

## Using Arc GIS to analyse urban growth towards torrent risk areas (Aswan city as a case study)

Omar Hamdy<sup>1</sup>, Shichen Zhao<sup>2</sup>, Mohamed A. Salheen<sup>3</sup>, Y. Y. Eid<sup>4</sup>

<sup>1</sup> Research Visitor, Department of Architecture and Urban Design, Faculty of Human-Environment Studies, Kyushu University, Japan

<sup>1</sup> Assistant Lecturer & PhD Student, Architectural Engineering Dept., Faculty of Engineering, Aswan University, Aswan, Egypt

<sup>2</sup> Associate Professor, Department of Architecture and Urban Design, Faculty of Human-Environment Studies, Kyushu University, Japan

<sup>3</sup> Associate Professor, Urban Planning & Design Dept., Faculty of Engineering, Ain Shams University, 1 Sarayat St., Abassia, Cairo, Egypt

<sup>4</sup> Professor, Urban Planning & Design Dept., Faculty of Engineering, Ain Shams University, 1 Sarayat St., Abassia, Cairo, Egypt

E-mail: omargem56@yahoo.com

**Abstract:** Areas suffering from storm water drains are considered to be the places most at risk, water torrents have an effect on urban areas and can cause a lot of damage to buildings and infrastructure. Moreover, there is dangerous situation whereby urban growth is occurring towards at-risk areas. The urban growth rate in risk areas rose up to 24.9% in 2001, and reached 48.8% in 2013. Urban growth in “Abouelreesh” village had been influenced by the construction of larger buildings, because most people were looking forward to live in bigger houses. We can discover the previous problem by observing the average size increase of the buildings’ areas from 2001 until 2013, especially in risky areas where the average building’s area had grown from 254 m<sup>2</sup> in 2001 to 411 m<sup>2</sup> in 2013. This Phenomenon is considered to be very important factor which attracts the urban growth towards the risky areas in spite of the danger surrounding them.

### 1. Introduction

Urban growth usually leads to the change of land use and the form of land cover at many areas around the world, especially in developing countries [1]. Moreover, urban areas have a natural extension in multiple directions, even sometimes they tend to grow towards places threatened by natural disasters. Hence, the governments’ decision makers and planners should solve this problem through risk management and prevention of urban growth 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 clusters of buildings, streets, areas of services, and land space. Urban sprawl which had become an issue for many rapidly developing areas refers to the uncontrolled growth of an urban area resulting from poorly or totally unplanned urbanization [2].

For example, the growth of urban areas depends on the population growth and buildings in a city. This type of metrics measures what is present and the householders’ relative amounts or properties



regardless to where on the landscape they may be located. Therefore, the analyst should be aware about the spatial / non-spatial nature of the selected metrics. [3]

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 danger 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 scholars focused on using indicators to measure urban sprawl by establishing multi-dimensional indicators by GIS analysis or descriptive statistical analysis [2]. Growing of urban sprawl is a serious concern worldwide for a number of environmental and economic reasons [4]. Rapid increase of urban sprawl in many countries worldwide had become a major concern because of its detrimental effects on the environment. Existing measures of urban sprawl suffer from a confusing variety of differing and sometimes contradictory interpretations of the term "urban sprawl" [5].

## 2. The impact of natural disasters on urban growth

The world had witnessed an alarming increase in the frequency and severity of disasters; 240 million people on average were affected by natural disasters world-wide each year between 2000 and 2005. During each of these six years these disasters claimed an average of 80,000 lives and caused damage of an estimated 80 billion US\$. Disaster losses are rising throughout the world due to a number of factors that include more frequent extreme weather events associated with increasing climate change. Population growth accompanied with demographic change and movements are leading to unplanned urbanization.

Catchments which are located in the east of River Nile at the region between Edfu and Aswan cities are dangerous, particularly at the area of Kom Ombo and the east of Aswan. In May of 1979 the runoff spate had resulted in disrupting the rail lines, besides affecting the central of Edfu, Kom-Ombo and Aswan which had led to the collapse of the 200 houses. Moreover, the torrents flooding had resulted in killing three children under the rubble and around 300 families had been displaced, besides the falling of boulders on some parts of the agricultural road and cutting the rail lines. These floods were repeated in October from the same year which led to the collapse of more than 300 buildings and cracking a large number of buildings. Moreover, torrents had accompanied with these dust storms, thunderstorm, cyclonic rain and frequent floods in the years 1980, 1987, 2005 and 2010 [6] [7].



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

Severe hurricane shocked the people of the province of Aswan on the evening of 17<sup>th</sup> Jan. 2010, which had followed directly by a torrential rain for half an hour continuously. About 50 electricity pylons of high voltage had dropped on the ground which led to the cutting of Aswan province power. After that, rains which accumulated on the eastern mountains had turned into a torrent and swept the home furnishings and people, leaving behind hundred houses destruction, which caused a sudden catastrophe that was new bad experience for people. In addition, hundreds of houses had been cracked because of directly rainfall and threatening to collapse at any moment. As rains and severe storms caused damage to thousands of acres of agricultural and uprooting 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 catastrophe

happened at the village of northern "Abouelreesh" at a distance of 5 kilometers northern 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 most vulnerable places to torrents were houses that had been built along the east of the railway, until the mid of the mountain. The competent administrative authorities had alerted the danger of this region and its surroundings for construction on it, because of the water storm risk (Fig.1).

Because of lacking of other available areas; people have been forced to build in this region and settle there. This time was not big damage, because there were not too much people at that time [8].

Around 20,000 people are living in this region. Therefore, torrents caused in the demolition of a total of about 25 houses and partially 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 inhabited by tribes Ababdh numbering about 3000 people can assess the damage, which suffered the destroy of 10 houses completely and about 30 homes in part also draws large tracts of agricultural land and the uprooting of many trees (Fig. 2) [7].



**Figure 2.** Roads and buildings affected by torrents in Egypt.

### 3. Study area

The study area (Northern Abouelreesh village) is located in the city of Aswan in southern Egypt Where it lies between longitudes 32°52'E to 32°55'E and latitudes 24°10'N to 24°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 (Fig. 3).

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.

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 [8].



**Figure 3.** The study area related the world.



#### 4. Methodology

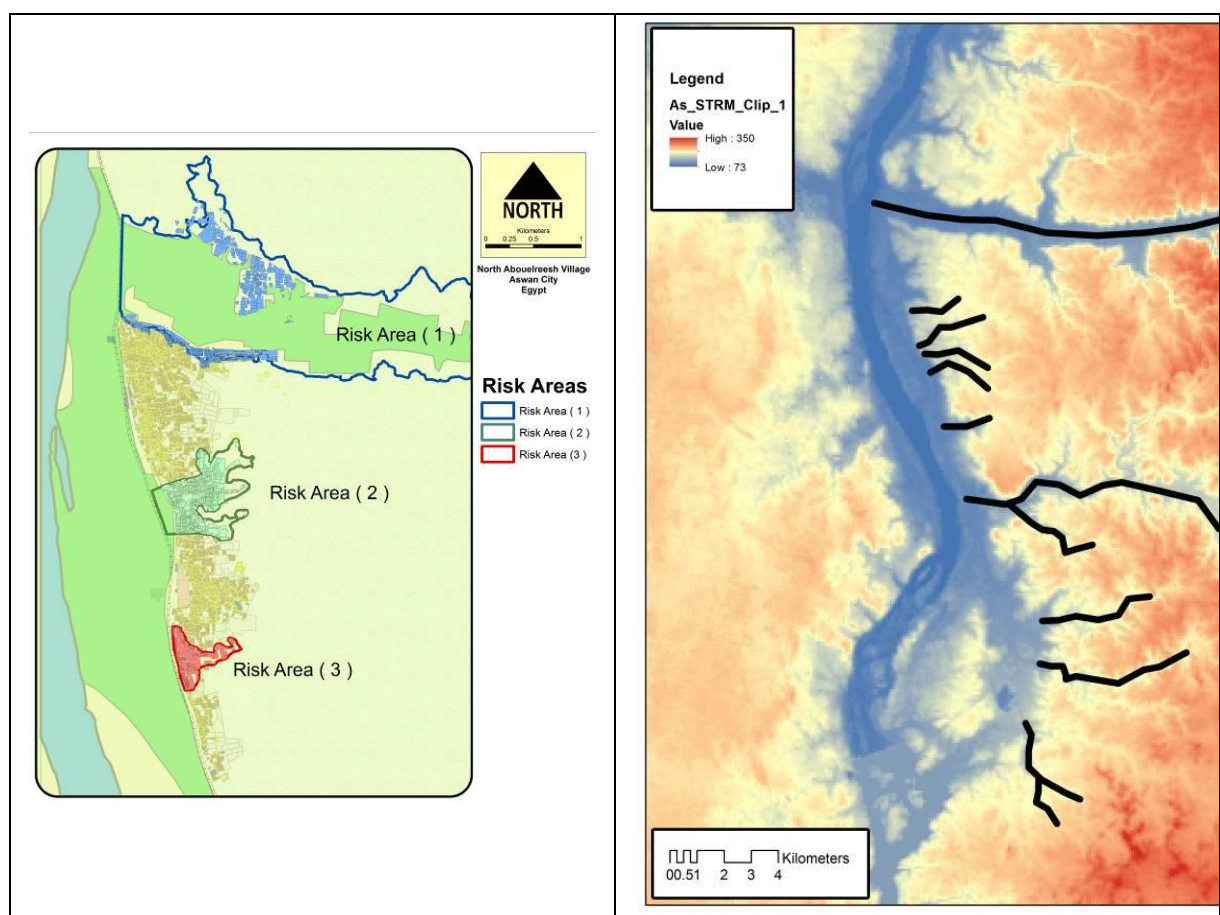
Research methodology is based on the study of the region in different time periods and identifies urban growth especially in risky areas which are facing natural hazards; it was conducted in several steps.

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 analyze 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.

Then, we were identifying risky areas 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.

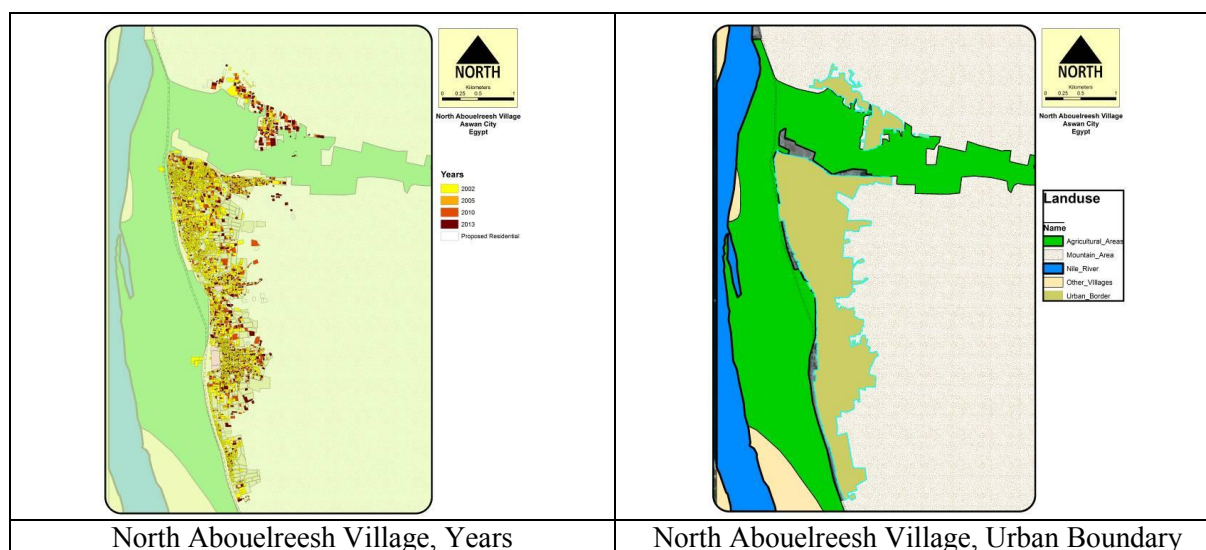
Finally, the study area was divided into two region types according to their exposure to the flooding risk; safe areas, and far from the scope of the water floods.



**Figure 4.** Identify the risk area by digital elevation model and convert it to contour map.

#### 5. Data Analysis

We studied and analyzed the buildings ages using Google Earth and land use in the study area according to (Fig. 4). 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 as shown in (Fig.5).



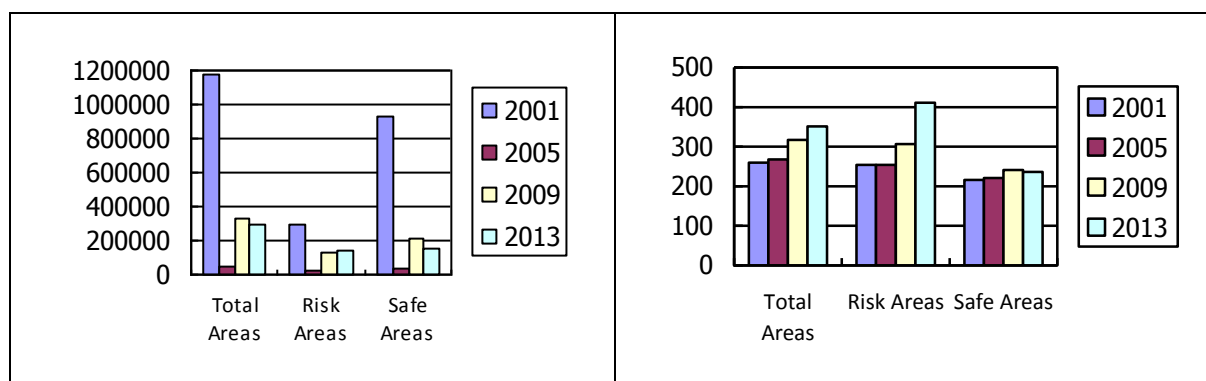
**Figure 5.** Study the current status of the village of Abouelreesh (land use – years of construction - Urban Structure).

We used Arc GIS to analyze the data about the time periods for buildings and obtaining the total area of buildings for each period (Fig. 5), Also calculate the average area of buildings for each year to compare between them and find the urban growth, Then we made the same analysis with the study of safe areas and risky areas to determine the total area and the average area of the buildings for each year separately in each region according to table (1).

**Table 1.** This table shows the area of urban areas and the average area units.

Year	Sum Total Area ( m <sup>2</sup> )			Percentage Area ( % )		Ave Total Area ( m <sup>2</sup> )		
	Total Areas	Risk Areas	Safe Areas	Risk Areas	Safe Areas	Total Areas	Risk Areas	Safe Areas
<b>2001</b>	1180287	293909	926074	24.9 %	78.5 %	260	254	216
<b>2005</b>	46075	18751	30326	40.7 %	65.8 %	268	254	221
<b>2009</b>	328853	124667	212978	37.9 %	64.8 %	317	307	241
<b>2013</b>	291523	142260	156462	48.8 %	53.7 %	351	411	236

Table (1) shows 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, also table shows the level of safe areas where amounted to 16.06%, while the highest rate was in risky areas around 24.54% between 2009 and 2013, But less than percentage between 2001-2005 about 2.49%.



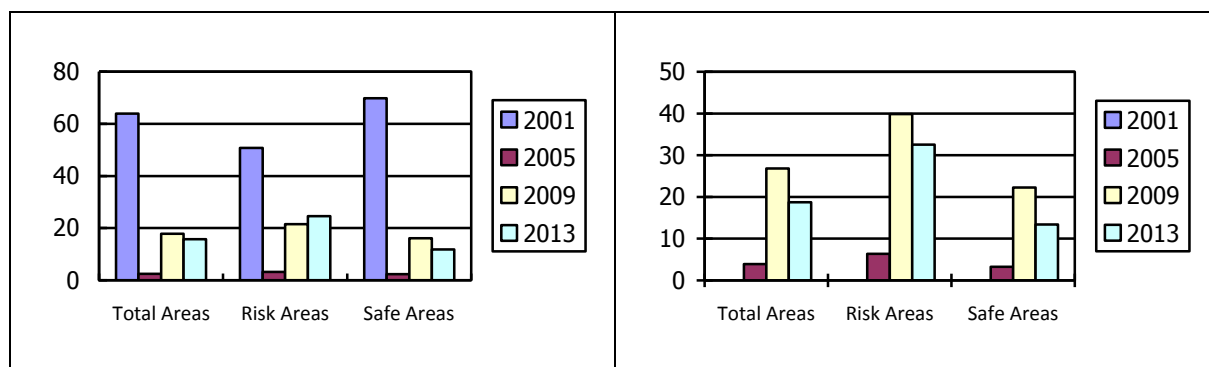
**Figure 6.** It is show the relationship between the Urban Area and average area for units in safe areas and risky areas.

As shown in Table (1) urbanization rate increase during the years of the study in all areas and showing that the highest increasing rate between the two years was 26.32% in total urban areas, but risky areas and safe areas were 39.87% and 22.27% respectively, It happened between 2005 and 2009 while it was less than the increasing rate between 2001 and 2005. (Fig. 6)

**Table 2.** The amount of urban growth each year and the percentage increase.

Year	Annual Extend %			Increase %		
	Total Areas	Risk Areas	Safe Areas	Total Areas	Risk Areas	Safe Areas
<b>2001</b>	63.91 %	50.71 %	69.85 %	0.00 %	0.00 %	0.00 %
<b>2005</b>	2.49 %	3.24 %	2.29 %	3.90 %	6.38 %	3.27 %
<b>2009</b>	17.81 %	21.51 %	16.06 %	26.82 %	39.87 %	22.27 %
<b>2013</b>	15.79 %	24.54 %	11.80 %	18.74 %	32.53 %	13.38 %

When we studied the relationship between the average area of building and urban growth we have noted that the average area is getting big in risk areas at about 411 m<sup>2</sup> in 2013, while the average area of building in safe areas reached 236 m<sup>2</sup> in the same year that It is an indication to the trends of the population in the urban sprawl around risky areas in search of big space table (2) and (Fig. 7).



**Figure 7.** Graphic shows the amount of urban growth each year and the percentage increase in the safe areas and risk areas.

## 6. Results

After studying urban growth in Abouelreesh village in each of the following years 2001, 2005, 2009 and 2013 we did that by selecting all of area urban and determine the ratio in each of the safe areas and risky areas, Research found that Abouelreesh village grows in risky areas that's where the percentage urban areas in risky area was 48.8 %, Which threatens the future of the village, the government requires to develop a plan to manage the risk in the village with the provision of alternatives for the population to avoid construction in risky areas.

Building area is one of very important factors that affecting on attract people to certain areas in urban growth areas, If it was one of the dangerous areas and explained that the average area of buildings in the study area that increases in risky areas for safe areas, where the advantage urban areas in risky areas terrain easy and vast areas which differ from the mountainous overcome the difficult nature of the village.

## 7. Conclusion

Some of the towns and villages exposed to the risk of natural disasters such as some villages in Aswan to the risk of torrents which requires the study of the behavior of urbanization and urban growth, moreover It should be study the relationship between the urban areas and risks and find the solutions to risk management and the protection of urban structure, in spite of we should study the causes of urban sprawl into risky areas and try to avoid it.

Abouelreesh village is facing a big problem that is the significant growth of the village in risky areas at risk of torrents so we must study the solutions to redirect the urbanization toward the safe areas with providing the means to manage the risk of storm water drains in the village.

**References**

- [1] Belal, A. (2011). Detecting urban growth using remote sensing and GIS techniques in Al Gharbiya governorate, Egypt. elsevier.
- [2] Noor, N. M. (2013). Determination of Spatial Factors in Measuring Urban Sprawl in Kuantan Using Remote Sensing and GIS. ASEAN Conference on Environment-Behaviour Studies. Hanoi, Vietnam.
- [3] Bhatta, B. (2010). Urban sprawl measurement from remote sensing data. elsevier.
- [4] Jaeger, J. A. (2014). Improving the measurement of urban sprawl: Weighted UrbanProliferation (WUP) and its application to SwitzerlandJochen oliferation (WUP) and its application to Switzerland. elsevier.
- [5] Jaeger, J. A. (2010). Suitability criteria for measures of urban sprawl. elsevier.
- [6] Nassar, W. M. (2001). The Impact of the Natural Disasters on Re-planning of the Disastered Zones.
- [7] Hisham Mubarak , C. (2010). A preliminary report on the torrent damage in Aswan. Cairo.
- [8] GOPP, G. O. (2010). Detailed planning for the village of Abouelreesh North - Aswan Governorate. Cairo.