics indicate that the urban area in risk zone number one formed the largest category of risk urban area (173.01 ha). Unfortunately, big ratio from urban area (31.39%) were in the risk area.

Table 2-3 the urban area in risk zone statistics.

	Urban Area (ha)	Percentage %
Risk Zone (1)	26.71	46.08 %
Risk Zone (2)	20.88	36.02 %
Risk Zone (3)	10.37	17.90 %
Total Risk Area	57.96	31.39 %
Total Safe Area	126.71	68.61 %
Total Urban Area	184.67	100.00 %

2.3.1.2 Watershed Delineation.

Urban areas in the case study were divided also into two groups, depending on the distance from watersheds area. As shown in Figure 2-11 the first group was located out of the watersheds in this area, this category was named a safe area it was about 77.26 ha, free from flash flood water as the expected no chance to affected by surface runoff water more over the stream drain has no impact on this areas as shown in Figure 2-12 ; the second group was about 107.41 ha, and was located in an area at risk of being inundated at different levels. All the risk area was located in watershed areas.

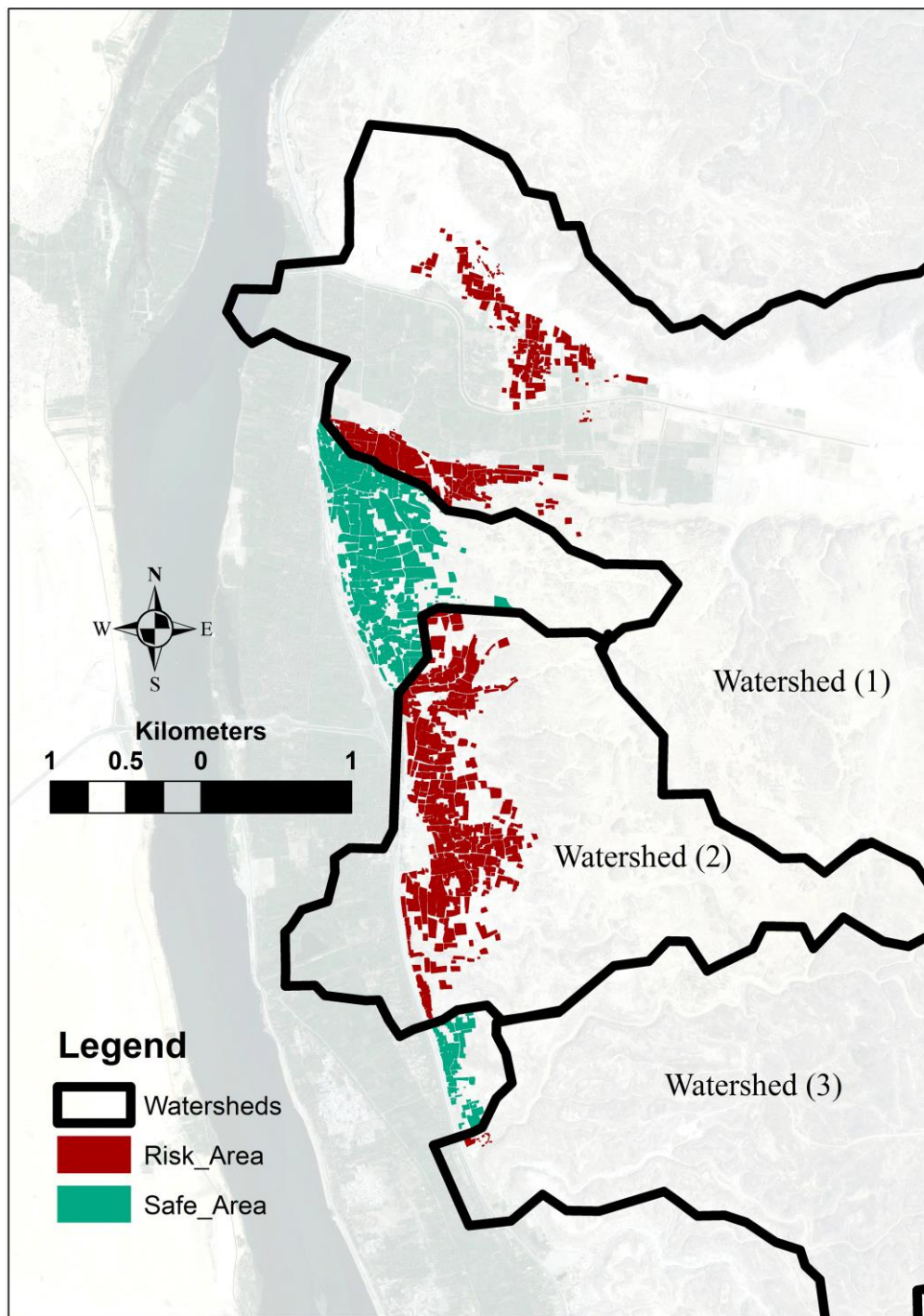


Figure 2-11 Watersheds divided the urban area to two groups.

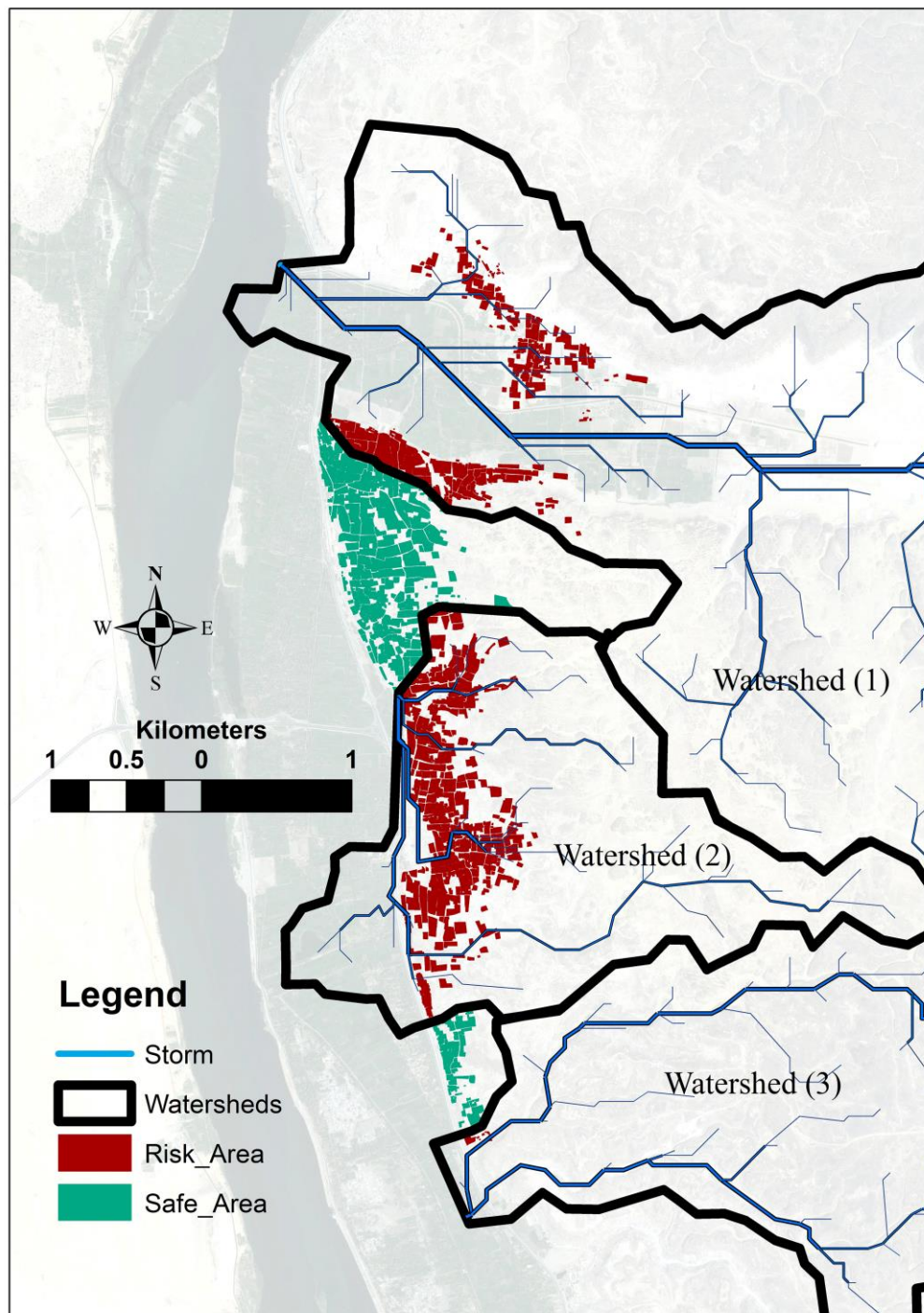


Figure 2-12 The watershed with stream drain.

Urban areas in the risk area was distributed according to three categories based on the watershed name as shown in Table 2-4. In the risk

area, land allocated in second watershed was the biggest category, occupying 67.75 ha or about 63.07 % of the total risk area, the second value was the urban area which located in first watershed it occupied 39.19 ha or about 36.49 %, while Urban areas in third watershed was the smallest category or ignored value (0.44 %) in the risk area.

These statistics indicate that the urban area in second watershed formed the largest category of risk urban area (107.41 ha). Unfortunately, biggest ratio from urban area (58.16 %) were in the risk area.

Table 2-4 The watershed risk area statistics.

	Urban Area (ha)	Percentage %
Watershed (1)	39.19	36.49 %
Watershed (2)	67.75	63.07 %
Watershed (3)	0.47	0.44 %
Total Risk Area	107.41	58.16 %
Total Safe Area	77.26	41.84 %
Total Urban Area	184.67	100.00 %

2.3.2 Identifying the Risk Areas by GSSHA Model

Data from the simulation exercise such as peak discharge rate, volume of rainfall and volume remaining on surface provided useful insights into how water flow might be predicted. Information on the relationship between time and water flow helped to identify the peak of the simulated crisis. From the results of the simulation where water depth was estimated every 15 minutes, water depth at peak runoff for each watershed could be determined. The water depth file (raster) was converted from WMS to ArcGIS for analysis. The first step in ArcGIS was converting the raster file of water depth to a vector file, followed by the division of the water depth to

five categories of hazard: Very Low Hazard, Low Hazard, Moderate Hazard, High Hazard, and Very High Hazard. The next step was assigning new attributes in the urban area data file for each building to depict the level of hazard, based on its location from the hazard level contour, as shown in Figure 2-13. The urban area divided into two parts (risk area and safe area) is shown in Figure 2-14.

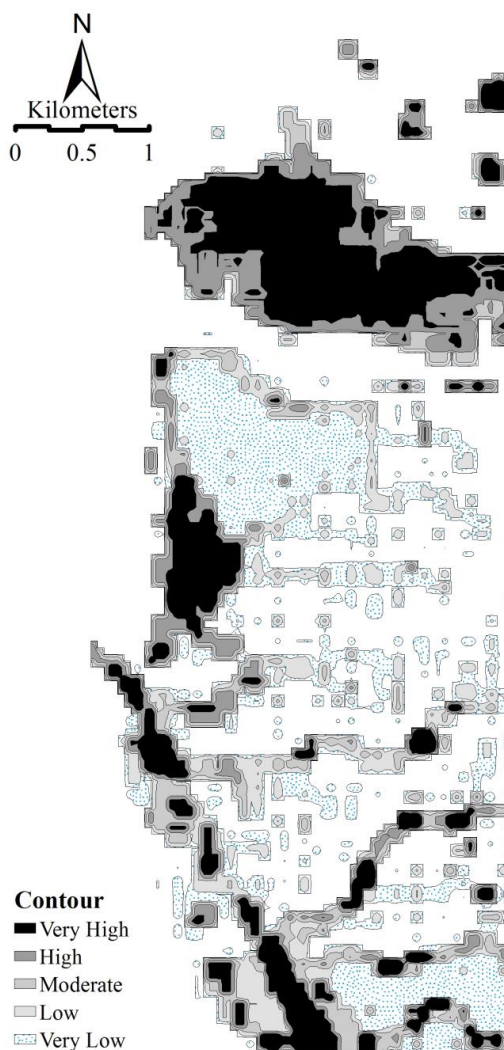


Figure 2-13 Contour lines for Hazard depth.

Figure 2-14 Urban area Hazard distribution.

Urban areas in the case study were divided into two groups, depending on the distance from areas prone to flash floods. The first group was located in a safe area about 72.18 ha, free from flash flood water as the expected water depth was zero; the second group was about 112.49 ha, and was located in an area at risk of being inundated at different levels.

The hazard region was divided into five areas based on the degree of exposure to the risk of flash floods. As shown in Table 2-5, during the study period, most of the areas at risk within the urban region (63.70 ha) were categorized as having exposure to very low hazard risk, while the urban areas categorized as more hazardous took up 48.78 ha. (Low hazard - very high hazard).

The final observation was that the urban regions that were built in areas rated high hazard or very high hazard took up about 20.26 ha from the total area of about 112.48. This meant that more than 18 % of the urban risk area was located in high and very high hazard areas.

Table 2-5 The hazard region division.

	Urban Area (ha)	Percentage %
Very Low Risk Area	63.70	56.63 %
Low Risk Area	21.50	19.12 %
Moderate Risk Area	7.03	6.24 %
High Risk Area	10.66	9.48 %
Very High Risk Area	9.60	8.53 %
Total Risk Area	112.49	60.91 %
Total Safe Area	72.18	39.09 %
Total Urban Area	184.67	100.00 %

2.4 Conclusion

The chapter gives three different methods can help in identified the risk area which it was prone to flash floods, all these methods depend on the free and easy access data especially Digital Elevation Model (DEM) files that can be downloaded easily from internet.

Methods used ArcGIS - Hydrology Tools that can gives fast tool to identify the risk area but still it has primary estimation because depends on single source of data , also it doesn't take into account the land use maps and soil maps when study or identify the risk area.

The other method is describes how the hazard areas were identified by using the GSSHA model in WMS software to simulate rainfall and surface water runoff For this part we can recommend two methods to verify the simulation, first one use the same data with other hydrological software such as MIKE FLOOD, CCHE, FLO-2D or TUFLOW, the second recommendation is using filed study data and high resolution data with the same software and model such as DEM, Soil Type and Land Use map, those kind of data doesn't obtainable on undeveloped countries and need very big budget for researches.

The use of free data in torrents simulation can generate primary results close to real live situations. The method would be helpful to decision makers and planners in countries which do not have enough data or do not have sufficient funding to bid for development projects, especially if it is necessary to perform simulations of the potential site to avert the threat of natural disasters. It would be most useful if more precise data were available to enable more accurate simulations so that the analysis of the hazards in the risk area would yield more reliable data. This would make a considerable difference in the appraisal of the area for proposed development.

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**CHAPTER THREE
GROWTH OF URBAN AREA
FROM PAST TO FUTURE**

Chapter 3

Growth of Urban Area from Past to Future

3.1 Introduction

Urban sprawl usually leads to the change of land use at several areas around the world, especially in developing countries [1]. Furthermore, urban areas have a natural extension in numerous directions, even sometimes they tend to sprawl towards places threatened by natural disasters. Hence, the governments' decision makers and planners should solve this problem through risk management and prevention of urban sprael in that direction with the provision of different alternatives. Moreover, changing the urban areas is considered to be an indicator of urban growth, in terms of growth rate and direction. The urban areas include urban groups of buildings, roads, areas of services, and land space [2].

For example, the growth of urban areas relies on the population growth and constructions in a city. This kind of metrics methods what is present and the householders' relative quantities or properties regardless to

where on the landscape they may be positioned. Consequently, the analyst should be aware about the spatial / non-spatial nature of the particular metrics [3].

Growing of urban sprawl is a serious concern in the world for a many of environmental and economic reasons [4]. Speedy increase of urban sprawl in numerous countries in the world had become a major concern because of its detrimental effects on the environment. Current measures of urban sprawl suffer from a confusing variety of differing and sometimes contradictory interpretations of the term “urban sprawl” [5].

City landscapes have been rapidly changing in the last few years in response to faster population growth and the transition from rural to urban areas [6]. According to United Nations reports, urban population will rise by 1.35 billion by 2030, at which period the population in urban areas in the world will be around 5 billion. It is prediction that worldwide urban land will increase by 1.2 million km² by 2030, which will be closely triple the global urban land area circa 2000 [7]. Furthermore, urban areas have a natural extension in numerous directions, even sometimes they tend to sprawl towards places threatened by natural disasters. Hence, the governments’ decision makers and planners should solve this problem through risk management and prevention of urban sprael in that direction with the provision of different alternatives

An indicator of urban growth in terms of growth amount and growth direction, urban sprawl is also a kind of low-density development with shopping, residential, and office areas. Actually, any form of suburban growth should be counted as urban sprawl [8]. Urban sprawl is nowadays one of the furthestmost extensively discussed issues in urban studies [9]. The encroachment of urban land usages on non-urban land has become a

common phenomenon throughout developing countries, and its impact has attracted increasing attention from planners and policy makers [8].

By the 1970s, urban sprawl was not only gotten as an incompetent pattern of urbanization but also as a phenomenon that injured inner cities, and consequently it had to be brought under stricter control [10]. By the 1970s, urban sprawl was not only gotten as an incompetent pattern of urbanization but also as a phenomenon that injured inner cities, and consequently it had to be brought under stricter control [7].

The phenomenon is mostly driven by unorganized growth, increased immigration, and rapidly growing birth rate [11]. Coupled with unplanned developmental activities, this has caused in the growth of several new urban areas that lack adequate infrastructure facilities [11]. Determining the trend and the rate of urbanization is bubbly to the establishment of rational land use policies [12].

Clarke et al., 1997, and Dubovyk et al., 2011 [13, 14] emphasized the importance of spatiotemporal analysis of urban sprawl and why the changes in landscape have lately received more attention. Policy makers in megacities face unprecedented challenges with esteem to governing, urban planning, and land use management because of the prevailing high dynamic growth. Consequently, knowledge concerning previous, current, and future growth plays an significant role in the decision-making process [15]. The annual expansion rate of the urban population is projected at 2.2 percent until 2050, exceeding the 1.8 percent annual expansion rate of the entire population [16].

Urban sprawl in Egypt is astounding as the magnitude of urban land expansion in Egypt has been much bigger than the urban population growth in the past 50 years [17]. This has caused in a large loss of arable land to

resistant land surfaces. In addition, the conversion from agricultural land, water areas, or grassland into urbanized land, combined with urban difficulties such as waste water discharge and vehicle exhaust emissions, has really disturbed the ecological equilibrium in urban areas [18].

Previous studies have mainly focused on single big cities, with few explorations of the spatiotemporal differences in driving forces of urban sprawl of different cities in the same organizational region [19]. This study aims to fill this gap and focus on small urban area or village scale.

3.1.1 Google Earth High Resolution Imagery

While some researchers have newly begun using this rapidly expanding, cost-free imagery source, the Google Earth (GE) provides high-resolution imagery archive that remains a chiefly unexploited resource for the scientific analysis and explanation of the Earth's land surface [20]. Google Earth is an significant development for the science community as it provides a trove of free geo-referenced and high resolution images that continue to enhance with increased spatial and temporal depths [21]. Furthemost high resolution image existing in GE is concentrated around urban areas, rivers, roads, and areas of economic interest [21]. Imagery at these resolutions lets observers to readily discriminate between main natural land cover classes, and to discern components of the constructed environment, such as industrial facilities, individual houses, and roads [20].

GE provides a commanding tool for viewing global imagery with combined GIS data, maps, and graphics. Also it can provide te identifying borders and streets, zooming in/out, placing labels, and viewing historical archived data amongst other tools [22]. One thrilling way in GE is to look at changes in land cover over time. Historical Imagery is a new map show

option in GE 5.0 [23]. Furthermore, a new capability of the GE plug-in (v6) is access to historical imagery with a time slider [21]. Although GE provides historical imagery of nearly to an endless number of places around the world, the United Nations' paired imagery is particularly useful for this exercise because it has been selected to represent a variety of causes of landscape change [24]. GE nowadays hosts high-resolution (< 2.5 meter) imagery from 2000 to 2010, with most images being from 2003 to 2007 [20, 21].

Google Earth high resolution images offers numerous important features for land-use/land-cover (LULC) mapping in that they: (1) are free for non-profit use, (2) stream quickly to the web browser from Google's server, even with relatively slow Internet connections, (3) have sufficient spatial and color details to distinguish basic LULC classes at multiple spatial scales, (4) are geo-referenced with sufficient accuracy for LULC mapping, (5) are distributed across the globe and cover a wide range of LULC classes, including those that are relatively small areas of the landscape, and (6) range in date from 2000 to the present, allowing temporal sampling [21].

Manual photointerpretation has the benefit of identifying real world items rather than the image objects extracted in object-based classification methods. The image interpreter may be better able to identify and to discriminate between the real world objects based on context, relationships to neighboring objects, and multifaceted variations in tone, color, and pattern [25]. Numerous recent studies have used visual interpretation of high resolution imagery in the GE desktop software to provide low-cost and reasonably accurate reference data, both for creating land-cover maps and testing their correctness [21]. Despite advances in automatic and semi-automated classification for instance geographic object-based image analysis, manual photointerpretation still remains, to be a good extent, the

process of choice for producing fine-scale forest and land-cover maps that cannot be complete in automated extraction [25]. It is strongly recommended to consult the GE historical imagery to help in identify the feasibility of studies on coastal landscape growth [26]. It might be the only suitable approach for identifying such diverse and fine-scale urban land use as urban agriculture, particularly on the scale of the home garden [25].

3.1.2 Driving Forces

Understanding the driving mechanisms of urban land spatial expansion (ULSE) is critical for the guidance of rational urban land growth, it is required to develop effective planning and management plans, and its foundation is the explanation of the driving mechanisms of urban land expansion. Previous studies have mainly focused on single big cities, with few explorations of the spatiotemporal differences in driving forces of urban sprawl of different cities in the same organizational region [19]. This study aims to fill this gap and focus on the small urban area or village scale.

Urban growth modeling goals to understand the dynamic procedures, and therefore interpretability of models is becoming crucial. Clarification of statistical models is desirable for gaining knowledge of the processes driving the change of spatial patterns [27].

The research methods of urban land expansion driving forces mainly include Multiple Linear Regression (MLR) [28], Structural Equation Modeling (SEM) [29], Analytic Hierarchy Process (AHP), System Dynamics (SD) [30], Artificial Intelligence [31], Logistic Regression (LR), etc. Among these, MLR and SEM are mainly applied to the area expansion of urban land, SEM is a specific type of regression analysis and explains relationships between independent (exogenous) and dependent

(endogenous) variables [29]. However, they are not applicable when dependent variables are categorical variables, or variables with spatial attributes [32].

The AHP method has been commonly used in several socioeconomic and engineering applications [33]. AHP is an appropriate method for deriving the weight allocated to each factor [34]. The AHP also lets decision alternatives to be prioritized using pairwise comparison [35]. Though, it is difficult to achieve pairwise comparison for raster data because of big number of alternatives [35]. Also the AHP is not efficient neither in evaluating a large amount of alternatives nor in selecting performance frontiers [36].

The SD model is mainly suited to the investigation of socio-economic driving factors and the simulation of complex systems [37]. Moreover, it can be joined to cellular automata to contain spatial dynamics [30], but it still has struggle in identifying factors and their effects [38]. However, it also has disadvantages in revealing the spatial pattern change of urban sprawl, and in including those spatial variables influencing urban expansion into modeling [37].

Recently, spatio-temporal models have become accessible. The integration of Remote Sensing (RS), Geographical Information Systems (GIS), and Spatial Statistics (SS) consequently provides a powerful and balancing suite of techniques for the monitoring and modeling of urban sprawl. The strength of these approaches is that they take the spatial correlations into account when explanation the variations in urban sprawl. Spatial models can be more effective in modeling urban sprawl when prior information about the spatial and temporal characteristics of urban development can be applied [16, 17].

Artificial intelligence algorithms are very accomplished of capturing urban land use and handle to an upper degree spatial heterogeneity well [31]. Approaches and techniques from artificial intelligence are used for the spatiotemporal analysis, the prediction of future trends and the development of urban regions [39]. Neural network modeling needs greater computational resources [40]. A neural network model is a comparative “black box” in comparison to a logistic regression model [41].

Regression is a method to determine the empirical relationships between a binary dependent and numerous independent categorical and continuous variables [42]. Logistic regression might handle the regression problems of dependent variables as non-continuous variables, which need no linear relationship between dependent and independent variables. When integrated with GIS, it could effectively reflect the variables' spatial characteristics, and can be used to driving forces analysis and prediction of land use change [43].

3.1.3 Land Change Modeler and Logistic Regression

In this study, in order to identify, quantify and analyze the changes, post classification change analyses by ArcMap and ‘Land Change Modeler’ in IDRISI®Selva have been employed [44], LCM module offers quantitative assessment of category-wise land use changes in terms of gains and losses with respect to each land use class [45].

The acquired data of the study area were handled and analyzed using GIS and RS techniques to obtain data for environmental and urban growth monitoring [44]. Empirical estimation models use statistical techniques to model the relationships between land use changes and the drivers based on

historic data. As an empirical estimation method, logistical regression has been used in deforestation analysis [27].

Logistic regression analysis was showed to reveal the relationship between urban sprawl and the driving factors of socioeconomic and biophysical factors [46]. Logistic regression models are developed to originate a land use change probability surface [47]. Logistic regression analysis has been one of the most regularly utilized approaches throughout the past two decades for predictive land use modelling thru means of variation of inductive modelling [48]. Thereby, it is crucial to consider spatial effects, namely spatial autocorrelation and spatial heterogeneity, to challenge regression assumptions [49]. However, the logistic regression model suffers from the quantification of change and temporal analysis [43].

Empirical statistical approaches such as logistic regression or hybrid geospatial methods have been conducted to investigate the reciprocal spatial-temporal effects of urban expansion and its possible driving forces [50]. LR analysis was conducted to reveal the relationship between urban sprawl and the driving forces of socioeconomic and biophysical factors [46], based on historic data [27].

The logistic regression-based Cellular Automata (CA-LR) model was first projected by Wu (2002) [51]. This hybrid approach, which was also implemented by Paulmans and Van Rompaey (2010) [52], helps to overcome the main limitations of logistic regression, which is the inability to quantify spatial and temporal changes (Arsanjani et al., 2013) [48], and of the CA approach that oversimplifies urban reality and does not provide enough evidence for informed urban planning [53].

3.1.4 Future Urban Sprawl

Observing future urban sprawl offers a picture of where sprawl is occurring, and aids to discover the environmental and natural resources threatened, and proposes the expected future directions and forms of sprawl, moreover helping in understanding the nature of this phenomenon. The power to manage urban sprawl is located in local municipal governments that vary significantly in terms of capability to address informal urbanization issues. An approach is thus required to aid assessing the haphazard urban sprawl phenomenon, trying to estimate future urban sprawl, and evaluating planning acts' influence of the hinder/ increase of urban sprawl at the cost of agricultural areas. This will offer infrastructure for complex urban environment, and updated information related to the sprawl dynamic processes within Aswan in Egypt.

Urban sprawl monitoring and modelling has been an important theme in academic world to improve and adjust theories of urban morphology [54, 55]. There is still an lack of combination between most dynamic simulation models and socioeconomic drivers. Tools such as city evolution trees presents a new method to examine urban sprawl on a global scale [56]. The agent-based models displays the latest technique to model the influence of the behavior of individuals on LUC [57, 58]. Alternative urban modelling methods depend on a set of fixed assumptions and approaches [59], for example cellular automata (CA) [60, 61], Markov chain (MC) models [62, 63], logistic regression (LR) model, rule-based models [64], and learning algorithms [65]. A variety of studies have been conducted in LUC science and each of these studies showed tried to show advantages and disadvantages of each LUC model.

3.1.4.1 CA-Markov Chain Model

Cellular automata (CA) were presented by Ulan and Neumann in 1940 and since 1980 many models have been developed for simulating urban growth [66]. CA are defined as discrete dynamics systems, represented by a grid of cells, in which local interconnected relationships exhibit global changes [51].

The applications of CA is used widely in the urban sprawl modelling studies [13, 67], specifically, have gained an increasing importance as urban areas have increasingly expanded and spatial data becomes further available for empirical research to be carried forth. While cellular automata for urban sprawl maintain usually similar outlines regarding testing, assembly, validation and calibration, some conceptual issues arise regarding the modelling techniques used [68].

As Figure 3-1 indicates, a wide variety of algorithms has been incorporated in Urban Growth Prediction Models (UGPMs) with cellular automata tested in the majority of the reviewed manuscripts [69]. Subsequently, these theoretical approaches found real world implementations. A large number of applications have incorporated CA for UGPM development using real data [30, 37, 69]. A combination of CA with Markov models has also appeared in multiple studies [48, 70-72].

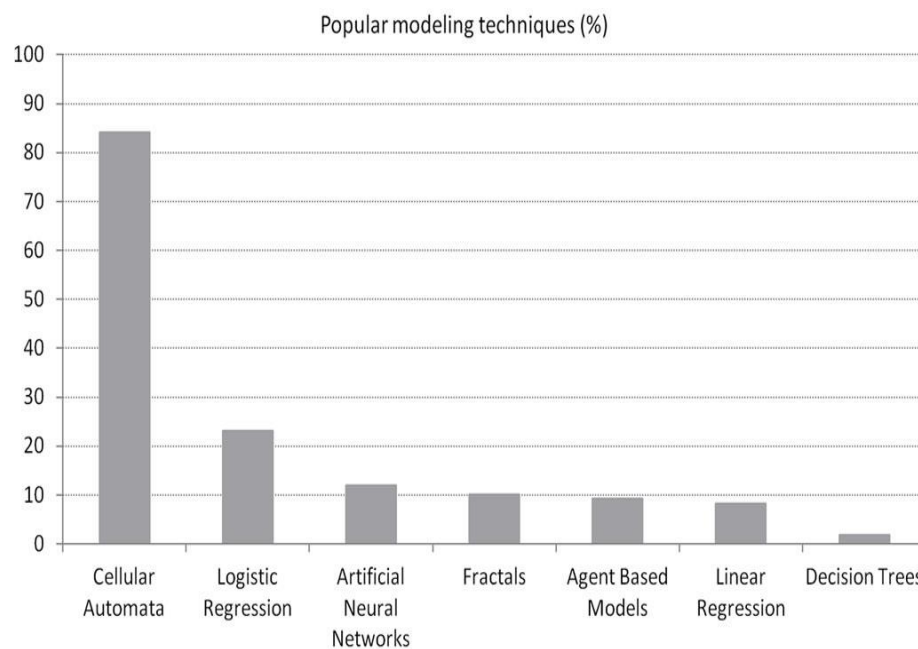


Figure 3-1 Underlying UGPM algorithms sorted by popularity (percentage of 156 manuscripts, a manuscript may contain multiple algorithms) [69].

The Markov Chain (MC) model and regression model have been working to change land use for the next 20 years. It can be considered as an effective tool for predicting urban sprawl [73]. Numerous researches had proved that the MC was suitable and valuable for modeling urban sprawl [74]. Markov Chain Analysis is a suitable tool for modelling land use change when procedures and changes in the landscape are difficult to describe. A Markovian procedure is one in which the future state of a system can be demonstrated purely on the basis of the immediately preceding state [75, 76].

Among all the several developed models, Cellular Automata and Markov chain Model is the furthestmost accepted model for the modelling of the trends of the growth pattern. The two techniques used in this exercise to model land use change are Markov Chain Analysis and Cellular Automata Analysis [76].

The capability of hybrid CA-MC model has been commonly employed in predicting changes in land use and land cover. In this hybrid model, Markov chain procedure controls temporal dynamics among the land use/cover classes based on transition probabilities, while the spatial dynamics are controlled by local rules determined either by the cellular automata spatial filter or transition potential maps [70, 72]. Therefore, coupling the MC and CA approaches provides a powerful modeling framework in which the shortcomings of each are eliminated [75]. The results of this study showed that the hybrid CA-MC model performed greatly in predicting urban growth for the coming years based on the growth pattern of previous years [70].

Due to restrictions of each individual modelling method, this study used the integrated models with each other, called MC-CA-LR after here, to take advantage of the best characteristic of each model. MC can compute the amount of LUC and identify the structural utilization; however, MC are spatially non-explicit since they only compute the probabilities of land use transitions and the quantity of change [77]. CA models avoid this restraint of MC based on predefined site-specific instructions to simulate land use transitions [37, 48]. Accordingly, several statistical and geospatial models have been advanced, including logistic regression models [43], Markov chains (MC) [72], cellular automata (CA) [37], and MC-CA models [68], among others.

This study uses the Land Change Modeler LCM for Land change prediction. LCM is an integrated software module in IDRISI@Selva v. 17.0 [78] that moves in a stepwise fashion from 1) Change Analysis through 2) Transition Potential Modelling to 3) Change Prediction. It is based on the historical change from time 1 to time 2 land cover maps to project future

scenarios [79, 80], The CA-Markov model was performed in LCM which is based on Markov chain matrices and transition susceptibility maps obtained by logistic regression [79, 81].

The aim of this part is to examine the driving forces of urban growth for small area (Abouelreesh Village) and predict the future sprawl areas in the same village for 2037 by applying a hybrid model of Markov Chain and Logistic Regression model. This part uses the free data source such Google Earth historical imagery and digital elevation model to achieve the above mentioned aims. The findings would be useful to urban planners and decision makers from developing countries where there is generally a dearth of official and high resolution data.

3.2 Study Area and Torrents

The study area (Northern Abouelreesh village) is located in the province of Aswan, in southern Egypt. It lies between longitudes $32^{\circ}52'E$ to $32^{\circ}55'E$ and latitudes $24^{\circ}10'N$ to $24^{\circ}14'N$. The study area is bordered to the east by mountains and from the west by an agricultural region, and the River Nile. Figure 3-2 shows the location of case study area location in relation to Egypt and the rest of the world.

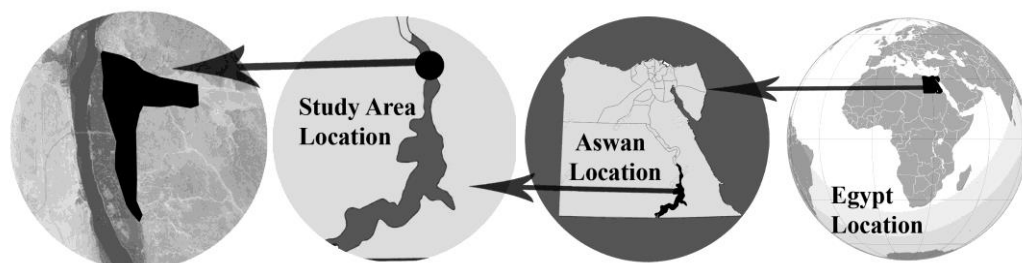


Figure 3-2 The study area in relation to Egypt and the world.

The area of urban development approved for northern Abouelreesh in 2010 was approximately 183.33 ha. While roads, pathways and urban spaces occupied 42.94 ha, not the entire allocated area was suitable for urbanization. The designated area also encompassed within its boundaries land space for private property (about 27.25 ha), desert land (approximately 51.09 ha) and farmland (about 1.91 ha). The population of the village was about 9896 in 1986, rising to 12206 inhabitants in 1996, then to 13189 in 2006.

The growth rate was 2.12% per annum in the period 1986-1996, decreasing to 0.78% per annum from 1996 to 2006. The average population growth rate was 1.45% per annum from 1986 to 2006. The total population of the village in 2010 was about 14202 and the average family size was about 4.16 [82].

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Figure 3-3 Buildings were destroyed in Abouelreesh village after a torrent in 2010.

Severe hurricane surprised the people of the province of Aswan on the evening of 17th Jan. 2010, which had followed through a torrential rain for 30 min continuously. About 50 electricity towers of high voltage had dropped on the ground which directed to the cutting of Aswan province power. Afterward, rains which collected on the eastern mountains had turned into a torrent and removed the home furnishings and people, leaving behind hundred households' destruction, which caused an unexpected catastrophe that was new bad experience for people. Furthermore, hundreds of houses had been broken because of directly rainfall and threatening to collapse at any moment. As rains and severe storms caused injury to thousands of acres of agricultural and displacing of trees from the root, as well as damaging tons of harvest dates which people had put them under the sun to dry out.

Houses most vulnerable to torrents were those that had been built along the east of the railway, stretching to the mountainside. Although the administrative authorities had alerted the people of the danger of constructing houses in this region and its surroundings because of the water storm risk, people did not heed the warning. This was because of the lack of other suitable areas.

On that occasion, the catastrophe did not wreak too much damage on the population of around 20,000, people living in the region [82]. About 25 houses were swept away while 50 homes were partially damaged. Flash flooding originating from small streams in urban areas can lead to major property damage and loss of life. Figure 3-4 shows the damage in Abouelreesh [83]. Ten houses were completely destroyed while about 30 homes were partially damaged [84].

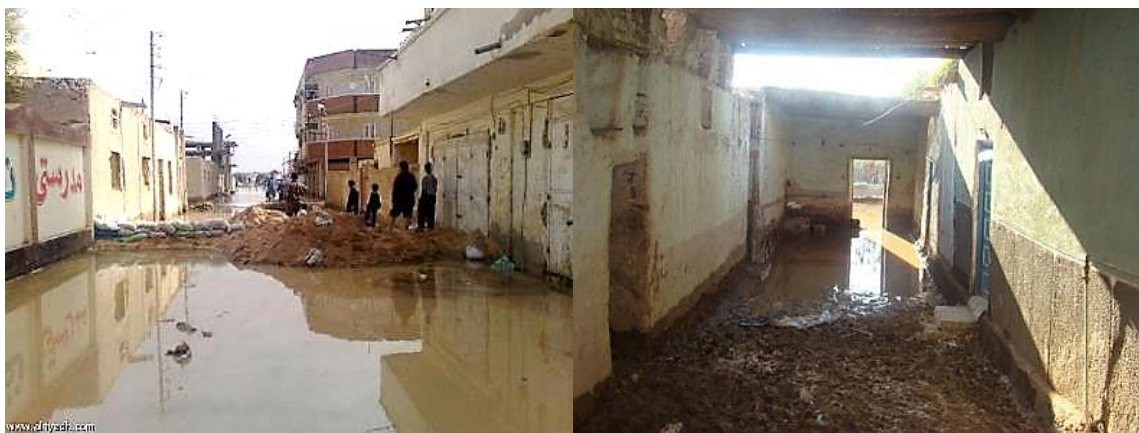


Figure 3-4 Roads and buildings affected by torrents in Egypt.

3.3 Method

Research methodology is based on the study of the region in different time periods and identifies urban growth especially in risky areas which are facing natural hazards; it was conducted in several steps.

It started by discussing the detailed outline of the study area and updating it by using Google Earth to determine the approximate periods for buildings that have been where construction by observing changes during the display of historical images in Google Earth.

Followed by using Arc GIS software to analyse the urban areas results, by studying the land use and the average area of the building for each time period and determine the ratio of the urban growth rate from period to another.

3.3.1 Identifying the Urban Sprawl

The research methodology in this section was aimed at studying the case study region in different periods of time in order to identify growth trends. The official detailed plan for the study area and updating information of the year of building construction was observed using Google Earth to manually extract the relevant data. This was followed by a visual analysis of high-resolution aerial images of the city in Google Earth. Manual photointerpretation of high-resolution images in Google Earth was the key process in this mapping methodology.

Manual photointerpretation of high-resolution images in Google Earth was the key process in this mapping methodology. While manual image analysis might be the oldest form of remote sensing [25], the method described in this part requires only personnel training in photointerpretation, minimal training (at most) in GIS, Internet access, and a computer with a relatively high-resolution monitor.

3.3.2 Choosing the driving forces

By reviewing related literature, it may be summarized that the driving forces of urban land use it is primarily include natural eco-environment, neighborhood factors, accessibility, socio-economic development, relevant planning and policies [19].

The research identify the driving factors from two sources, first one by reviewing related literature [27, 46-48]. The second one by analyzed the official detailed plan and the experience of researcher with the study area after that using LCM's Test and selection of site and driver variable module was used to test the potential power of explanatory variables Only variables with values higher than 0.15 in Cramer's V Test were used.

Table 3-1 shows that, we have found the variables that have a Cramer's V of around 0.15 or higher are beneficial while those with values of 0.4 or higher are good [79]. The driving factors in this study were divided in four groups: Accessibility, Planning and Policies, Services Buildings and Natural eco-environment.

Table 3-1 Cramer's value for variable.

Variables	Cramer's V
Accessibility	
Distance to Main Roads	0.6050
Distance to Regional Road	0.2779
Distance to Railways Station	0.3682
Planning and Policies	
Proximity to Old Urban Area	0.4022
Proximity to Nearby City (N. Aswan City)	0.3596
Distance to Railways Foot cross	0.3096
Services Buildings	
Distance to Commercial	0.4073
Distance to Educational	0.4189
Distance to Religious	0.5302
Distance to Social	0.4487
Distance to Different Services	0.4131
Natural eco-environment	
Distance to Streams	0.1795
Slope	0.0205
Elevation	0.3687

3.3.3 Hybrid model of CA-MC and LR

The research methodology in this part applied the integrated model of LR, MC, and CA which offer certain advantages when compared with traditional techniques. Firstly, this method is capable of integrating environmental and socio-economic explanatory factors of LUC, which are not measured in current CA models [48]. Secondly, any spatial factor could be combined using this approach in order to measure its influence on urban growth and, therefore, can be rejected after statistical calculation. However, this approach takes into contemplation the limitations in non-linear temporal changes in the model predictions based on the logistic regression. In reference to these limits, although the explanatory factors are updated so as to generate a new map of the potential land use change, the integrated method

does not have the ability to self-updated the state of the CA–MC model, resulting in a delay in the temporal dynamic [43].

These three techniques were combined for the following purposes: firstly, LR model was used to create a probability surface and to determine the furthestmost probable sites for development, furthermore a hybrid model was designed to improve the performance of the standard LR model [48, 85]; secondly, the MC model was used to recover the quantity of change. Thirdly, the CA model is a significant tool to assign probable changes under predefined conditional rules. An integration of CA and MC models (CA–Markov model) has been previously implemented and carried out on the same study area by Jokar Arsanjani et al. (2011) [86] and its results have verified the cogency of this approach [48]. the present approach was designed and performed to rectify the aforementioned constraints, and to discover the interaction of various environmental and socio-economic variables which may result in urban expansion [85].

By comparison, LR analysis model suffers from the quantification of change and temporal analysis [43, 48]. In difference, MC models can predict the amount of land use change and identify the structural utilization, but MCs are spatially non-explicit because they only calculate the probabilities of land use transitions and the quantity of change [86]. Spatial CA models avoid this limitation of MC based on predefined site-specific rules mimicking land use transitions [37, 48], then CA models absence the ability to account for the actual quantity of change. Because of limitations of each individual modelling technique, Poelmans and Van Rompaey (2009) proposed a hybrid method based on LR coupled with CA transition rules, which resulted in an improved model quality; nevertheless, their model was not able to quantify the amount of land use change [87]. Jokar Arsanjani et al. (2013) reported

promising results by integrating the LR, MC and CA models to simulate urban sprawl; though, the hybrid model unsuccessful to consider a spatial auto-regression in determining the driving forces of LUCCs.[48, 85]. The following Figure 3-5 shows the framework of future urban sprawl prediction.

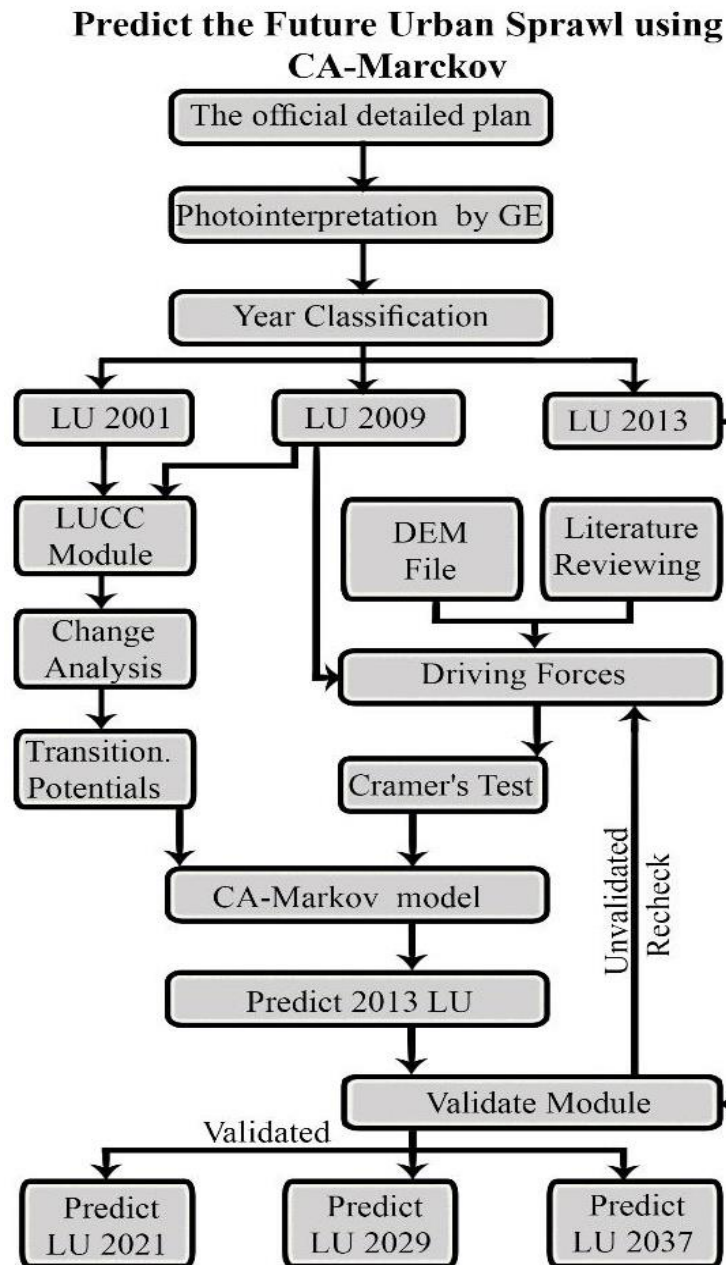


Figure 3-5. Predict the Future Urban Sprawl workflow

The dependent variable was prepared by processing the LUC 2001 and LUC 2013 using the Land Change Modeler (LCM) in IDRISI®Selva. The independent variables were prepared from the shape files of the driving factors by using ArcGIS.

The raster layers for the independent variables were exported to IDRISI®Selva and used with the dependent variable in the logistic regression model that is available in the LCM [46].

The dependent variable in this model is a binary value representing the location of land use (0 if the land use is not present at the location, and 1 if the particular land use is present at the location) [47].

3.3.4 Land use/cover change Modeler

This study uses the Land Change Modeler for Ecological Sustainability. Land Change Modeler is an integrated software module in IDRISI®Selva that achieves land change analysis, change prediction, and habitat and biodiversity impact assessment [78], Land use/cover change (LUCC) has become one of the key issues in global change research [19].

Use of such model also gives an improved understanding of the functions of the land use schemes and the support needed for planning and strategy making. Such models can also predict the possible future change and use of the land cover under different scenario [79, 88].

Land Change Modeler (available in IDRISI®Selva or as an ARC-GIS extension) is grounded on Markov chain matrices and transition susceptibility maps obtained by logistic regression or by training learning machines [79, 81].

3.3.5 Identify the future urban sprawl

Markov Chain Model is a special random moving from one state to another at each time phase which possibility distribution over the next state is probable to only rely on the current state, but not on the earlier ones [89]. MC analysis is an appropriate tool for modelling LUC when alterations in the landscape are hard to explain. The model can be served as a metric of the direction of alterations in the future due to the capability to describe projection trends of LUC [63]. In this part, MC analysis is utilized to compute the transition area matrix of LUC, and to identify the quantity of LUC. The transition area matrix for simulation periods is created by the MC module in IDRISI®Selva.

The urban sprawl modelling by connection the LR and MC (LR-MC) methods is built to enhance the quality of the standard LR model. First, LU maps in 2001 and 2013 were obtained with IDRISI®Selva application, the main driving factors determining LUC by LR model were examined and the transition potential maps of urban sprawl were acquired. The transition probability matrices of LUC were utilized in the next step to recognize the future structure of LUC based on the MC model. To prove the results, LU map of 2013 was estimated and compared against real LU maps. Finally, by setting historical growth scenarios, the model was utilized to identify future patterns of urban sprawl for 2035.

3.3.6 Research Data

Fulfillment of the research targets required detailed data. Unfortunately, the data available for the case study area were incomplete. For example, we could not conduct a proper analysis of the urban sprawl because the detailed plan from the government did not contain information

on when the buildings in the urban areas were constructed. Secondly, there was the problem of low resolution files provided free online, for example, the DEM (Digital elevation models) files. High resolution DEM files were expensive to acquire. Table 3-2 shows all data files used in simulation and their sources.

Table 3-2 Data used in this study and their sources.

	Data Source
Detailed plan	General Organization for Physical Planning - Aswan
DEM file	U.S. Geological Survey (USGS) Website

Digital elevation models (DEM) as shown in Figure 3-6 are an important source of information in GIS applications. The two most widely applied satellite-derived DEM datasets (SRTM and GDEM) were used in this study [90].

Owing to constraints faced in data collection, the methodology for this chapter depended on the resolutions to the two problems mentioned. To overcome the first problem of incomplete information regarding the year of building construction, we used Google Earth historical images to obtain the necessary information. To resolve the second problem regarding the costs of obtaining high resolution imagery, we used the free online data despite their low resolution. We were able to obtain free DEM files.

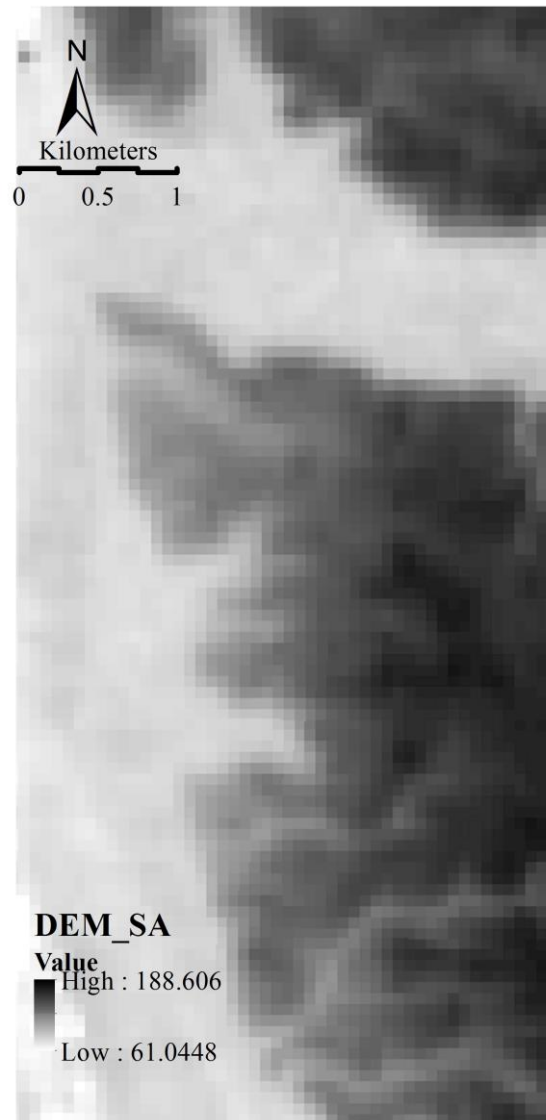


Figure 3-6 Digital Elevation Model File for the case study area.

3.4 Study area

The study area (Northern Abouelreesh village) is located in the city of Aswan in southern Egypt where it lies between longitudes $32^{\circ}52'E$ to $32^{\circ}55'E$ and latitudes $24^{\circ}10'N$ to $24^{\circ}14'N$. Limiting the study area to the east of the mountain and from the west was agricultural area and then River Nile and in the village there are three areas at risk torrents (Figure 3-7).

The area of urban space approved for the village of northern Abouelreesh approximately 453.01 acres in 2010 and that the total area of roads and pathways and urban spaces (106.11) acres, land space (private property) about (67.33) acres, desert land of approximately (126.25) acres and farmland of about (4.73) acres.



Figure 3-7. The study area related the world.

The population of the village was about 9896 inhabitants in 1986 rose to 12206 inhabitants in 1996, Then to 13189 in 2006, The growth rate was 2.12% per annum in the period 1986/1996, decreased to 0.78% per annum in the period 1996/2006. The average of growth rate was 1.45% per annum in the period 1986/2006. The total population of the village in 2010 about 14202 and the average family size is about 4.16 and 3204 the number of families [82].

3.5 Running model

3.5.1 Change Analysis

The Change Analysis tab offers a set of tools for the fast assessment of change, allowing one to create one-click evaluations of gains and losses, net change, perseverance and specific transitions both in map and graphical form [79].

3.5.1.1 LCM Project Parameters

This panel allows for the requirement of the essential files associated with the land cover change analysis of a specific study area. Some aspects of LCM can be used deprived of specifying these files, most particularly the species modeling with biodiversity modeling tools on the Implications tab. Though, they are required for furthestmost elements of LCM [79].

For the change and prediction analyses, a minimum condition is the specification of two land cover maps that can be used as the basis of understanding the nature of change in the study region and the means of establishing samples of transitions that should be modeled [79]. Figure 3-8 shows the two land cover maps.

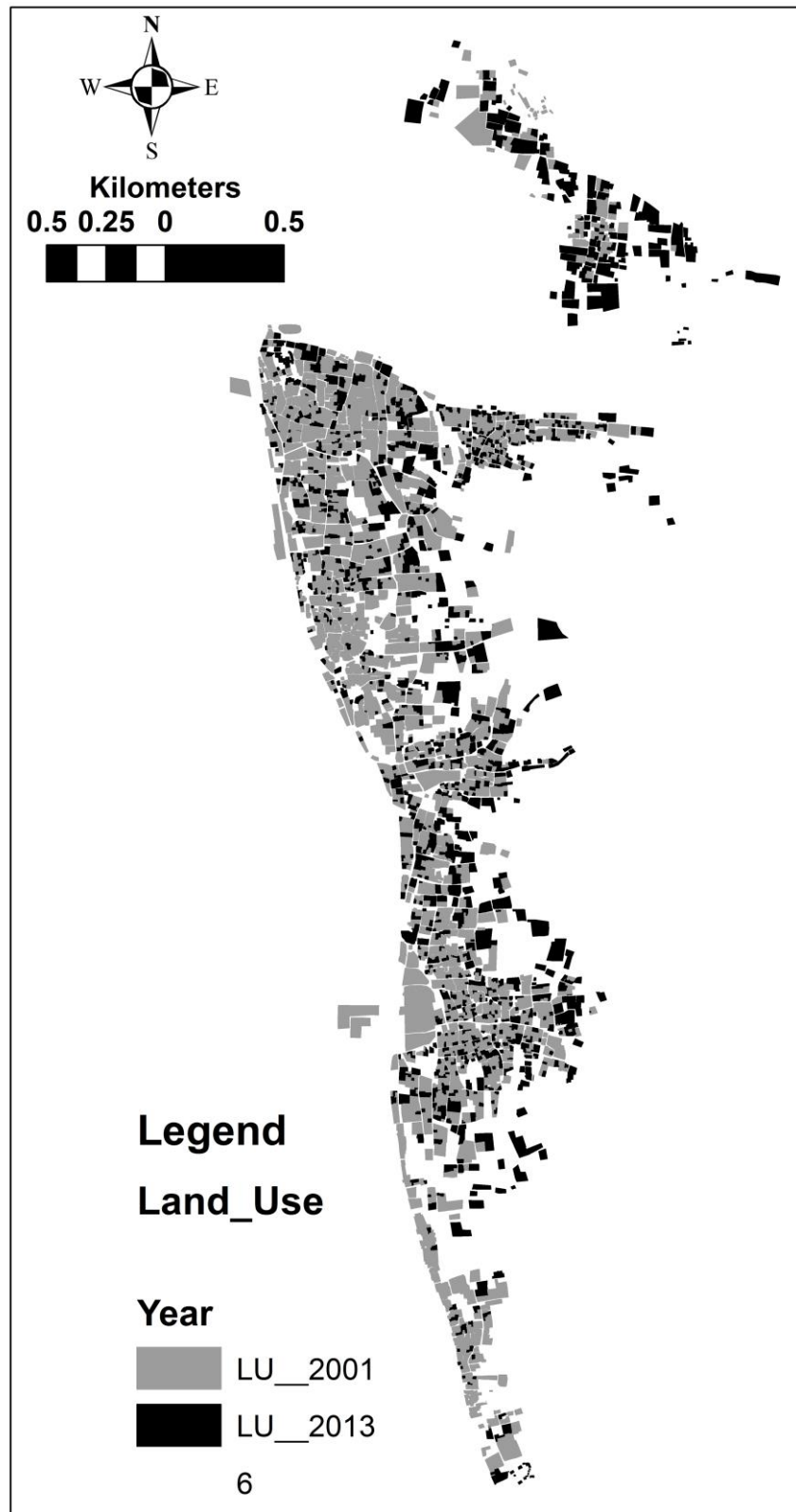


Figure 3-8 Urban area in 2001 and 2013.

3.5.1.2 Change Analysis - Land Change Modeler

The Change Analysis panel offers three graphs of land cover change between the two land cover maps quantified in the Project Parameters panel you can observe these graphs in a multiplicity of units (cells, kilometers, hectares, square acres, square miles, and % of area). Reminder that changing the units on this panel reasons the units on the Change Maps panel to also change, and vice versa. Figure 3-9 shows the gains and losses between 2001 and 2013.

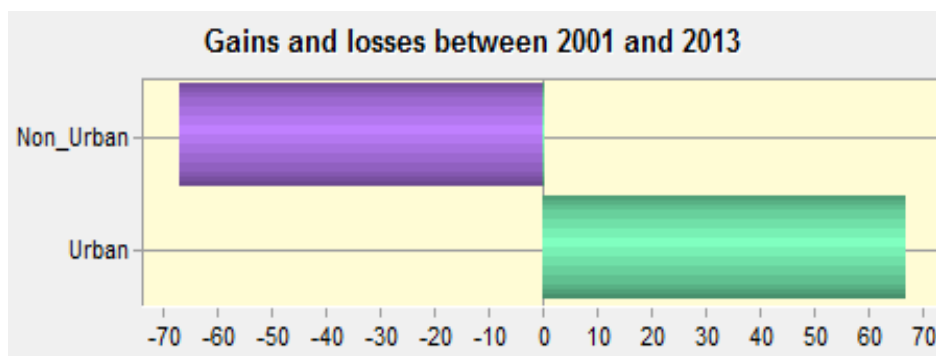


Figure 3-9. Changing in land use between 2001 and 2013.

3.5.1.3 Change Maps - Land Change Modeler

This panel offers the ability to create a variety of change maps, containing maps of persistence, losses and gains, transitions and exchanges. Note that changing the units on this panel causes the units on the Change Analysis panel to also change, and vice versa.

3.5.1.4 Spatial Trend of Change - Land Change Modeler

In landscapes conquered by human interference, patterns of change can be multifaceted, and thus very difficult to decipher. This panel offers the

capability to map trends with a top fit polynomial trend surface to the pattern of change.

3.5.2 Transition Potentials

In order to predict change, we have to generate a map of the potential of land. The Transition Potentials tab lets one to collection transitions between two land cover maps into a set of sub-models subsequent in a transition potential map for all transition an expression of time-specific potential for change.

3.5.2.1 Transition Sub-Models : Status

The table on this panel tilts all transitions that be between the two land cover maps and requires the user to identify which transitions are to be used for calculating the transition potentials. As shown in Figure 3-10.

Transition from LU_2001 To LU_2013

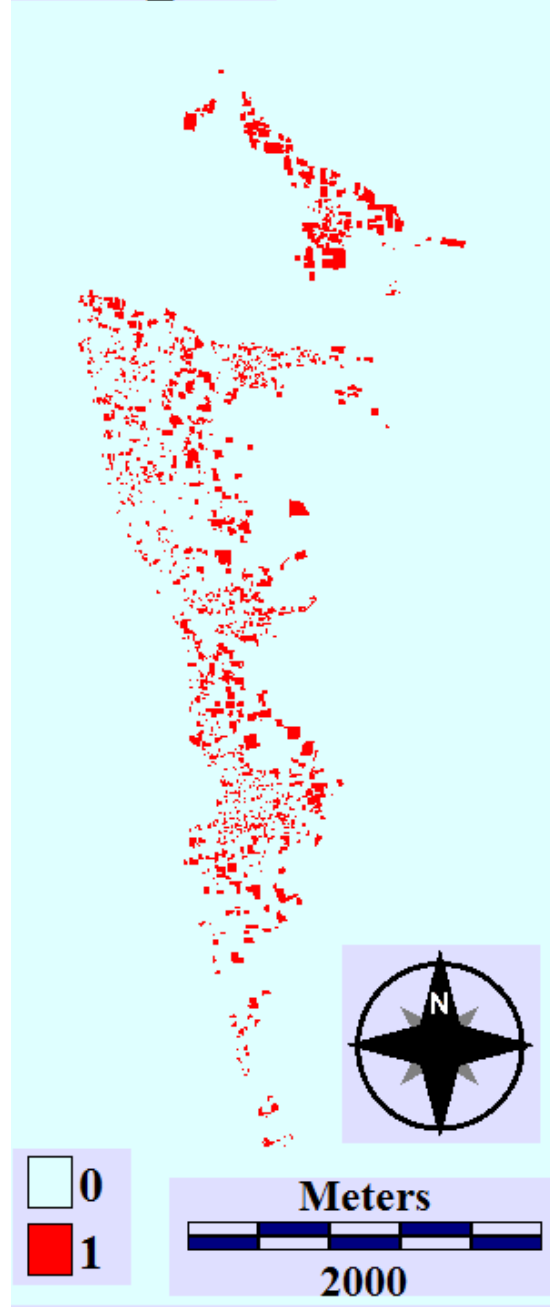


Figure 3-10. Transition of land use.

3.5.2.2 Variable Transformation Utility

The Variable Transformation Utility panel is a possible panel for transition potential modeling that offers a selection of usually used transformations. The transformations available include: natural log, square root, exponential, logit, power, and evidence likelihood.

These are particularly critical if the Logistic Regression modeling option is chosen since it requires that the variables be linearly related to the potential for transition. This research used the natural log to prepare the driving forces. Because the natural log transformation is commonly effective in linearizing distance decay variables.

3.5.2.3 Test and Selection of Site and Driver Variables

This is an optional panel that provides a quick test of the potential explanatory power of a variable. You must have specified a project in the Project Parameters panel before opening these tools. In general, we have found the variables that have a Cramer's V of about 0.15 or higher are useful while those with values of 0.4 or higher are good.

3.5.2.4 Structure and Run of Transition Sub-Model

The Run Transition Sub-Model panel is where the real modeling of transition sub-models is applied. This panel runs the transition sub-model specified in the Sub-model to be assessed combo box in the Transition Sub-Models: Status panel. This model assumes binomial Logistic Regression and prediction using the Maximum Likelihood method.

3.6 Result & Discussion

We studied and analyzed the buildings ages using Google Earth and land use in the study area according to (Figure 3-11), It appears the distribution of land uses inside the village which is divided into a small part in the north and big part in south which separated by agricultural land, The greater part has mountainous area of rugged terrain from the east, There is agricultural land and the Nile River in the west, In south located the village of southern Abouelreesh.

Table 3-3 Land use in the risk area and the safe area.

	Urban Area (ha)	Percentage %
Residential	173.01	91.92 %
Services	8.56	4.64 %
Graves	6.35	3.44 %
Total	184.67	100.00 %

3.6.1 The past Urban Growth

We used Arc GIS to analyze the data about the time periods for buildings to try understand the urban growth and directions. Moreover obtaining the total area of buildings for each period. To find the urban growth,

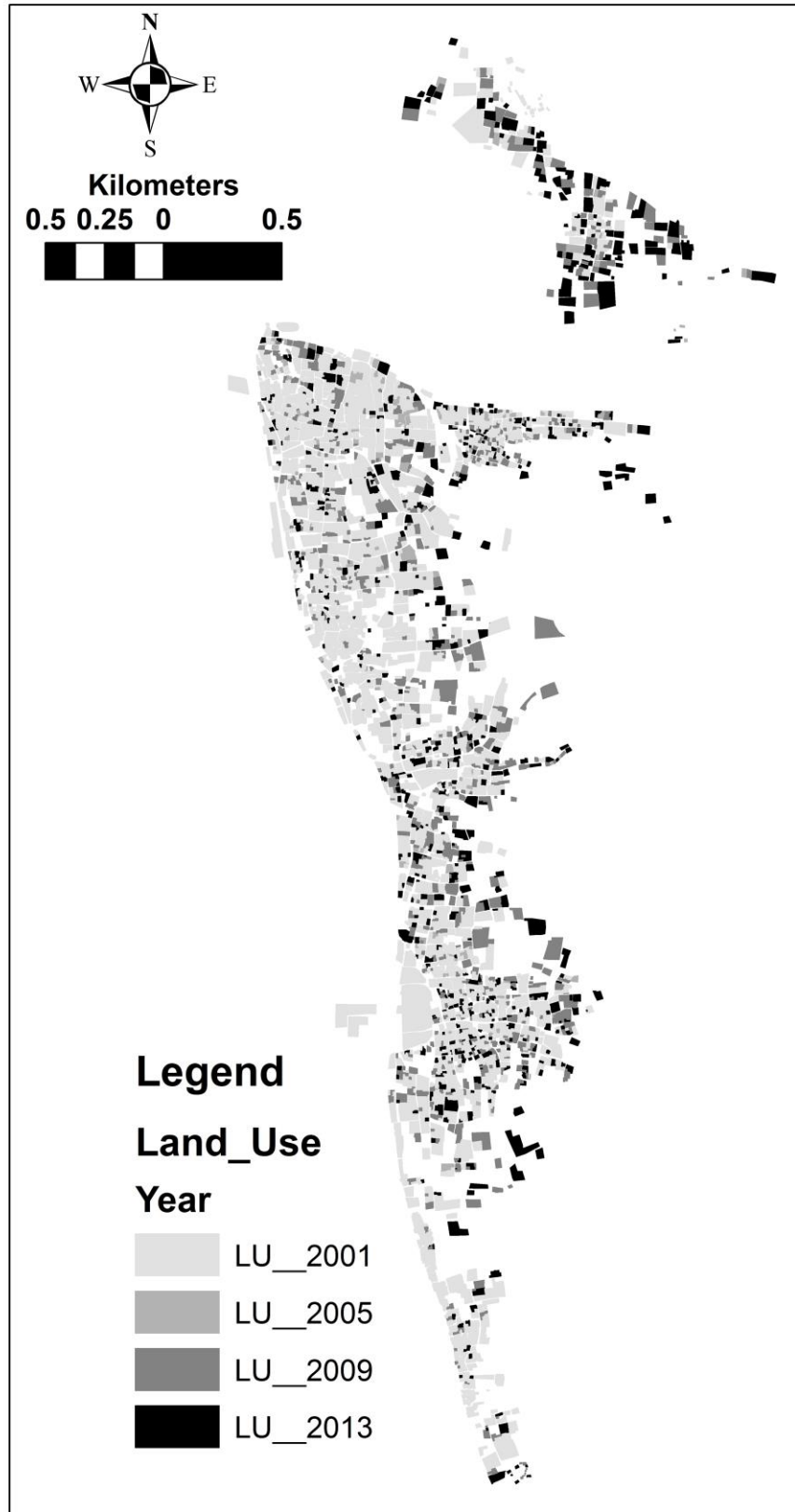


Figure 3-11 Urban sprawl over the years.

Land use in the study area was distributed according to three categories as shown in Table 3-3 and Figure 3-13. In the study area, land allocated for residential use was the biggest category, occupying 173.01 ha or about 91.92 % of the urban area, while land used for services in the study area was only (4.64%) from the urban area. Graves took up about 6.35 ha of the total land area. These statistics indicate that residential land use in the urban area formed the largest category of land use (173.01 ha).

Table 3-4 Urban areas from 2001 to 2013

	2001	2005	2009	2013
Total Urban Area (ha)	118.03	4.61	32.88	29.15
Annual Extend_ %	63.91	2.49	17.81	15.79
Increase_ %	0.00	3.90	26.82	18.74

Table 3-4 shows and Figure 3-12 the percentage of urbanization in each year of the study years of 2001 to 2013 excluding the first year. Also shows the highest rate of growth that was between 2005 and 2009 amounted to 17.81% of the total area of urbanism at the public level as shown in Figure 3-14.

As shown in Table 3-4 and Figure 3-15 urbanization rate increase during the years of the study in all areas. Moreover, it was showing the highest increasing rate between the two years was 26.82% in total urban areas between 2005 to 2009.

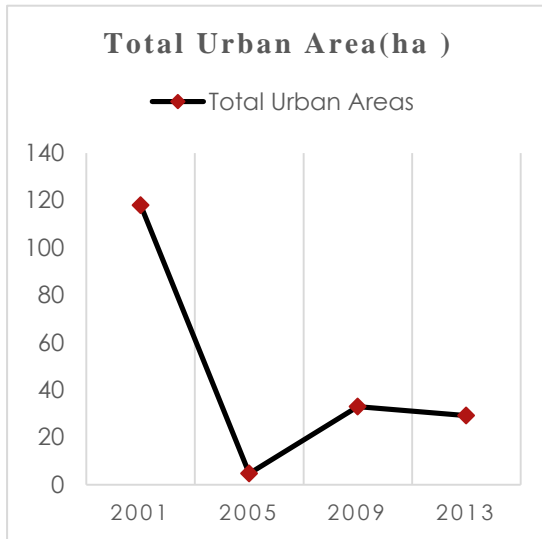


Figure 3-12 Urbanization in each year

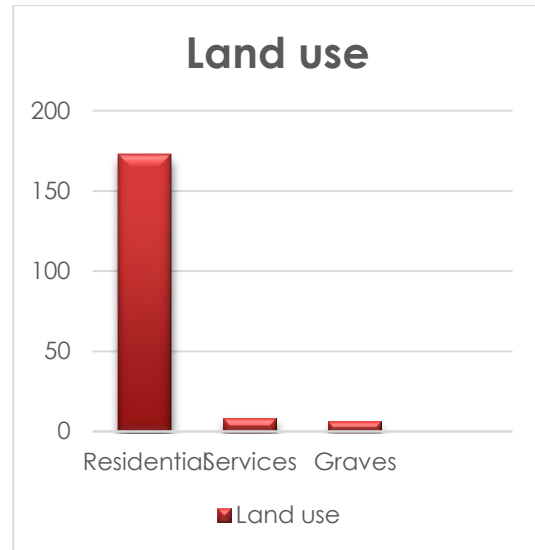


Figure 3-13 Land Use categories

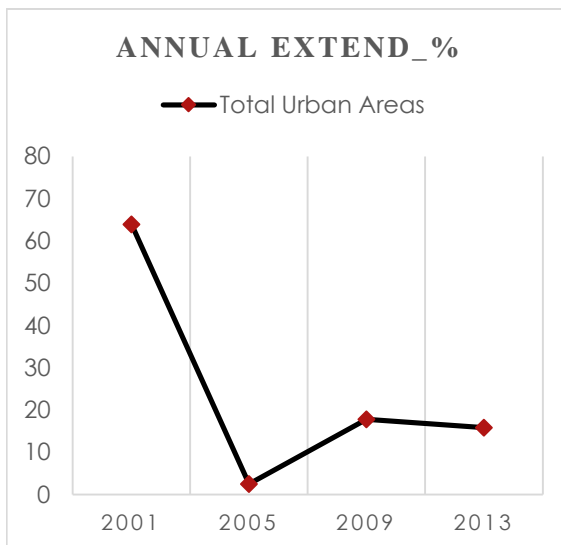


Figure 3-14 the amount of urban growth each year and the percentage increase in Urban Areas

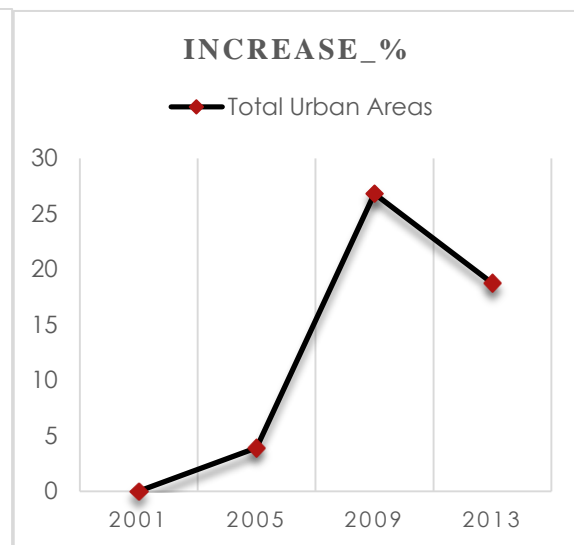


Figure 3-15 Annual rate of increase in developed Urban Areas

3.6.2 Driving forces

The result of change analysis between 2001 and 2013 was gain 67 ha from the urban area as urban sprawl in this period, this is area changed from non-urban area to urban area throw 12 years. After transformed the driving forces file to natural log the research made very important step that was test and select the driver variables based on the Cramer's V factor. Figure 3-16. Shows the driving variable.

From the Table 3-1. We can observe that all driver variables have Cramer's V more than 0.15 or higher this values are useful while those with values of 0.4 or higher are good [79]. The research method excepted from the previews issues only one driver variable that was slope because this variable is very important to check its effective value in model while this study area has mountainous natural.

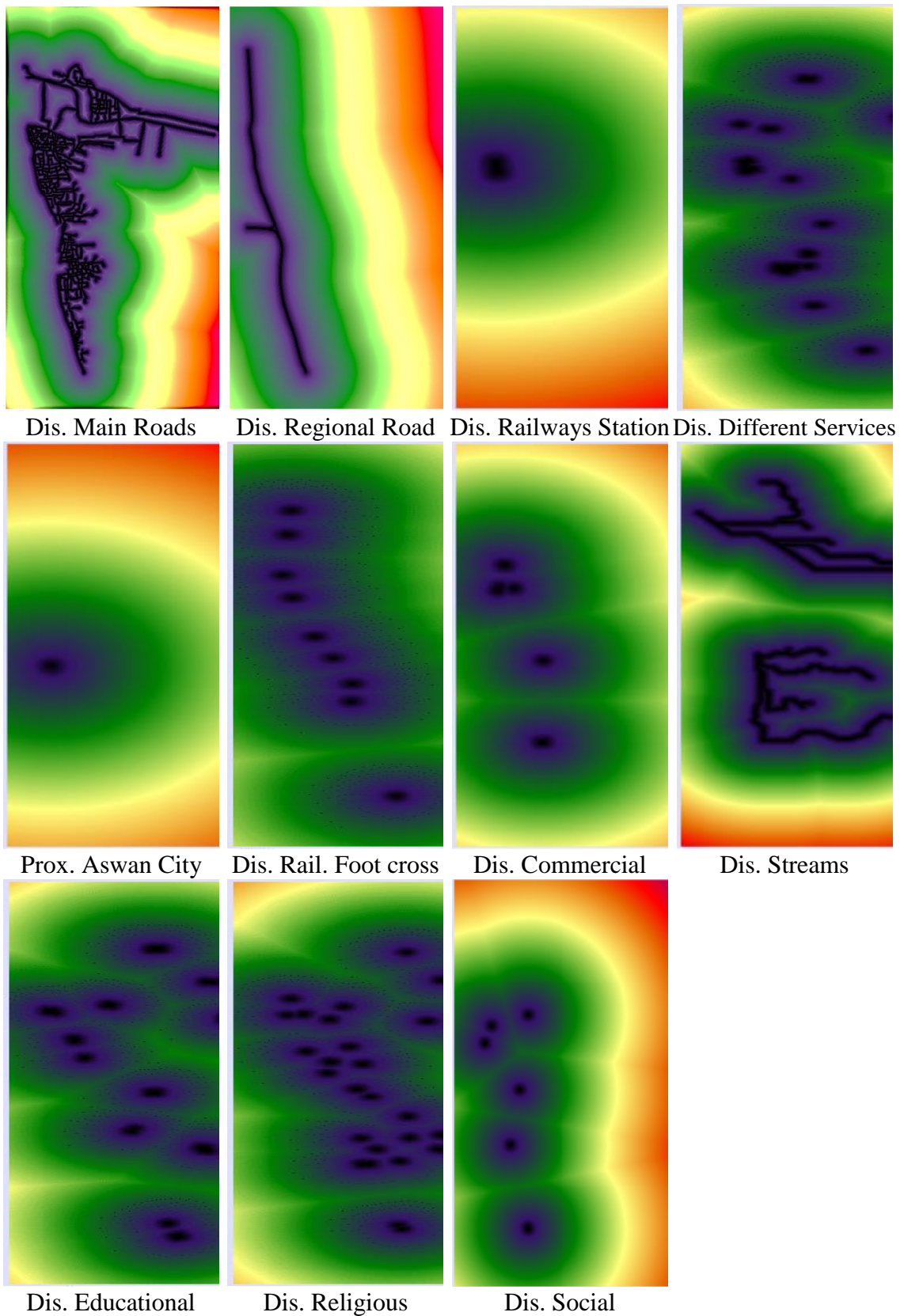


Figure 3-16. Driving factors.

ROC (Relative Operating Characteristic) ROC is an excellent method to compare a Boolean map of "reality" versus a suitability map. Thus, ROC is included here as an excellent statistic for measuring the goodness of fit of logistic regression. The ROC value ranges from 0 to 1, where 1 indicates a perfect fit and 0.5 indicates a random fit [79]. The result of the ROC statistic was 0.9626, which is a very strong value and indicates the soft prediction was very accurate.

Using R^2 , or in our case the Pseudo R^2 , as a measure of goodness of fit for the logistic regression is questionable; in general, however, Thus, pseudo $R^2 = 1$ indicates a perfect fit, whereas pseudo $R^2 = 0$ indicates no relationship. Pseudo R^2 greater than 0.2 is considered a relatively good fit. The result of pseudo R^2 value is 0.3875 that is indicates a perfect fit.

The regression equation outputs the regression coefficients for each of the independent variables and the intercept. The intercept can be thought of as the value for the dependent variable when each of the independent variables takes on a value of zero. The coefficients indicate the effects of each of the independent variables on the dependent variable [79].

The parameter coefficients (positive or negative) in the equation are relative indicators of a positive or negative relationship between the probability and the independent variables [79]. The correlation coefficient can vary from -1.0 (strong negative relationship) to 0 (no relationship) to +1.0 (strong positive relationship) [79].

As shown in Table 3-5, the evaluation of various factors' regression coefficient (b) for independent variables can be divided to two types, the first one based on the sign of coefficient relationship value was negative or positive, the second type was divided based on the category of variables.

Table 3-5. Coefficient value for variable between 2001-2013.

Variables	Coefficient
Accessibility	
Distance to Main Roads	- 0.44303725
Distance to Regional Road	- 0.05626237
Distance to Railways Station	0.00285688
Planning and Policies	
Proximity to Old Urban Area	0.57026085
Proximity to Nearby City (N. Aswan City)	- 0.53736236
Distance to Railways Foot cross	- 0.13624385
Services Buildings	
Distance to Commercial	- 0.59613874
Distance to Educational	- 0.19707816
Distance to Religious	- 0.77670819
Distance to Social	- 0.24063162
Distance to Different Services	- 0.44598478
Natural eco-environment	
Distance to Streams	- 0.09407333
Slope	0.00147021
Elevation	0.00976199

3.6.2.1 Sign Evaluation

The first evaluation type is sign evaluation, as shown in Table 3-5 all independent variables that has positive sign for coefficient indicate to positive relationship, if the value of independent variable increased the probability of urban growth will decrease, as selected in this study all independent variable test the distance to same driving forces except the slope an elevation, so that it can be conclude that whenever to be closer to the positive relationship factors the probability of urban growth will decreased especially when the value will be higher so that it can be consider the closing to this factor has a negative effect on urban growth , Only five factors has a positive coefficient , distance to Regional Road and old urban area has strong

positive relationship while the distance to railway station, slope and elevation has very weak effect on urban growth because the coefficient for them was very small.

On other hand most of independent variables has negative coefficient that is indicate that whenever to be closer to the inverse relationship factors the probability of urban growth will increased and this factors will have attractive effect to urban sprawl, the most inverse relationship factors were Distance to Religious and Proximity to Nearby City (N. Aswan City) the coefficient was -0.775 and -0.617 respectively, they have very strong effect to attract the urban sprawl, while Distance to Streams and Distance to Railways Foot cross had weak effect in attract on urban sprawl the coefficient was -0.092 and -0.136 respectively.

3.6.2.2 Category Evaluation

The first evaluation type is category evaluation, in this type can be evaluate the effect of etch categories based on the average of coefficient on it, as shown in Table 3-5. it can be observed that the most effective independent variables category was the services buildings, all factors in this group has the negative sign which mean inverse relationship between factors and urban sprawl with average of coefficient value about - 0.452 moreover the stronger factors was the Distance to Religious -0.775 and the most weak one was Distance to Educational -0.195.

The second category has most effective on urban sprawl was the Planning and Policies, this category has two strong factors Proximity to Old Urban Area and Proximity to Nearby City (N. Aswan City) and one has inverse relationship with weak value it was Distance to Railways Foot cross.

In addition Accessibility category has only one strong independent variables it was the Distance to Main Roads which has inverse relationship with strong value -0.423 while the other two independent variables was very weak. The weakest effective category was the Natural eco-environment if can be neglect the sign we can found that the average of coefficient was 0.034 , this value has very weak effect in urban sprawl even the sign was negative or positive.

3.6.3 Future Urban sprawl

3.6.3.1 Change Analysis

The Change Analysis panel offers three graphs of land cover change between the two land cover maps quantified in the Project Parameters panel you can observe these graphs in a multiplicity of units (cells, kilometers, hectares, square acres, square miles, and % of area). Reminder that changing the units on this panel reasons the units on the Change Maps panel to also change, and vice versa. Figure 3-17 shows the gains and losses between 2001 and 2009 more than 37 ha transfer from Non-urban to Urban area.

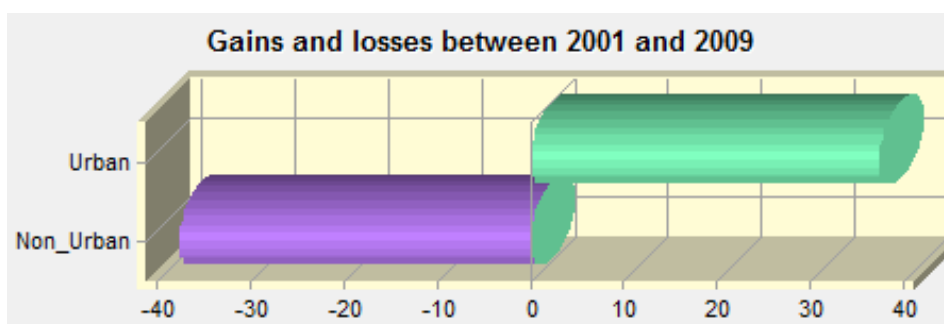


Figure 3-17 Changing in land use between 2001 and 2009.

3.6.3.2 Transition Potentials

In order to predict change, we have to create a map of the potential of land. The Transition Potentials tab allows one to group transitions between two land cover maps into a set of sub-models resulting in a transition potential map for each transition an expression of time-specific potential for change, as shown in Figure 3-18.

A) Test and Selection of Site and Driver Variables

Figure 3-18. Transition of land use between 2001-2009.

This is an optional panel that provides a quick test of the potential explanatory power of a variable. You must have specified a project in the Project Parameters panel before accessing these tools. In general, we have found the variables that have a Cramer's V of about 0.15 or higher are useful while those with values of 0.4 or higher are good.

B) Structure and Run of Transition Sub-Model

The Run Transition Sub-Model panel is where the actual modeling of transition sub-models is implemented. This panel runs the transition sub-model specified in the Sub-model to be evaluated combo box in the Transition Sub-Models: Status panel. This model undertakes binomial Logistic Regression and prediction using the Maximum Likelihood method.

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Accessibility	
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Proximity to Old Urban Area	0.57026085
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Services Buildings	
Distance to Commercial	- 0.59613874
Distance to Educational	- 0.19707816
Distance to Religious	- 0.77670819
Distance to Social	- 0.24063162
Distance to Different Services	- 0.44598478
Natural eco-environment	
Distance to Streams	- 0.09407333
Slope	0.00147021
Elevation	0.00976199

As shown in Table 3-6, the evaluation of various factors' regression coefficient (b) for independent variables can be divided to two types, the first one based on the sign of coefficient relationship value was negative or positive, the second type was divided based on the category of variables. Figure 3-16 shows the maps of variables

3.6.3.3 Future sprawl in 2037

The scenario of historical growth trends: According to transition potential map and LUC tendency, CA model primarily uses the transition matrices probabilities of the period from 2001-2009 to predict 2013 LU, and allocated simulated cells using a 7 by 7 neighborhood matrix with one year iteration stages. By assuring the model qualification and validation process,

sprawl was computed for 2001 and 2009. Modeled LUC map were identified for 2013, according to LU data 2001 -2009, and matched with the 2013 actual LU map to calculate the kappa index calculated 83.66% which confirmed that selected model variables were appropriate for next modelling procedures. Therefore, the model output was matched with identical parameters attributes applying 2013 LU data, transition probabilities 2001-2013, and a similar map of probabilities.

The future potential sprawl map was then identified for 2013. Lastly, spatial preparations for 2013 LUC modeling was examined by point type analyses. Under the scenario of historical growth trends, urban sprawl will continue emerges in whole study urban areas both minor and major counties. Moreover, Under this scenario, the total simulated urban area for 2037 was about 2.59 Sq. Km. The net rise in urbanized areas from 2013 to 2037 was about 0.74 Sq. Km, identifying a raise of 40 % in comparison with the basic area in 2013.

The increase of urban area in our research zone has increased gradually during 24 years of simulation period. The urban area in 2013 was 1.85 km² and increased to 2.02 km² in 2021, then jumped to 2.31 km² in 2029 and ultimately reached to 2.59 km² in 2037, as shown in Figure 3-19.

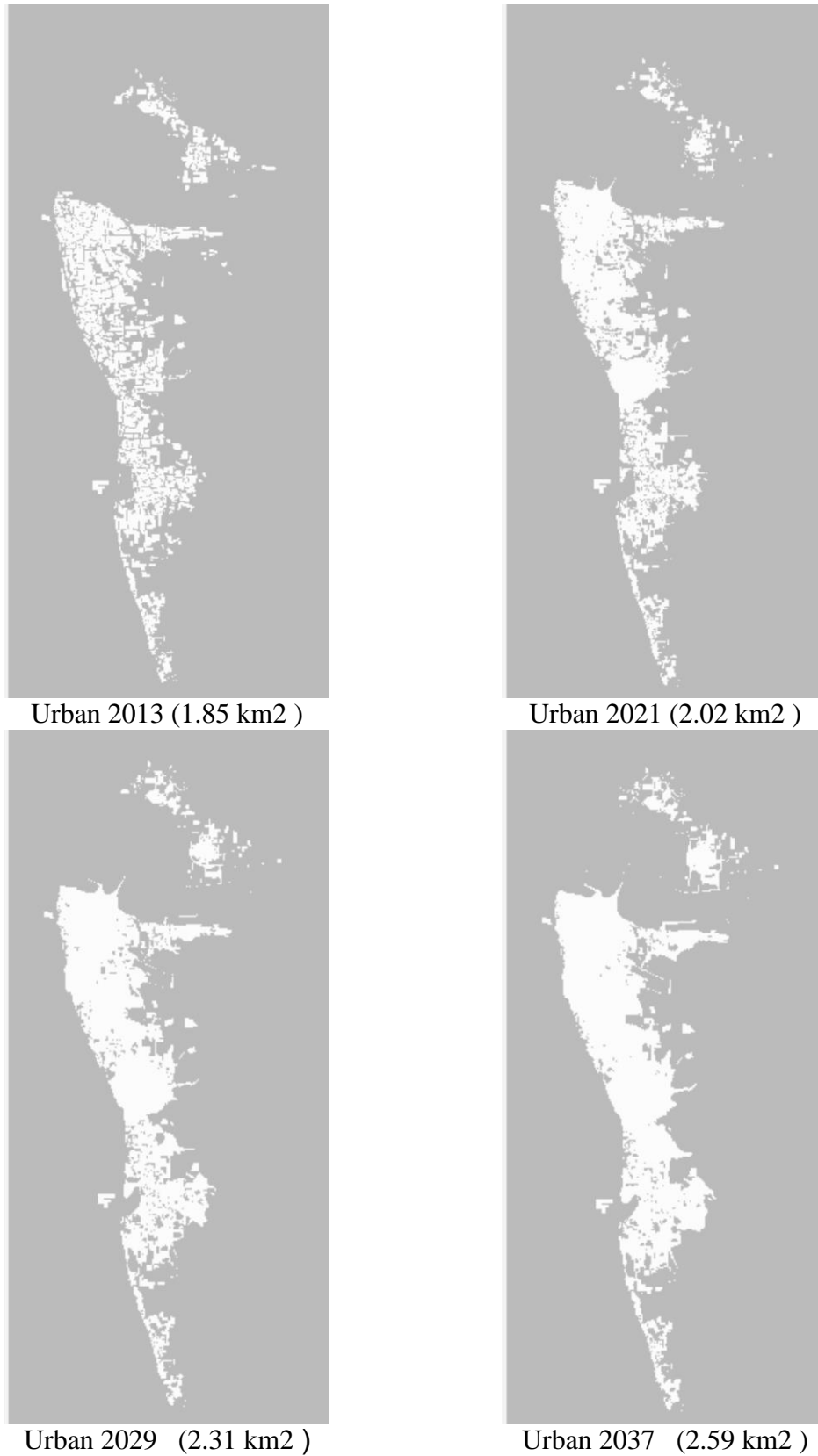


Figure 3-19 The increase of urban area 2013-2037

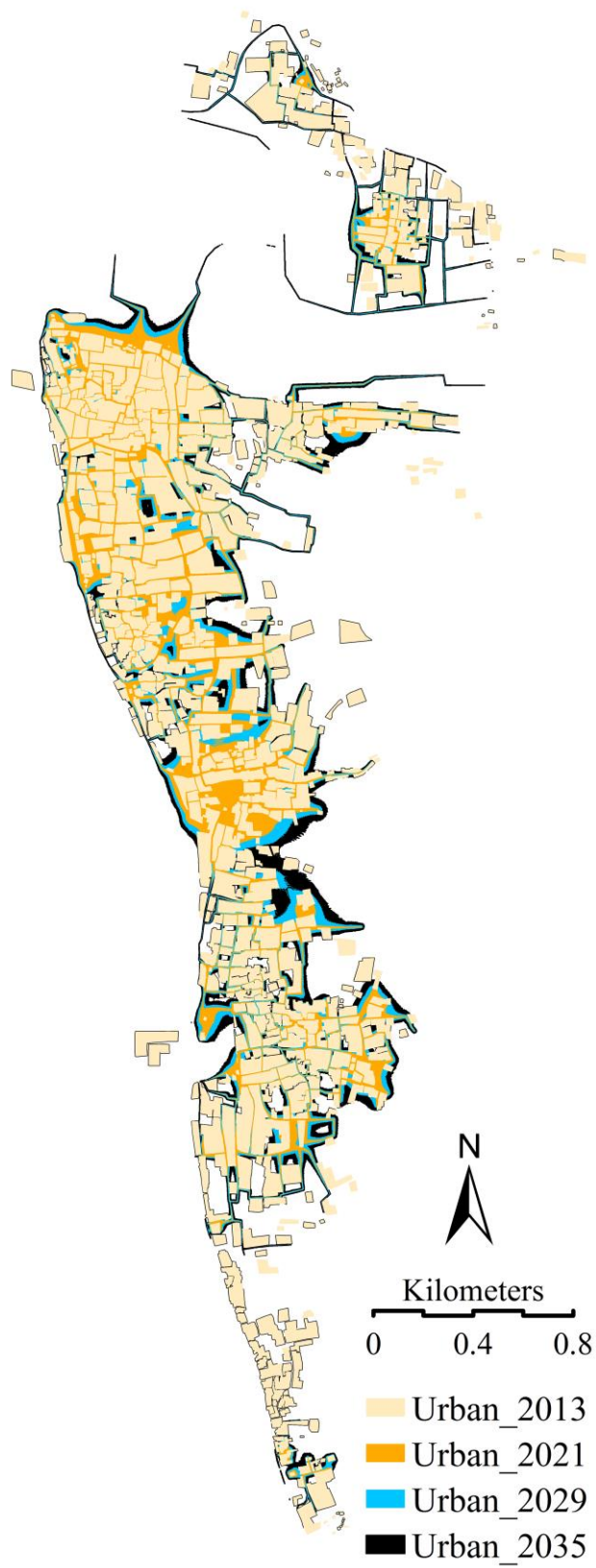


Figure 3-20 The total predicted urban areas 2013-2037.

3.6.3.4 Model Validation

The VALIDATE module in IDRISI was used to assess the level of agreement between the observed 2013 and simulated 2013 land use datasets based on the Kappa spatial correlation statistic. All statistics ($K_{standard} = 0.8366$, $K_{no} = 0.9751$, and $K_{locality} = 0.8552$) were well above 0.80, demonstrating that the two datasets had a very high level of agreement, therefore, the transition probability matrix can be used to predict the distribution pattern of land use cover datasets in study region [91].

ROC (Relative Operating Characteristic) ROC is an excellent method to compare a Boolean map of "reality" versus a suitability map. Thus, ROC is included here as an excellent statistic for measuring the goodness of fit of logistic regression. The ROC value ranges from 0 to 1, where 1 indicates a perfect fit and 0.5 indicates a random fit [79]. The result of the ROC statistic was 0.96, which is a very strong value and indicates the soft prediction was very accurate.

Using R^2 , or in our case the Pseudo R^2 , as a measure of goodness of fit for the logistic regression is questionable; in general, however, Thus, pseudo $R^2 = 1$ indicates a perfect fit, whereas pseudo $R^2 = 0$ indicates no relationship. Pseudo R^2 greater than 0.2 is considered a relatively good fit. The result of pseudo R^2 value is 0.34 that is indicates a perfect fit.

From the Table 3-1, we can observe that all driver variables have Cramer's V more than 0.15 or higher this values are useful while those with values of 0.4 or higher are good [79]. The research method excepted from the previews issues only one driver variable that was slope because this variable is very important to check its effective value in model while this study area has mountainous natural.

The regression equation outputs the regression coefficients for each of the independent variables and the intercept. The intercept can be thought of as the value for the dependent variable when each of the independent variables takes on a value of zero. The coefficients indicate the effects of each of the independent variables on the dependent variable [79]. The parameter coefficients (positive or negative) in the equation are relative indicators of a positive or negative relationship between the probability and the independent variables [79]. The correlation coefficient can vary from -1.0 (strong negative relationship) to 0 (no relationship) to +1.0 (strong positive relationship) [79].

3.7 Conclusion

The method in this chapter would be helpful to decision makers and planners in countries which do not have enough data or do not have sufficient funding to bid for development projects, It would be most useful if more precise data were available to enable more accurate results so that the analysis of the urban growth would yield more reliable data. This would make a considerable difference in the appraisal of the area for proposed development.

Identify the driving factors that can led the urban sprawl is very useful method to try understanding the expansion of urban area, and helping the decision-makers and planners to expect the urban growth in future.

Urban growth in Abouelreesh had been effected by several factors some of them had positive relationship such as Proximity to Old Urban Area that has the stronger positive relationship with urban sprawl and unattractive factors in urban area. While the most attractive driving factors in study area

was Distance to Religious, this factor has inverse relationship that mean the high probability to urban growth when the distance with it will be short.

I was observed that the urban sprawl was spread in everywhere without concentration in specific areas due to the highly rated sprawl drivers were regional roads and religious services are affecting in the whole study area as shown in Figure 3-19. The potential urban sprawl will significantly continue under the historical trends simulation for 2037 and will emerge the whole study urban areas.

Particularly, the urban sprawl will discontinuously expand around old urban cores, and continue surround major road networks. The findings proved that the desired urban sustainable development in Aswan will not be assured in 2037, proving that the historical growth trends is not a proper scenario to achieve the urban development sustainability goals of GOPP, 2005.

Our analysis proved that urban modelling offers a superior explanation to grasp the potential tendencies of sprawl activities in near future, and provide significant facts to help policy makers to formulate adequate regulations for achieving urban sustainability in Aswan. However, the applied methodology had the ability to combine numerous sprawl factors, it had some constrains in applying two models in parallel, like , individuality of models behaviors, treating with behaviors of non-factoring in governmental actions and the diverse in priorities of LU alterations.

Thus, Next related studies should be fulfilled by agent-based modeling on Aswan to compare their consequences on LU dynamics and intensity analysis with existing utilized models. Furthermore, to explain whether the simulated forms of sprawl are precise to Aswan, this method requires more additional evaluations by comparing the findings of several researches for same study area.

Finally, the prominent results of this study could be guide decision makers, urban planners, and local urban municipalities to enhance a realistic regional development strategy for Aswan. Urban planners are able to submit proper urban plans regulations to manage the potential inescapable urbanization activities.

Planning and urban management authorities need to learn more advanced tools and techniques for improving infrastructure supply, energy service provisions, and protect the environmental conditions which ultimately enhance the required regional sustainable development.

This chapter has main part in thesis methodology, that how to identify the year of building construction of urban land use by using manual photo-interpretation from satellite imagery obtained from Google Earth, To verify this part We recommend that a field survey be undertaken first to identify the old urban areas. After this, a comparison can be made between the field observations and manual photo-interpretation from satellite imagery obtained from Google Earth. This would give a good indication of the urban sprawl. At the same time, the discrepancies between the two methods would help researchers calibrate the manual photo-interpretation that can be used to obtain a rapid result without cost. On other hand we can add other verification method by using remote sensing analyses to high resolution satellite images to identify the change detection but these images are very expensive, so that this method need high badged project to fund the researcher or planner in non-development countries.

3.8 References

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Chapter 4

A Study on Urban Growth in Torrent Risk Areas

4.1 Introduction

Like many developing countries, Egypt has to contend with the problems caused by urban sprawl. For the earlier five decades, there has been an unprecedented sprawl process despite the government's efforts to slow it down. While only fewer than 10% of the current total population lived in cities at the opening of the 20th century, the urban population rose by 45 % by the end of the century. The annual growth rate of the urban population is projected at 2.2 percent until 2050, exceeding the 1.8 percent annual growth rate of entire population [1]. Urban population growth is a worldwide phenomenon but the rate of urbanization is especially fast in Egypt.

The world has witnessed a frightening increase in the frequency and harshness of disasters, with 240 million people on average being pretentious

by natural disasters universal each year between 2000 and 2005. In 2007 alone, 414 natural disasters were informed, killing 16847 persons, harming or displacing more than 211 million others, and affecting damage estimated at over 74.9 US\$ billion [2]. In 2014, the number of stated disasters confirmed the worldwide upward trend in natural disaster incidence. This trend is mostly driven by the increase in the amount of reported hydro-meteorological disasters. Hydrological (essentially floods) and meteorological (storms) disasters are the main contributors to this pattern. In latest decades, the amount of reported hydrological disasters had been growing by 7.4% annually on average. At the same time, there had also been an upward trend in population growth, with an average annual growth rate of 8.4% in the 2000 to 2007 period [2], Flash floods are regularly characterized by raging torrents afterward heavy rains that rip through river beds, urban roads, or mountain valleys, sweeping all thing before them [3]. The phenomenon of the flash flood is one of the furthestmost difficult natural disasters to predict in relations of time and place of occurrence. As a result, it is challenging for the concerned authorities and communities to respond an appropriately; effective response plans are indispensable tools to mitigate the danger of flash floods [4].

Table 4-1 Number of people affected by natural hazards in Egypt.

	1979	1992	1993	1994	1995	1996	2002	2008	2010
Earthquake	-----	92,649	-----	-----	69	-----	250	-----	-----
Flood	66,000	-----	-----	160,660	3000	260	800	-----	3500
Landslide	-----	-----	-----	-----	-----	-----	-----	697	-----
Storm	15,000	-----	-----	-----	-----	-----	-----	-----	-----

Egypt is positioned in the global belt of hot dry desert land with scarce rains. The Eastern desert has a network of intertwined olden valleys. When water exceeds the level of fullness in these deserts, it concentrates in the

valleys and decants either into the Red Sea or the Nile Valley. Geographic topographies assist in giving water a drive to destroy anything in its way [5]. Flooding on January 18, 2010, for instance, affected over 3500 persons and claimed 12 lives, while a similar flood in 1994 affected over 160,000 persons as shown in Table 4-1 [5, 6]. Egypt has also suffered from periodic flash floods in the Sinai Peninsula, and the areas of the Red Sea port of Hurgada and Aswan [7]. Torrential rains as high as 20 mm/ day over Saint Catherine on October 18, 1997 and similar amounts in Al Qusseir, Ras Benas, Ras El Naqb and Aswan on the same day, led to very severe floods [5].

4.1.1 The impact of natural disasters on urban growth

Disaster losses are increasing throughout the world due to a amount of factors that include more recurrent extreme weather events associated with increasing climate change. Population increasing accompanied with demographic change and movements are leading to unplanned urbanization.

The villagers in this area lived in constant fear of natural disasters. This was because the watersheds, positioned to the east of the River Nile in the region between the cities of Edfu and Aswan, are a source of hazard. This is mainly so in the vicinity of Kom Ombo and east of Aswan. In May 1979, runoff rash resulted in travel disturbance and rail lines being cut off, also the collapse of 200 houses in the dominant parts of Edfu, Kom-Ombo, and Aswan [8]. Torrential floods instigated the deaths of three children who were buried under the rubble, and around 300 families were expatriate. In addition, some streets in parts of the agricultural land were blocked by boulders. These floods were recurrent in October the same year, leading to the collapse of more than 300 constructions and cracks in a large number of the remainder. Moreover, torrents had escorted dust storms, thunderstorms, cyclonic rain, and frequent floods were experienced in 1980, 1987, 2005, and 2010 [8, 9].

Severe hurricane surprised the people of the province of Aswan on the evening of 17th Jan. 2010, which had followed through a torrential rain for 30 min continuously. About 50 electricity towers of high voltage had dropped on the ground which directed to the cutting of Aswan province power. Afterward, rains which collected on the eastern mountains had turned into a torrent and removed the home furnishings and people, leaving behind hundred households' destruction, which caused an unexpected catastrophe that was new bad experience for people. Furthermore, hundreds of houses had been broken because of directly rainfall and threatening to collapse at any moment. As rains and severe storms caused injury to thousands of acres of agricultural and displacing of trees from the root, as well as damaging tons of harvest dates which people had put them under the sun to dry out. That disaster happened at the village of northern "Abouelreesh" at a distance of 5 kilometers northerly Aswan adjacent to the Red Sea Mountains at a length of 500 meters north-south and at the depth of 1300 meters east-west. The furthestmost vulnerable places to torrents were houses that had been constructed along the east of the railway, pending the mid of the mountain. The competent administrative establishments had alerted the danger of this region and its surroundings for building on it, because of the water storm risk (Figure 4-1).



Figure 4-1. Buildings are destroyed in Abouelreesh village after a torrent in 2010.

Because of lacking of other existing areas; people have been forced to construct in this region and settle there. This time was not big harm, because there were not too much people at that time [10]. Around 20,000 people are living in this region. Consequently, torrents caused in the destruction of a total of about 25 houses and incompletely demolished for about 50 home mostly built of stone and mortar clay addition water storm Abu Spirh, It is away from the city of Aswan about 15 kilometers to the north and then eastward about 4 kilometers and occupied by tribes Ababdh totaling about 3000 people can measure the damage, which suffered the destroy of 10 homes totally and about 30 houses in part also draws big tracts of agricultural land and the uprooting of many trees (Figure 4-2) [8].



Figure 4-2. Roads and buildings affected by torrents in Egypt.

4.2 Method

This chapter aims to identify the risk areas affected by torrents in the case study area and to investigate the relationship between the risk areas and urban sprawl. Using the WMS software, the collected data would be used to simulate the torrent and runoff water so that risk areas could be identified. Moreover the simulation method using WMS software was the more accurate method because the take in account many kind of data source such as soil type map, land use map and the rain precipitation so that in this chapter will use this method to identify the risk area in case study.

4.2.1 Simulation Data Sources

Fulfilment of the research targets required detailed data. Unfortunately, the data available for the case study area were incomplete. For example, we could not conduct a proper analysis of the urban sprawl because the detailed plan from the government did not contain information

on when the buildings in the urban areas were constructed. Secondly, there was the problem of low resolution files provided free online, for example, the Land Use map, Soil Type map and DEM (Digital elevation models) files. High resolution DEM files were expensive to acquire. A third problem was the difficulty in obtaining official governmental data on the case study area. Table 4-2 shows all data files used in simulation and their sources.

Digital elevation models (DEM) (Figure 4-3) is an important source of information in GIS software. They have been widely used for modeling surface hydrology, including the automatic delineation of catchment areas [11].

To overcome the first problem of incomplete information regarding the year of building construction, we used Google Earth historical images to obtain the necessary information. To resolve the second problem regarding the costs of obtaining high resolution imagery, we used the free online data despite their low resolution. We were able to obtain free Land Use map, Soil Type map and DEM files with the help of the WMS software. To overcome the third problem, i.e. the difficulty of obtaining topographic coverage of the study area, we used collected data from journal articles and reports from our own institutes.

4.2.2 Identifying the Risk Areas

The methodology in this section describes how the hazard areas were identified. We had to determine which parts in the case study area would experience flash floods in relation to its distance from the hazard area. To achieve this objective, we used the same method which was mentioned in section no. 0. In order to make the map easily understandable, a same

reclassification was performed to define five flood hazard intensity levels/categories—very low, low, medium, high and very high [12].

Table 4-2 Data used in flood simulation

	Data Source
Detailed plan	General Organization for Physical Planning - Aswan
DEM file	U.S. Geological Survey (USGS) Website
Land Use map	USGS Land Cover Institute
Soil Type map	Food and Agriculture Organization of the United Nations(FAO) Digital Soil Map of the World (DSMW)
Precipitation	Master Thesis http://www.cpas-egypt.com/ [9]

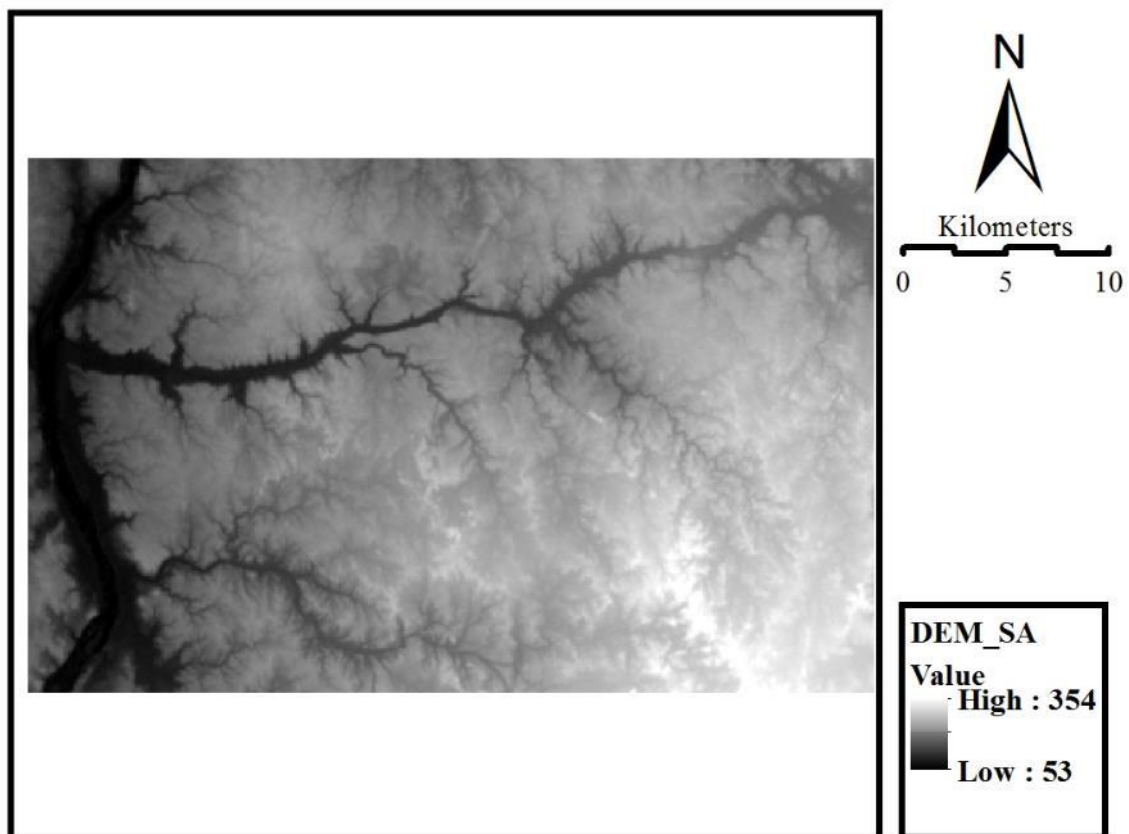


Figure 4-3 Digital Elevation Model File for the case study area.

The risk areas were further divided into five parts based on the range of water depth. There were 5 levels of flood hazards: Very Low Hazard with < 0.07 m depth of flood, Low Hazard with 0.07 m 0.24 m depth of flood, Moderate Hazard with 0.24 m 0.58 m depth of flood, High Hazard with 0.58 m 1.09 m depth of flood, and Very High Hazard with > 1.09 m depth of flood [13].

4.2.3 Identifying the Urban Sprawl

The research methodology in this section was aimed at studying the case study region in different periods of time in order to identify growth trends. We used the same official detailed plan for the study area which mentioned in section no.3.1.1. The method described in this part requires only personnel training in photointerpretation, minimal training (at most) in GIS, Internet access, and a computer with a relatively high-resolution monitor.

4.3 Result & Discussion

4.3.1 GSSHA Simulation

From the results of the simulation where water depth was estimated every 15 minutes, water depth at peak runoff for each watershed could be determined. Figure 4-4 shows the water depth file (raster) that was converted from WMS to ArcGIS for analysis. The first step in ArcGIS was converting the raster file of water depth to a vector file, followed by the division of the water depth to five categories of hazard: Very Low Hazard, Low Hazard, Moderate Hazard, High Hazard, and Very High Hazard. The next step was assigning new attributes in the urban area data file for each building to depict the level of hazard, based on its location from the hazard level contour.



Figure 4-4 Contour lines for Hazard depth.

4.3.2 Urban Sprawl towards the Hazard Area

Urban areas in the case study were divided into two groups, depending on the distance from areas prone to flash floods. The first group was located in a safe area about 72.18 ha, free from flash flood water as the

expected water depth was zero; the second group was about 112.49 ha, and was located in an area at risk of being inundated at different levels.

Land use in the study area was distributed according to three categories as shown in Table 4-3. In the risk area, land allocated for residential use was the biggest category, occupying 106.23 ha or about 61.10 % of the risk area, while land used for services in the safe area was the largest category (55.37%) in the safe area. Graves took up about 6.35 ha of the total land area, with only 1.15 ha in the safe areas as most of the graves were located in the risk area, taking up 5.20 ha. These statistics indicate that residential land use in the urban area formed the largest category of land use (173.01 ha). Unfortunately, most residences (61.4%) were in the risk area.

Table 4-3 Land use in the risk area and the safe area.

	Total Area (ha)	Safe Area (ha)		Risk Area (ha)	
Residential	173.01	66.78	38.60 %	106.23	61.40 %
Services	8.56	4.74	55.37 %	3.82	44.63 %
Graves	6.35	1.15	18.11 %	5.20	81.89 %
Total	184.67	72.18	39.09 %	112.49	60.99 %

In the same risk area, 44.63 % of the land allocated for services was prone to flash floods. Land use distribution over a period of 12 years was compared. As indicated in Table 4-4, development of urban areas from 2001 to 2013 in the risk area was 112.49 ha (60.91%), compared with 72.18 ha (39.09%) in the safe area. In 2001, 47.46 ha (40.21%) of total urban areas was in the safe area. The year 2005 saw the smallest urban expansion at 4.61 ha in the period under study; land use in both the safe area and risk area was 47.20% and 52.71% respectively.

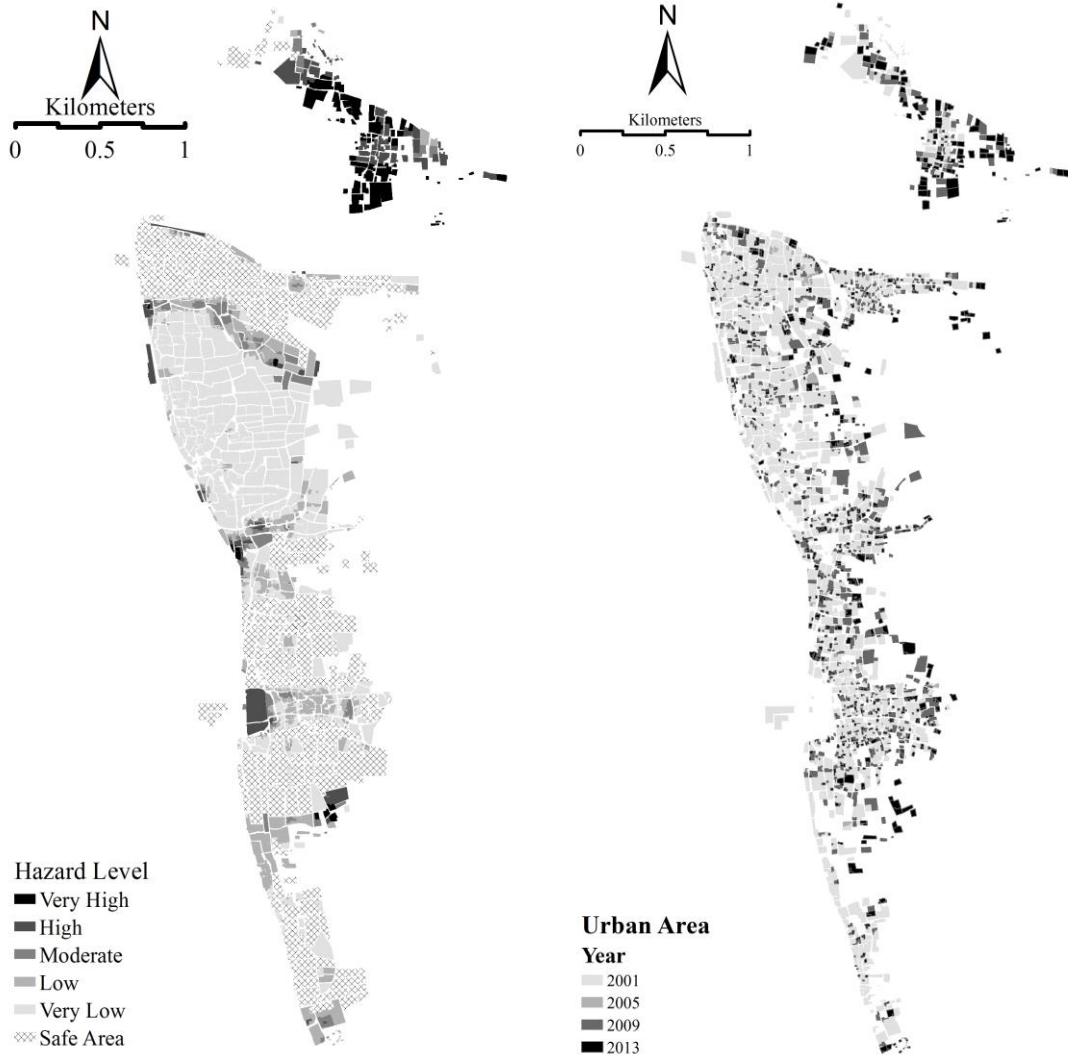


Figure 4-5 Urban area Classification.



Figure 4-6 Urban sprawl over the years

Figure 4-6 and Figure 4-7 shows the urban area that was divided into four periods, together with buildings on them. Table 4-4 also shows that built urban areas increased by 32.89 ha in 2009, but dropped to 29.15 ha in 2013. Our findings, as shown in Figure 4-7 and Table 4-4, indicated that generally, during the period of study, urban expansion in the risk area was greater than that in the safe area.

Table 4-4 Urban areas from 2001 to 2013

	Total Area (ha)	Safe Area (ha)		Risk Area (ha)	
2001	118.03	47.46	40.21 %	70.57	59.79 %
2005	4.61	2.18	47.29 %	2.43	52.71 %
2009	32.89	12.48	37.94 %	10.40	62.06 %
2013	29.15	10.07	34.55 %	19.08	65.45 %
Total	184.67	72.18	39.09 %	112.49	60.91 %

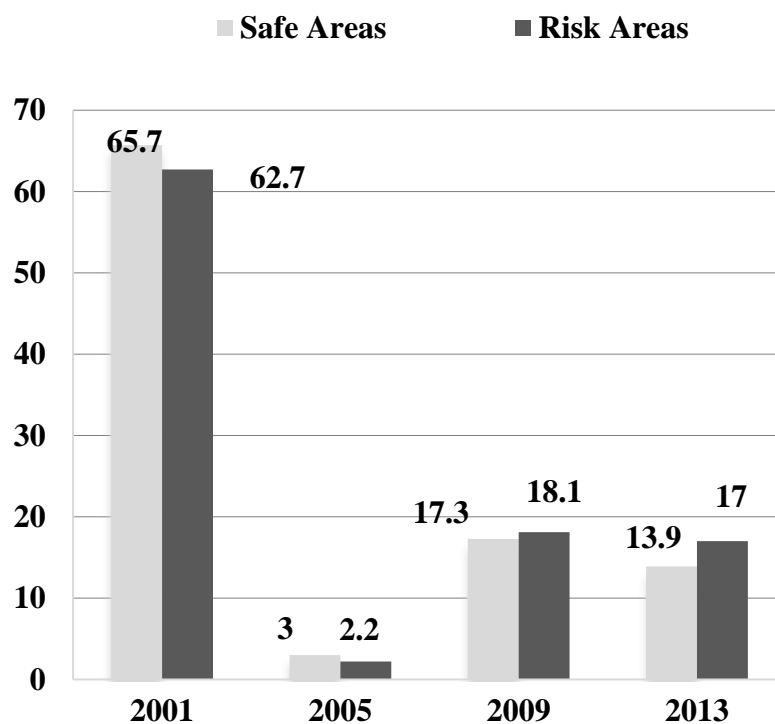


Figure 4-7 Proportion of safe and risk areas developed according to year

The most extensive urban development (20.4 ha) occurred in 2009, and this was located in the risk area (Table 4-4). Figure 4-7 shows that 65.7%

of the urban development located in the safe area had been built before 2001. This was slightly higher than the proportion of development in the risk area (62.7%) completed prior to the same point in time. Figure 4-8 shows the annual rate of increase in urban developed area rising from a low rate of 3.44 % in 2005 for risk area to 27.95% in 2009, before declining slightly to 20.43% in 2013. The trend in urban development in the safe area followed closely, reaching 25.14% in 2009, and 16.21% in 2013.

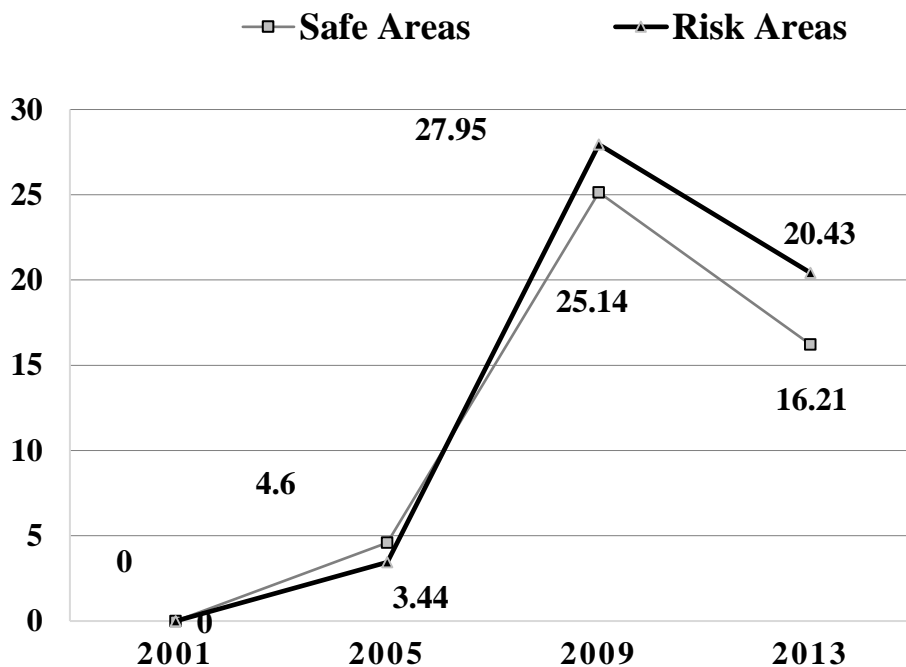


Figure 4-8 Annual rate of increase in developed safe and risk areas

4.3.3 Classes of Hazard Areas and Urban Sprawl

The hazard region was divided into five areas based on the degree of exposure to the risk of flash floods. As shown in Table 4-5, during the study

period, most of the areas at risk within the urban region (63.70 ha) were categorized as having exposure to very low hazard risk, while the urban areas categorized as more hazardous took up 48.78 ha. (Low hazard - very high hazard). In addition the distribution of the urban area over the 12-year period years showed the following: First, until 2001, the biggest urban area had been built in a very low hazard area, occupying 45.15 ha; the smallest urban built area in the same hazard degree was 1.12 ha in 2005.

Second, the smallest built area was in 2005 at 0.11 ha, located in the moderate hazard area. Third, in 2013, the biggest new urban area (4.49 ha) was located in the very high hazard area while the smallest very high hazard urban area at 0.35 ha was developed in 2005.

The final observation was that the urban regions that were built in areas rated high hazard or very high hazard took up about 20.26 ha from the total area of about 112.48. This meant that more than 18 % of the urban risk area was located in high and very high hazard areas.

Table 4-5 Urban risk area distribution based on hazard level

	Very Low Hazard Area (ha)	Low Hazard Area (ha)	Moderate Hazard Area (ha)	High Hazard Area (ha)	Very High Hazard Area (ha)
2001	45.15	13.96	4.48	4.92	2.07
2005	1.12	0.39	0.11	0.46	0.35
2009	11.31	3.25	1.11	2.04	2.69
2013	6.11	3.90	1.33	3.25	4.49
Total	63.70	21.50	7.02	10.66	9.60

4.3.4 Characteristics of Urban Sprawl in the Risk Area

Development of the services area had not been very rapid since most service units had already been built at the commencement of the study

period. In residential area development, however, much more new housing was added over the years, with the average size of the built-up rising, especially those in the risk area.

4.3.4.1 Relationship between Urban Sprawl and Size of Residence Blocks

Urban sprawl increased rapidly from 4.29 ha built in 2005 to 32.37 ha built in 2009, before decreasing to 28.54 ha built in 2013. It was observed that there was a change in the average of size of buildings, from 241 m² in 2001 to 346 m², an increase of more than 100 m² in just 12 years. From 2001-2005, the size of residence blocks in the safe area decreased slightly from 218 m² to 209 m². There was a small decrease again during the period 2009-2013, from 281 m² to 271 m² but overall, the average size of buildings in the safe area increased from 218 m² to 271 m² during the 2001-2013 period.

In contrast, average house size in the risk area increased much more, from 260 m² to 407 m² in the same period, with only one decrease from 260 m² to 230 m² in the first four years of the study period, i.e. from 2001 to 2005. Table 4-6 shows that as the urban sprawl grew, so did the size of residence blocks. In the same context, it was observed that on average, residence blocks in the risk area were bigger than those in the safe area. The greatest discrepancy in size between residence blocks in the safe area and those in the risk area was seen in 2013, with the latter reaching more than 150% in average area as compared with the former.

Table 4-6 Average size of residential buildings.

	Residential in Total Area			Residential in Safe Area			Residential in Risk Area		
	Area (ha)	count	Ave (m2)	Area (ha)	count	Ave (m2)	Area (ha)	count	Ave (m2)
2001	107.77	4466	241	42.50	1951	218	65.27	2515	260
2005	4.29	167	257	2.11	101	209	2.18	66	230
2009	32.37	1031	314	12.15	433	281	20.22	598	338
2013	28.54	824	346	10.01	369	271	18.53	455	407
Total	173.01	6488	267	66.78	2854	234	106.23	3634	292

4.3.4.2 Relationship between Urban Sprawl and Services Area

Most of the services area (7.22 ha) had been developed by 2001. Over the subsequent 12 years ending in 2013, only 1.34 ha of development was added. As shown in Table 4-7, a greater number of the developed services infrastructure was located in the safe area.

Between 2005 and 2013, the greatest increase in the area allocated to services was 0.44 ha, comprising 4 units in the high risk area, while the lowest increase the same year was one unit occupying 0.05 ha in the low risk area. The greatest total increase in services area occurred in 2009 when 0.52 ha was added. Of this, one unit of 0.34 ha was located in the safe area while 7 units in the risk area accounted for 0.18 ha.

Table 4-7 Average size of services buildings

	Services in Total Area			Services in Safe Area			Services in Risk Area		
	Area (ha)	count	Ave (m2)	Area (ha)	count	Ave (m2)	Area (ha)	count	Ave (m2)
2001	7.22	64	1141	4.28	29	1477	2.94	35	840
2005	0.32	5	640	0.06	3	214	0.26	2	1279
2009	0.52	8	646	0.34	1	3364	0.18	7	257
2013	0.50	5	992	0.05	1	532	0.44	4	1107
Total	8.56	82	1069	4.73	34	1393	3.82	48	830

4.3.5 Government Orientation toward Urban Sprawl

The government's Master Plan to redirect the urban sprawl includes a move to limit new urban development in risk areas. Of the residential locations identified in risk areas, 33.27 ha have been proposed for development in areas with very low hazard Table 4-8. This is already more half of the total allocation for residential development in the risk area. On the other hand, only 1.89 ha and 3.15 ha of high hazard and very high hazard areas respectively have been earmarked as future residential areas. In this regard, only about 3.13 ha of areas deemed to be of moderate hazard have been proposed for residential development. Whereas the total risk area slated for residential development is 52.04 ha (or 53.4% of the total), that in the safe area niece is 45.36 ha (46.6%). In contrast, only 66.78 ha (38.6%) of the total residential area of 173.01 ha was developed in the safe area.

Table 4-8 Proposed residential development in risk areas

Area of Risk Residential Parts	Total Residential 2013 (ha)	Proposed Residential (ha)
Very Low Hazard	62.08	33.27
Low Hazard	20.60	10.60
Moderate Hazard	6.70	3.13
High Hazard	7.63	1.89
Very High Hazard	9.23	3.15
Total Risk Residential	106.23	52.04
Total Safe Residential	66.78	45.36
Total of Residential	173.01	97.40

4.4 Conclusion

Villages in the Aswan province are occasionally threatened by the risk of torrents which cause loss of lives and property as well as damage to buildings and disruption to services. This study found that despite the risk of torrents, people still continued to build houses, even bigger ones, in the risk area. Urban growth from 2001 and 2013 reflected this phenomenon. The use of free data in torrents simulation can generate primary results close to real live situations. The method would be helpful to decision makers and planners in countries which do not have enough data or do not have sufficient funding to bid for development projects, especially if it is necessary to perform simulations of the potential site to avert the threat of natural disasters. It would be most useful if more precise data were available to enable more accurate simulations so that the analysis of the hazards in the risk area would yield more reliable data. This would make a considerable difference in the appraisal of the area for proposed development.

There are different trends of urban growth, but one that poses danger to people and property is the sprawl that heads towards areas which are

exposed to natural disasters. The findings in this study showed that in the case study area, urban growth in the period between 2001 to 2013 headed towards the risk area which was prone to torrents, posing varying degrees of hazard.

Urban growth in the risk area of this case study area, Abouelreesh, had special characteristics that were noteworthy. Firstly, the average size of residence blocks in the risk area was considerably bigger than the residence blocks in the safe area and also much bigger than those built in earlier years. The second characteristic concerned the government's unexplained distribution of proposed residential area because more than 53 % of the area would be located in the risk area.

This chapter has two main parts in methodology, First one how to identify the year of building construction of urban land use by using manual photo-interpretation from satellite imagery obtained from Google Earth, To verify this part We recommend that a field survey be undertaken first to identify the old urban areas. After this, a comparison can be made between the field observations and manual photo-interpretation from satellite imagery obtained from Google Earth. This would give a good indication of the urban sprawl. At the same time, the discrepancies between the two methods would help researchers calibrate the manual photo-interpretation that can be used to obtain a rapid result without cost. On other hand we can add other verification method by using remote sensing analyses to high resolution satellite images to identify the change detection but these images are very expensive, so that this method need high badged project to fund the researcher or planner in non-development countries.

Second method is describes how the hazard areas were identified by using the GSSHA model in WMS software to simulate rainfall and surface

water runoff For this part we can recommend two methods to verify the simulation, first one use the same data with other hydrological software such as MIKE FLOOD, CCHE, FLO-2D or TUFLOW, the second recommendation is using filed study data and high resolution data with the same software and model such as DEM, Soil Type and Land Use map, those kind of data doesn't obtainable on undeveloped countries and need very big budget for researches.

By simulating flash floods in risk areas, alternative approaches to the planning of urban growth can be considered and this could form the basis of policy recommendations for sustainable urban development. We further recommend the use of the GSSHA model to identify the flash flood risk areas for a rapid preliminary estimate. However, more accurate results would require analyses based on high resolution data that would require expenditure to secure. Future research on the urban sprawl in this region would allow a better appreciation of how new urban areas would be exposed to the risk of torrents and floods. Hopefully, new findings would help to mitigate the loss of life and property.

4.5 References

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CHAPTER FIVE
CONCLUSIONS

Chapter 5

Conclusions

5.1 Research Summary

This is the final chapter in thesis and it can explain how the research could add provision to the important step in managing the risk of natural environmental disaster procedure, this chapter can display the previews aim by the following research conclusions.

Firstly, the methodology of this research could provide three easy and fast different tools to identifying the risk area which it was prone to torrents as a part of the risk management procedure for natural disasters, two of them using ArcGIS - Hydrology Tools to delineate the Contour Map and Watersheds, the third tool which used in identifying the risk are is GSSHA model to simulate the torrents, this tool was the most detailed from the others method and it can generate primary results close to real live situations.

Secondly, the research could again provide simple and plain method to analyses the previews development in urbanization by determine the approximate periods for buildings that have been where construction by using manual photo-interpretation from historical satellite imagery in Google Earth, this method can be consider as a very important step in studying the urban growth in the past and predict the future situation.

Thirdly, by using Land Change Modeler the research could extract the driving factors that can led the urban sprawl to try to understanding the driving forces that have high impact on of urban area expansion in the past, This methodology would be very useful in determine the future urban sprawl by using Markov Chain Model.

Finally, the research could provide all the previews method in identify the risk area, an analyses the previews development in urbanization and expect the future urban sprawl with using free and easy access data such as Digital Elevation Model (DEM) files, Soil maps, Land use Map and historical satellite imagery in Google Earth, It would be helpful to the decision-makers, planners and the government officials in countries which do not have enough data or do not have sufficient funding to bid for development projects, especially if it is necessary to perform simulations of the potential site to avert the threat of natural disasters.

5.2 Future work

It is important to strengthen the coordination and cooperation between scientific centers and universities within Egypt with the decision-makers, planners and the government officials to provide the researchers with all data needed in disasters risk management moreover they have to put the very strong plan to develop early warning and response systems from natural environmental disasters.

It would be most useful if more precise data were available to enable more accurate simulations so that the analysis of the hazards in the risk area would yield more reliable data. This would make a considerable difference in the appraisal of the area for proposed development.

More work needed from the government officials on capacity building improving transparency and accountability, enforcement of zoning and building codes, development of social housing at affordable prices away from high-risk zones, and ensuring a fair policy for land acquisition.

It is likely that climate change will increase Torrents with more frequent and intense rainfall in areas traditionally known as dry land with dry climate. In addition, and in Arab cities that have combined infrastructure for sewage and rainwater, there is risk for public health when wastewater contaminates flood water.