

Quest of Urban Growth Monitoring from Myth to Reality

Sheeba Afsar, Syed Jamil Hassan Kazmi* and Sumaiya Bano

Department of Geography, University of Karachi, Karachi, Pakistan

Abstract: The Earth's surface is changing rapidly, mainly because of the anthropogenic interventions. At many point of times, these changes are local, regional, national, and even global in scale, interconnected both horizontally and vertically. Some changes have natural causes, such as earthquakes or floods. Other changes, such as urban expansion, agricultural intensification, resource extraction, and water resources development are examples of human-induced change that have significant impacts upon people, the economy and resources. As the urban growth in the world as major element of change, the appraisal and monitoring of these areas is a matter of great concern for a quality life of human beings. For this purpose, an appropriate and instantaneous technology is required to monitor the unwanted change. Hence, the main objective of this paper is to monitor the spatial extension of urban growth of the Metropolitan Karachi during 1955-2010 using different data sets and series of satellite imageries. In addition to that the growth corridors have also determined both in terms of magnitude and direction. The spatial change detected through successive satellite imageries has revealed a gigantic change from 1955 to 2010. The average annual growth rate of the Metropolis has taken place at an outstanding 13.35 %. It has been also found that the increase in urban growth has been noted towards the East and West of the city mainly but due to rapid expansion of housing schemes in north-eastern part of the city an enormous urban growth has taken place there as well. The paper has also revealed the utility of the Geo-Informatics for the monitoring of urban growth.

Keywords: Urban growth, Change detection, Spatial extension, Geo-informatics.

INTRODUCTION

This millennium will be the most urbanized millennium of the World. Today, almost 50% of the world's population are urban. The urban population currently estimated is about 3.4 billion people, is expected to double by 2020. Perhaps more significantly, it be predicted that 93% of this increase will be associated with the third world cities. If this is the case, approximately two billion people will be added to these already congested urban areas during the lifetime of just a single generation. In this context, a recent report by the World Bank about developing countries which is declaring urbanization as one of the most explosive problems of this century [1].

Urban growth is difficult to monitor, yet essential for the implementation of effective planning strategies. This is even more difficult in developing countries, with limited monitoring resources. One way that urban growth manifests itself is in the spatial expansion of built-up areas. There are a number of different approaches to the problem of identifying and measuring the extent of new urban development. Aerial photographs and ground surveys have traditionally been used to obtain the information that is needed to update existing maps [2-4]. However, particularly in Pakistan and in developing countries in general, these data sets are of inconsistent quality, are often outdated and, in many cases, their availability cease to exist.

When they do exist, the acquisition has been time consuming, bureaucratic and expensive. Remote sensing data products are helpful for detecting and monitoring urban area to study urban growth because its repetitive coverage [5].

REVIEW OF SOME MAJOR CONTRIBUTION OF SCIENTISTS IN REMOTE SENSING TO MONITOR URBAN GROWTH

Several urban studies have been conducted with the use of aerial photographs, Landsat data, SPOT data both panchromatic and multi-spectral analysis. Since 1970s a tremendous amount of literature has been published on the applications of GIS for urban studies [6].

Belal and Moghanm (2011) used remote sensing and GIS techniques for detecting urban growth in the Al Gharbiya governorate, Egypt [7]. Ibrahim, *et al.*, (2009) recognized the urban sprawl pattern since 1976 to 2005 using remote sensing and GIS in Shiraz city in the southern part of Iran [8]. Chen, *et al.*, (2000) reported the remote sensing and GIS for urban growth analysis in China [9]. Gao and Skillcorn (1998) described the capability of SPOT XS data in producing land cover maps at the urban-rural periphery [10]. Brouwer, *et al.*, (1990) used GIS and remote sensing techniques for rapid assessment of urban growth [11]. Anthony and Xia, (1997) studied the integration of GIS and remote sensing for application in urban growth management in the Pearl River delta, China [12]. Kupfer, (1987) used aerial photographs for monitoring

*Address correspondence to this author at the Department of Geography, University of Karachi, Karachi, Pakistan; E-mail: jkazmi@usa.net

urban growth and improvement planning in Nairobi [13]. Mahavir and Galema (1991) monitoring urban growth using SPOT image and aerial photograph the city of Chiangmai in northern Thailand. It is found that the city expanded at a fast pace between 1976 and 1989. Growing from a total built-up area of 4,689 ha in 1976 to 7,550 ha in 1985 and 9,302 ha in 1989 and an overall accuracy of 92.7%, was achieved in interpretation of the SPOT image and an overall accuracy of 84.2%, was achieved in interpretation of the of the aerial photographs [14]. Shukla and Ray (1989) used satellite remote sensing for mapping the urban land use and monitor the urban sprawl during the period of 1975-89 along with the dominant growth pattern of Kanpur metropolis, India land used categories extracted by the visual interpretation of Landsat MSS, Landsat FCC, IRS-1A LISS -2 FCC. They also work on analysis the dynamics of urban sprawl. The extend of the Khan pour city in 1974 -75 which computed from the survey of India was 115.28 Km² with the Landsat MSS FCC of 1975 was 114.22 Km². It shows that Landsat MSS imagery provides an accurate boundary of urban sprawl and they also calculate that the average annual growth rate of the metro police is found to be 4.3 % per annum during

1975-86, but has shown increases of 7.9% per annum during 1986-89. It has been noticed that the urban sprawl extended along the east west transportation network. Furthermore, a specific growth has been identified in the south of the city. It is suggested that SPOT data are very suitable for detailed urban land used classification [15].

Study Area

Karachi is the capital city of the province of Sindh and the largest city of Pakistan, one of the world's largest cities in terms of population. The Karachi division occupies an area of 3527. Km² and 9,856,318 persons population [16]. The average annual growth rate of being 3.52 percent. The population density is 2794.53 persons per square kilometer, highest in Pakistan. In 2005 the total population of Karachi was about 15119,000 and in 2012 the total population of Karachi is 21,200,000 [17, 18]. The total urban population of the city jumped from 1,068,459 in 1951 to 14,500,000 in 2007 which means that since last fifty seven years Karachi urban population is continually on the increase. It is situated about 129 km due west of present Indus mouths. The area extends between the latitude 24°-45'North and 25°-38'North and longitude

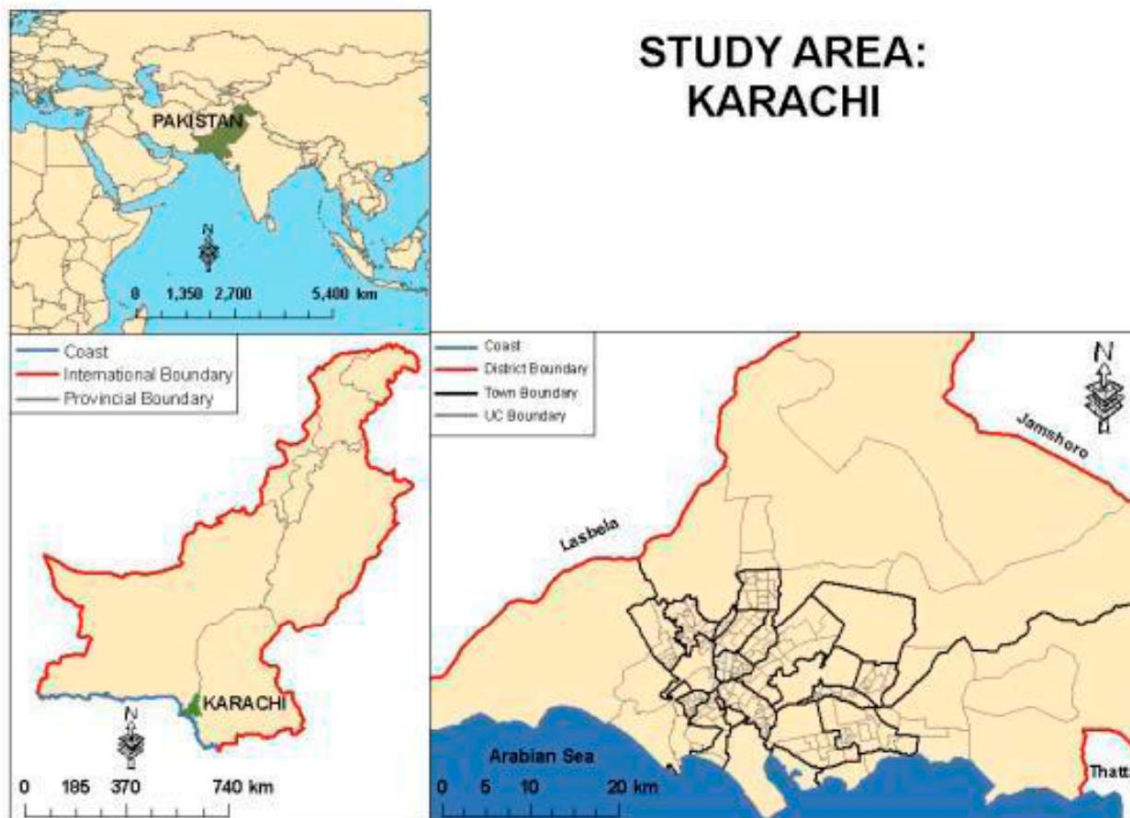


Figure 1: Karachi: Study Area.

66°-40' and 67°East -34' East (Figure 1). It is bounded on the northeast and southeast by districts of Jamshoro and Thatta respectively and in the south and southwest by the Arabian Sea and in the North West by the Lasbela district of Balochistan province. It is located on the northern coast of North Arabian Sea, which gives its climate the marine touch. Physiographical it is located within the Kohistan Subdivision of the western highland Division. Geometrically Manora conglomerates have provided it a location of the sheltered harbor to serve the fertile hinterland and its most favorable geographical situation as a center of three great continents, Europe, Africa and Asia [1, 19].

Objectives

1. To Map the extent of the city limits from 1947 to 2010;
2. To monitor the urban growth and the notable spatial change in Karachi during the last sixty years;
3. To explore the major urban growth corridors along with the magnitude and orientation; and
4. To determine the future urban growth corridors in the city.

METHODOLOGY

As reported earlier many urban planners, geographers and the scientist have used GIS and adopted identical methodologies for the evaluation of urban areas [6]. The data sources for urban growing monitoring includes the published and surveyed maps, Aerial photographs, SPOT XS and Landsat TM satellite images. The maps available were scanned and then geo-referenced for vectorization. These data sets were then imported into ArcGIS 9.3 for the cartographic processing.

As obvious from Table 1, showing various datasets which were used in the extraction of urban expansion in Karachi. The available maps and satellite image datasets coordinated with different systems, As the first instance, the entire data sets were converted to the identical projection system (WGS-1984) with image rectification techniques. Figure 2 portrays the methodology of extraction of urban growth on the corrected images. These maps and images acted as the baseline raster themes which were converted into vector data layers, which are ideally superimposed on the each other. With the help of on-screen digitization substantially change has been picked-up (Figures 3 and 4). Furthermore, for the spatial change have been monitored with the help of "Change Detection Algorithms" in ERDAS Imagine. The change is quite

Table 1: Urban Growth

S. No.	Year	Data Base Source	Urban Area	Urban Growth	% Urban	% Growth
			(Km ²)	(Km ²) (base 1955)	Growth (base 1955)	per annum
1	BEFORE	Pithawalla Map	8.352	-		
	PARTITION					
	1944					
2	1955	Aerial Photograph	104.258	-		
3	1974	KDA Land Use Map	286.302	182.044	174.609	9.1
4	1986	SPOT XS	402.972	298.714	286.514	9.2
5	1987	KDA Land Use Map	461.22	356.962	342.383	10.6
6	1992	Landsat TM	516.465	412.207	395.372	10.6
7	1995	Land use Map	681.52	577.262	553.686	13.8
		(Survey of Pakistan)				
8	1998	SPOT XS	695.929	591.671	567.506	13.1
9	2001	SPOT XS	726.151	621.893	596.494	13.2
10	2005	SPOT XS	753.548	649.29	622.772	13.2
11	2010	QuickBird and GeoEye	820.052	715.794	686.56	13.3

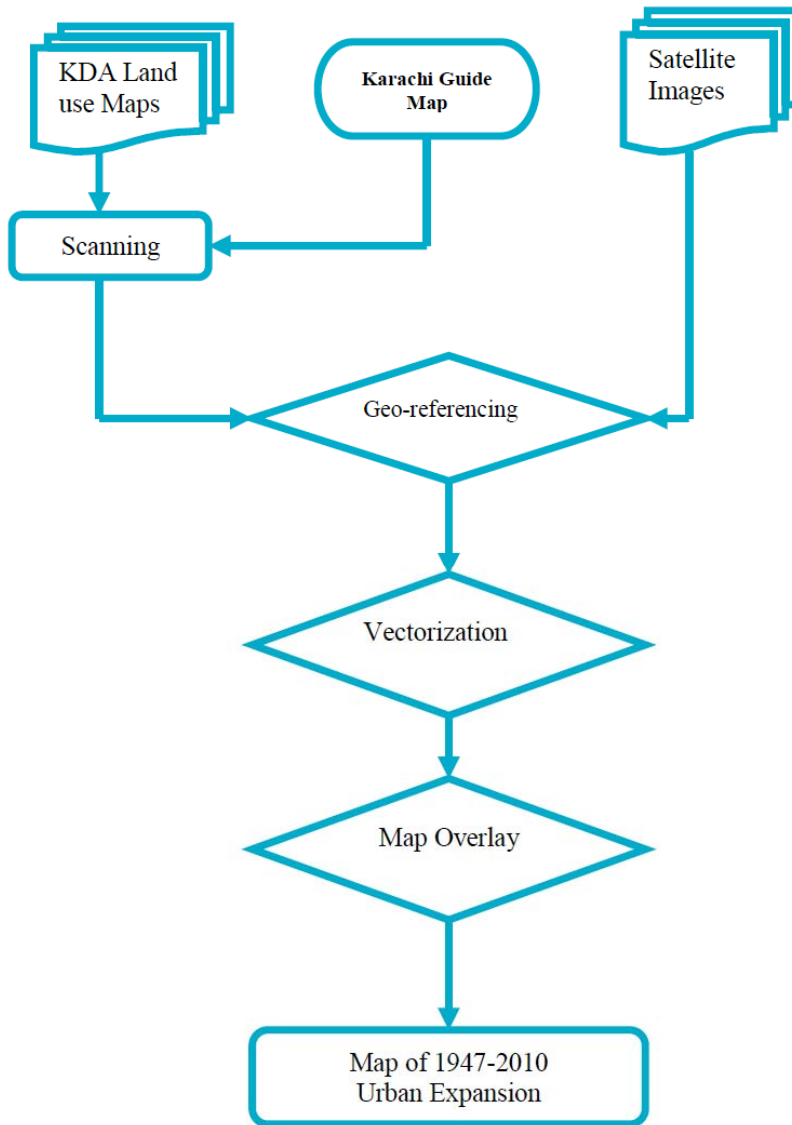


Figure 2: Extraction of Urban Expansion from Maps and Satellite Images.

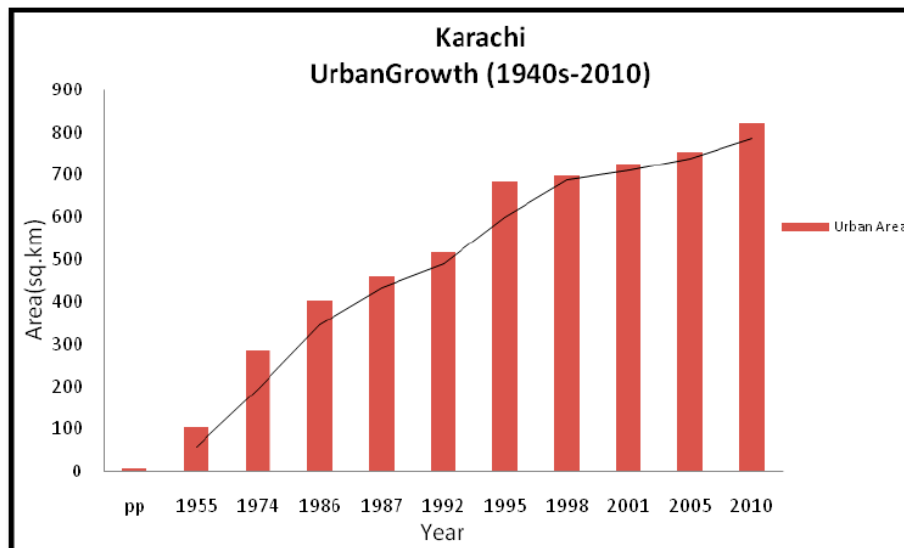


Figure 3: Karachi Urban Growth (1940s-2010).

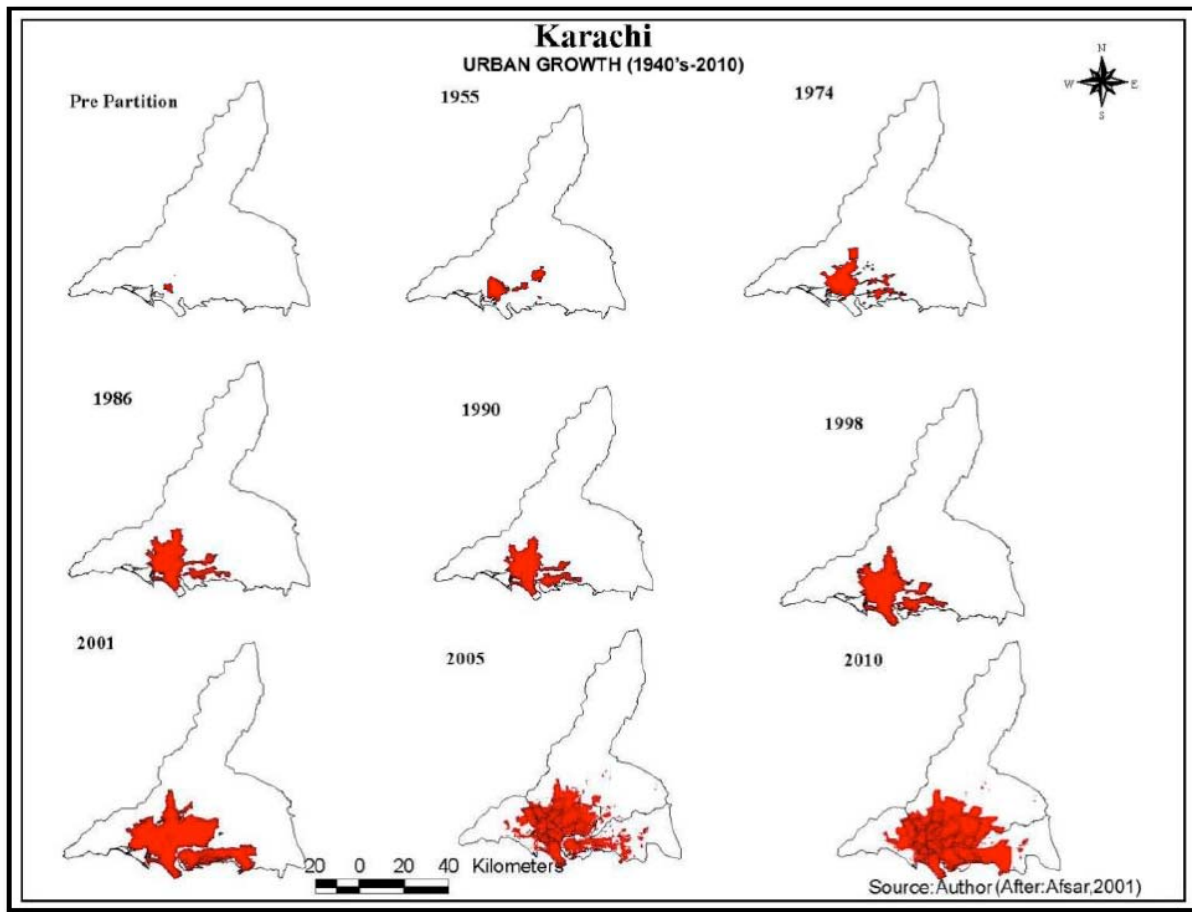


Figure 4: Karachi Urban Growth (1940s-2010).

obvious in different areas and could be portrayed through archived SRS data (Figure 6).

RESULTS AND DISCUSSION

Karachi emerged from a very small village, located at the present site of the Karachi harbor around 250 years ago. This small village was known as “Kalachi Jo Kun”. Kun means deep ditch and kalachi was the name of fisherman [20]. In 1729 A.D. a large number of people started to settle at Dibro (site of present harbor) from near port of Karak Bunder, located at the mouth of the Hab River. The port of Karak Bunder was silted up, therefore the merchants selected Dibro as a new port. This was the turning point when a fishing village turned into an embryo city, which covered an area 0.12 Km² [20]. In the beginning, Karachi was a small town of 1000 dwellers. In 1798, the population of Karachi increased to 10,000 [17]. The first official census was held in 1813 by Talpur Mir and according to this the population of Karachi was 13,000 living in 3,250 houses [20]. Pakistan came into existence in 1947 and Karachi was made its capital. It retained its status as capital till 1960 when the capital of Pakistan shifted to

Islamabad. Soon after the creation of Pakistan large scale of migration from India to place. Between 1947 to 1951 about one million migrants came from different part India. Apart from this influx, a large number of people also migrated to Karachi from different parts of Pakistan. As a result the population of Karachi increases rapidly. In 1951 Karachi with a population of 1.6 million became the largest city of Pakistan Km² [20]. For monitoring the growth of Karachi Megapolis, the Survey of Pakistan topographical sheets has been used as the backdrop database. The urban extent of the metropolis as interpreted from Aerial photograph of 1955 is 104.258 Km². The urban area, as extracted from the Landsat TM FCC of 1992 is 516.465 Km². The urban extent of the Megapolis as interpreted by SPOT XS imagery of 1998 is 695.929 Km², while from SPOT XS data of 2001, it is 726.151 Km² [1] analysis revealed a continuous urban growth Table 1, while from SPOT XS of 2010, it is 820.052 Km². Thus the urban growth recorded during the 55 years during 1955-2010 is 715.794 Km². This increase in the area not only engulfed the surrounding agricultural land but also the land is reclaimed from the sea through landfills. The average annual growth rate of the

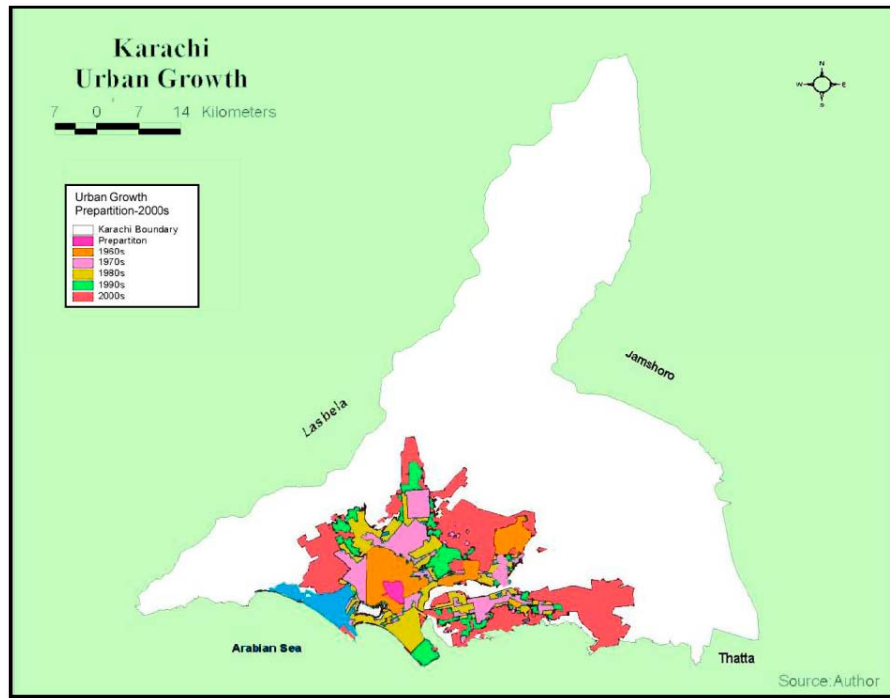


Figure 5: Karachi Urban Growth Prepartition-2000s.

metropolis is found to be 13.35 % during 1955-2010. Similar studies of urban sprawl were also conducted in Lahore [21 and 22] and different cities of the world. From the available image and ancillary data sources, the historical development and growth of urban area

has been evaluated and presented in Figures 3, 4 and 5.

Satellite remote sensing data used for identifying residential units for change detection in Karachi. A

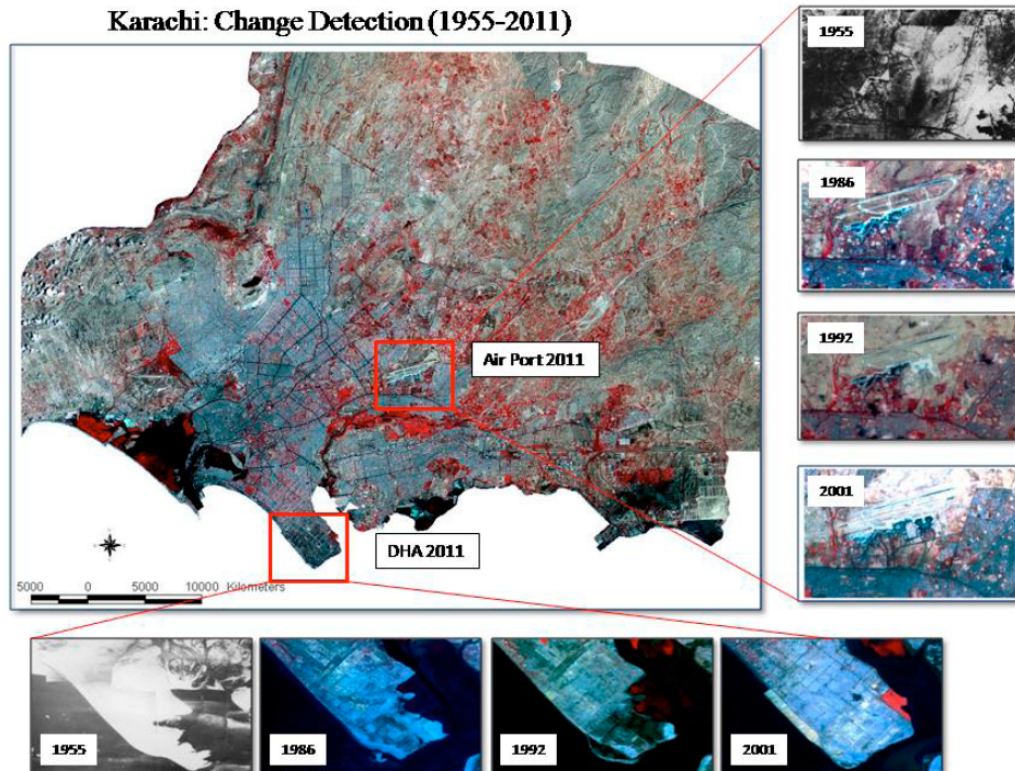


Figure 6: Karachi Change Detection (1955-2011).

follow-up study described the urban growth monitoring and development planning using remote sensing and GIS technologies. It is concluded that the systematic monitoring of urban growth, proper management of the city and planned future expansion would lead to improvement in the living standards and environmental conditions of the city as a whole, especially the poorest residential areas [23].

Figure 6 shows the major growth corridors in Karachi that are Sirjani Town, Balidia Town, Glistan-e-Johar, Gulzar-e-Hijri, Gulshan-e-Maymar, KDA Scheme, Korangi Industrial Area, DHA and Gulshan-e-Hadid. In this study three future growth corridors are identified in Karachi East, Northeast and West as shown in Figure 7. It is obvious that the urban area is extending eastward and westward, while the northward and southward expansion is restricted due to the presence of mountain ranges and the sea.

First Future Growth Corridors in the East

For the reasons of development of Port Qasim and the major eastern industrial complexes in the vicinity of

the Steel Mills, it would be a natural corridor. The eastern concentrate would facilitate extremely to keep down population and activity pressure on the existing central city. Continue development in the east would make it relatively easy to provide a desirable balance between workplaces and residential development. Development there would be highly accessible to the environmental attractions of the Malir agriculture belt, the hills to the north of Prpri and the coastal recreational opportunities in the Pipri creek.

Second Future Growth Corridors in the Northeast

The second future growth corridor transfer development concentrate to the northeast would be maintaining a satisfactory balance between workplaces and residential development. It is highly reachable to the new metropolitan trade and services complex in the vicinity of Rashid Minhas Road and University Road. It would be reachable to the industrial complex on the eastern side of North Karachi. It lies astride the Superhighway, the main road link from Karachi to the east and upcountry. It could be serviced easily with water supply, sewerage, electricity and gas.

Major and Future Growth Corridors in Karachi

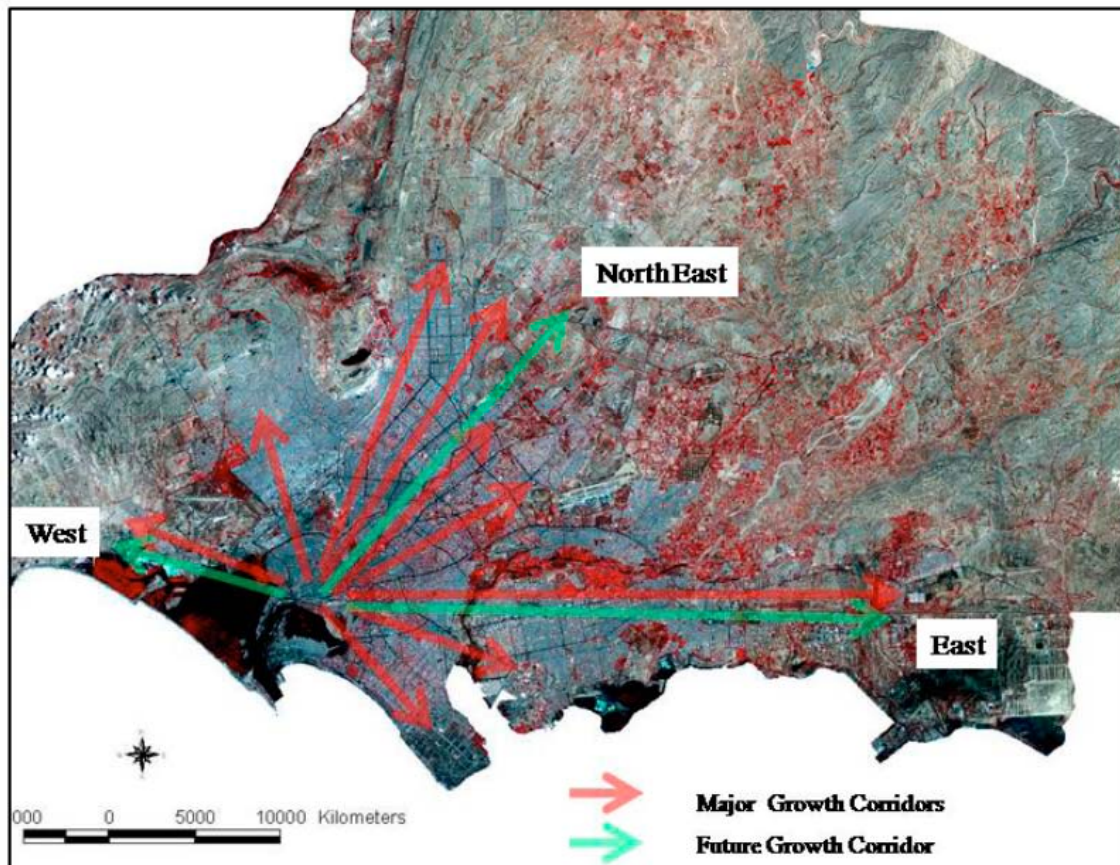


Figure 7: Major and Future Growth Corridors Karachi.

Third Future Growth Corridors in the West

Emphasis on the west could maintain a reasonable balance between workplaces and residential development, but probably would rely on job opportunities in the existing Karachi City Area somewhat more heavily than would the first future growth corridor. It is highly accessible to existing industrial areas and downtown job opportunities. It also lies on the RCD highway, the main route to the northwest and Baluchistan. Figure 7 shows the change detection in the airport area and DHA (Defense Housing Society) from 1955-2011. In 1955 Karachi old airport shows and 2011 new airport Jinnah Terminal was clearly visible.

CONCLUSION

Karachi is one of the largest city in Sindh and the commercial capital of the country. It is experiencing a rapid growth in the urbanization. The study period has been since pre-independence upto year 2010. It was concluded that the city has grown at unprecedented rate since the creation of Pakistan. The urban area of Karachi in 1940 was only 18.352 Km² and with the passage of time it has become about 820.052 Km² in 2010. It has been revealed with the help of this study that the urban expansion of Karachi has been dominant in North East, East, and West directions.

The area of the metropolitan is increasing and there is tremendous growth of the sprawl.–This growth calls for the attention of planners, decision makers and researchers as it translates into demand for infrastructure facilities, utilities and energy supplies.

Satellite remote sensing techniques provides an effective system of temporal monitoring of urbanization with consequent depletion of other natural resources in the immediate environs of big cities. It will provide input in the urban land use planning of large cities with a futuristic trend based on the past dynamic observations. As the final word, Geo-informatics could use to monitor and plan urban growth and gross misuse of resources may be ignored to a feasible extent. It has been revealed that with the help of Geo-informatics quest for urban growth could perfectly be translated from myth to reality, as this tool is the only one which could see in the past with almost identical eyes.

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