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**Impact of Emerging Geo-Informatics Technologies
in City and Regional Planning of Pakistan**

Abstract

Geo-informatics is a term portraying the integral role of GIS, Remote Sensing, GPS and Surveying. The magic of this wonderful set of tools timely realized by the planners in developing and developed countries. Today, Geo-informatics must be an integral part of a successful Planning Department in many countries . Speed, efficiency, and accuracy in information exchange have become competitive tools to satisfy customer demands, improve productivity and enhance innovation and creativity. This paper is an attempt to achieve the following objectives:

1. To examine the historical evolution of geo-informatics as planning tool;
2. To highlight the role of geo-informatics with pragmatic examples; and
3. To evaluate the utility of this technology in Master and Regional Plans.

Urban management and development is shown to work best with participative and inclusive methods which geo-informatics can provide very effectively and thus a suitable framework for its inclusion in city planning is recommended in developing countries (Forrester, 2000). This will be discussed in this study at length.

Key words: Geo-Informatics, Remote Sensing, GIS, Urban Planning and Management, Urban Sprawl, Risk Assessment, Hazard Management.

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Background:

With the advent of Information Technology revolution around the globe the Geo-Informatics technologies are gaining considerable grounds in Pakistan. Third world cities in general are experiencing a real demographic explosion (UNCHS, 2001). This exponential growth of population in developing countries often resulted in rapid and haphazard urbanization which further emphasizes the need of Geo-informatics technologies in Pakistan. Urban sprawl often resulted because of rural to urban migration rather than natural increase mainly in search of employment – a process related to the industrialization of the developing countries. Such a rapid growth of urban centers in the developing countries is usually affixed with the lack of adequate and well-timed planning. Unexpected expansion not only involves the change in land use patterns and land cover but also creates great number of economic, social and environmental problems. Consequently, provision of proper facilities and services becomes a real challenge for the governments at large especially at the municipality level. The appraisal and monitoring of these land use changes are crucial to understand land use cover dynamics over different spatial and temporal time frames for effective land and natural resource management (Lata, 2004). Particularly, if the government is determined to transfer the power at the grass root levels to meet the basic necessities of the common people.

Pakistan, during the last few decades is critically facing the adverse impacts of urbanization and which often addressed by local bodies and *katchi abadies* ordinances by various governments. In this context, the most recent change we have witnessed is the "Devolution Plan" of the Federal government in 2001, which ceased to exist in 2010. This initiative involves the creation of a new structure of local bodies and the transformation of major urban cities of the country into city districts like Karachi, Faisalabad, Hyderabad, Peshawar, Quetta and Lahore. The local administration of these city districts in order to address the problems need frequent monitoring systems, initiated several Development and Master Plans.

The problem is not merely resolved by devising the development plans or master plans but such a substantial system is required, that can easily be stored, manipulated, updated, and accessed by several agencies or end users and is flexible enough to monitor and assimilate any changes with the passage of time. Urban Management is a complex process, which requires an appropriate information base and a large coordination between the stakeholders, responsible for the management of these cities (Repetti and Prelaz-Droux, 2004). Furthermore, it must have the potential to project the future scenarios and be able to evaluate the resources to meet these challenges. These objectives could be met by the use of most advanced tools namely the GIS, Remote Sensing and GPS technologies (Geo-informatics is the combined term for such technologies practiced by many countries around the globe).

To address these challenges, GIS could effectively be used as the storage, manipulation, retrieval and dissemination of information along with its basic and advanced applications. Whereas, Remote Sensing would be helpful to study planning region through up-to-date and synoptic satellite imageries. Integration of both remote sensing and GIS data helps to map and monitor dynamic processes like urbanization and hence provide means for the better management and planning. Remotely sensed data generate products which can help to meet the information needs of urban analysis (Weber, 2001).

Karachi Development Authority (KDA) was the first planning agency used remote sensing and GIS technologies for Master and regional planning during 1980s, which is being followed by Lahore Development Authority (LDA) and Capital Development Authority (CDA) during 1990s. Peshawar Development Authority (PDA) took lead to use high resolution satellite KVR data for the better management and initiated a Digital Master Plan Urban Planning and Development Management System of Peshawar (UPDMS) from February 2001 to January 2002. This has been followed by the City District Government of Hyderabad (CDGH) as they have been using very high resolution QuickBird satellite Imageries of 61 cm for planning purposes in Hyderabad. Hyderabad has become the first ever city in Pakistan, which developed interactive GIS mapping system on the web (HyderabadGIS.Com).

This technology is emerging in Pakistan at various sectors of planning both in municipality and utility agencies. Therefore, this paper is an attempt to appraise the significance of Geo-informatics tools Remote Sensing and GIS for urban and regional planning. This paper is an attempt to achieve the following objectives:

1. To examine the historical evolution of geo-informatics as planning tool;
2. To highlight the role of geo-informatics with pragmatic examples; and
3. To evaluate the role of this technology in Master and Regional Plans

1.1 Study Area:

As case studies we are considering Peshawar, Karachi and Hyderabad City districts as our testing platforms to validate the utility of Geo-informatics.

1.11 Peshawar:

For the Master Plan the whole City District of Peshawar was considered as study area though the main focus was Peshawar Urban Area that only involves the Town I and III but population studies, projections till 2020 and population distribution were carried out for all the 4 towns and 92 union councils in the whole Peshawar District. The Socio – Economic and Environmental studies covers the whole District of Peshawar. Since

Peshawar not only undergone urbanization but also the huge influx of Afghan refugees.

1.12   **Hyderabad:**

After the announcement of Hyderabad as a City District the Government of Hyderabad has decided to plan the whole city and to extend the area in a properly planned way to form modern Hyderabad. Their focus was the adjoining areas of the Hyderabad that include the agricultural fields. To achieve it whole region has to be studied on broader scale, with the most fresh and up to date scenario which is only achieved through the remotely sensed satellite data.

1.13   **Urban Sprawl of Karachi:**

Another component of this paper is to study the urban Sprawl of Karachi, one of the largest cities in Pakistan that epitomizes the rapid growth of urban centers in developing countries especially. Rate of population growth in Pakistan is very high particularly in the urban areas as compared to rural areas (Hussein, 2004). In many respects Karachi is the representative city of Pakistan where people from all over the country migrates in search of better economic opportunities. After the independence of Pakistan the city received greater influx of migrants. After 1979 a huge chunk of Afghan refugee also arrives here after 1979. During 1980s, infiltration from all over the country is continued. Cities are no longer isolated in the middle of nowhere, but rather belong to one or more city networks, and are inextricably linked in evolutionary terms. To be a part of the network is crucial , in order to ensure social and economic development, and membership criteria are defined in terms of population size, economic activity rates, employment characteristics, attractiveness, etc. (Weber, 2001)

2.   **Methodology:**

Digital base maps on scale of 1: 5000 and 1:25000 was prepared for the whole Peshawar District and on a Scale of 1: 10000 was prepared for the Peshawar Urban area. The base maps included major land uses like residential, commercial, industrial, agricultural, religious, recreational, educational health etc, primary and secondary roads along with their intersections and right of ways, Railway line, network of Utilities including sewerages and drainage pattern. The Land cover mainly involves the vegetation cover and the river systems.

  Essential surveys such as Landuse Survey, Socio- Economic Survey, and traffic Count, Surveys of major intersection and detailed topographic survey of GIS pilot project site were conducted. Ground Truthing was conducted

for the verification features and detailed topographic surveys were conducted of the major road intersections, e.g., Ring Road and G.T Road for the future planning of these intersections and location of any facility. (UPDMS Project Report, 2002) Future planning of roads involves the extension of Ring Road, removal of encroachments along the roads, allocation of properly planned areas for different land-uses

The Peshawar structure Plan 1986, Development Program 1987, Area Action Plans 1988, Ring Road Land Development Strategy 1996, Sarhad Provincial Conservation Strategy 1996-98, census report 98, Pakistan Urban Sector Study 2000 and all other relevant report proceedings, proposals and recommendations were carefully reviewed (UPDMS Project Report, 2002).

The Customization through Avenue Script was also performed of the ArcView Interface for the project, to achieve the purpose of classifying the land-use interactively during data entry and calculation of Area under each land-use.

For Karachi maps and aerial photograph were transformed into digital form through scanning. These digital maps and satellite images were geo-referenced to a similar coordinate system in order to be compared on a similar platform. Urban area of Karachi for different years was extracted in the form of vector layers through digitization of these maps and satellite images.

2.1 Data Sources

The acquisition of satellite image data depends upon the type of study being performed. In case of studies that involve rapid change through time, in which data may vary within days or sometimes within hours, like monitoring weather, construction of any feature, migration of any particular species etc, very high temporal resolution is required. Similarly spatial resolution depends upon the size and space occupied by the phenomena, for regional planning spatial resolution of up to 30 meters (Landsat TM) is enough. Change detection of land cover spreading over large areas is usually executed on Landsat TM images. Spectral resolution is usually of importance when environmental studies like vegetation cover, land and water contrast, temperature variations etc are a matter of consideration.

As far as urban planning is concerned very high spatial resolution are required. High spatial resolution, Earth-orbiting satellite sensors, in particular, is becoming an important source of spatial and temporal information on urban areas (Weber, 2001). Since very minor features are studied in details including roads with their right of ways, streets, utility lines, sewerage systems, precise demarcation of residential, commercial, industrial, agricultural and other land uses, very high spatial resolution ranging from 2 meters (KVR), 1 meter (IKONOS and DK-1), 0.6 meter (QuickBird), are recommended.

Satellite Data of 2m resolution KVR for Peshawar Urban Area was acquired as the 1meter IKONOS data was too expansive at the time of initiation of the project and QuickBird data was not available.30 meters resolution Landsat TM data for the whole District of Peshawar was acquired to extract general land cover patterns for regional planning.

Since the urban sprawl of Karachi occupies a larger area and small scale features were avoided in the study therefore finer resolution was not required. To observe physical changes in the overall urban area of Karachi for the last fifty years, from the independence of Pakistan in 1947 till 2006 medium resolution satellite data was acquired. Since satellite data feasible for the studies of landuse was available after 1970's, therefore, a map extracted from the book of Pithawala was taken to compare the area of Karachi for 1946 (before independence) with the present day Mega City. Aerial photograph for the year 1955 and where the satellite data could not be acquired KDA Landuse Maps were utilized. For the Urban Sprawl of Karachi 30 meter resolution (Land Sat TM) data and (SPOT XS) 20 meter resolution data was taken. QuickBird satellite data (0.6 meter) is taken only for the year 2006. In the case of Hyderabad, there is one greater advantage that 0.6 meter resolution data of QuickBird Satellite on the google-earth platform.

TABLE - 1: Data Sources for the Urban Area of Karachi

Sr. No.	YEAR	Data Source	Urban Built-up Land	Area Added
			(Sq. Km)	(Sq. Km)
1	1946	PITHAWALA'S MAP	8.35	--
2	1955	AERIAL PHOTOGRAPH	104.26	95.91
3	1974	KDA LAND USE MAP	286.30	182.04
4	1986	SPOT XS	402.97	116.67
5	1987	KDA LAND USE MAP	461.22	58.25
6	1992	LANDSAT TM	516.47	55.25
7	1995	LAND USE MAP OF KDA	681.52	165.05
8	1998	SPOT XS	695.93	14.01
9	2001	SPOT XS	726.15	30.22
10	2006	QuickBird	785.45	59.30

Results:

The vector layers obtained for different years during the period from 1946 to 2006 about sixty years show a tremendous increase (Figure-1& Table-1). 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. In 1946 the area occupied by Karachi was only about 8.35 square kilometers; this area increased to 286.30 sq. Kms in 1974, within thirty years, about 97%. In the next ten years, until 1986 it increased up to 402.97 square kilometers. In 1986, emergence of Landhi and Korangi Industrial Area is quite obvious (Figure-1) which appears as patches in 1974. Until 1995 the urban sprawl of Karachi was quite abrupt and the area increased to 681.52 square kilometers after that the increase in urban area smoothes out and finally in 2006 the area is 785.45 square kilometers.

   The table shows that area of Karachi increased from 8.35 kilometeres to 785.45 kilometers a difference of 777.1 kilometers within 60 years. This increase in area not only engulfed the surrounding agricultural land but also land is reclaimed from the sea through landfills (Figure-2). Such reclaimed areas are quite fragile and prone to hazards like storms - being open to the sea and earthquakes – since the plate boundary lies close to the coast of Pakistan. A clear example is the Clifton Area and Defence Phase VII that are under the control of Defence Housing Authority. These areas are not only reclaimed for the residential purpose but also for recreational activities. A marked evidence of their fragility is the recent earthquake of 8th October 2005 Earthquake, when slight shocks were also felt in these areas when the major rupture jolted the northern areas of Pakistan.

   Geologists and experts stated that all construction on filled and reclaimed land was highly prone to earthquake shocks. Following the October earthquake tremors were felt in the Clifton and Defence areas of Karachi and not in the rest of the city. The reason is that these areas were filled and reclaimed areas and buildings built here started shaking on the slightest tremors.

   Another risk to which the coastal areas especially, Karachi is greatly vulnerable are cyclones. Every year, Southern Sindh coast is prone the cyclones that originate during the Monsoon season in the Indian Ocean and move toward the coast. Under these conditions extension of land into the sea will prove to be quite hazardous as in the case of Defence and Clifton areas where land reclamation for residential, commercial and above all recreational purposes. Land thus reclaimed, increases the vulnerability of the area. A clear picture of the risk of cyclone hazard could be seen in Figure-3.

   The area of Clifton and Defence was about 14.03 sq.kms. in the year 1955. In 2006 a total area of 5.57 sq.kms is reclaimed that is 19.6 square kilometers (Table-2).

   Most notable phenomena in all the three cases of Peshawar, Hyderabad and Karachi is that as the city expands it engulfs its surrounding land

whether it is barren or under another land use type predominantly agricultural. (Figure-4)

The problem which is faced in the case of expansion of Defence and Clifton area can be altered if more emphasis is exerted on the inland expansion, i.e the surrounding barren land near super highway and national highway.
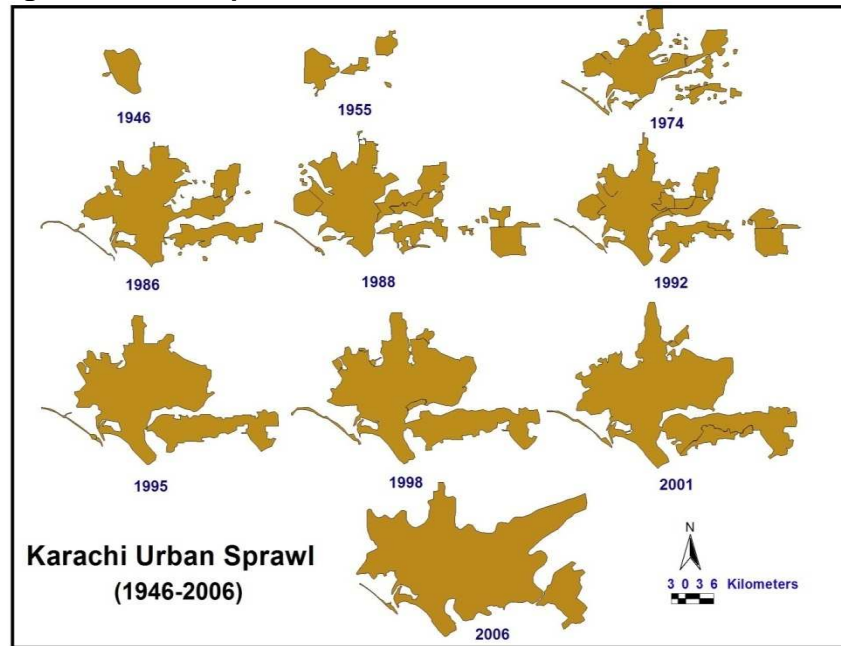
3.   Discussion:

Planning through the use of Geo Informatics Technology becomes quite cheaper, easier and accurate. As the tedious work of redrawing the plan maps, for showing each and every change with the passage of time or element of future planning, can be avoided. Patterns of landuse and changes can easily be monitored and mapped through the use of remote sensing resources which would otherwise take a long period of time and expense of a lot of resources. Conventional methods of surveying for such large urban areas like Peshawar, Karachi and Hyderabad may take months or years to records different landuse for urban planning. Besides, existing resources may not be updated so frequently to give fresh contemporary information about the existing extent and condition of landuse.

The 'Master Plan' concept is too static. Typically master plans are prepared and need updation every five to ten years. Generally master plans are outdated before they are approved and published for implementation. The Peshawar Structure Plan 1986 was not approved till the end of the century and therefore could not be implemented because of which, despite some available fragments of legal cover, building and land development could not be regulated properly during the last 15 years. (PDA, 2002)

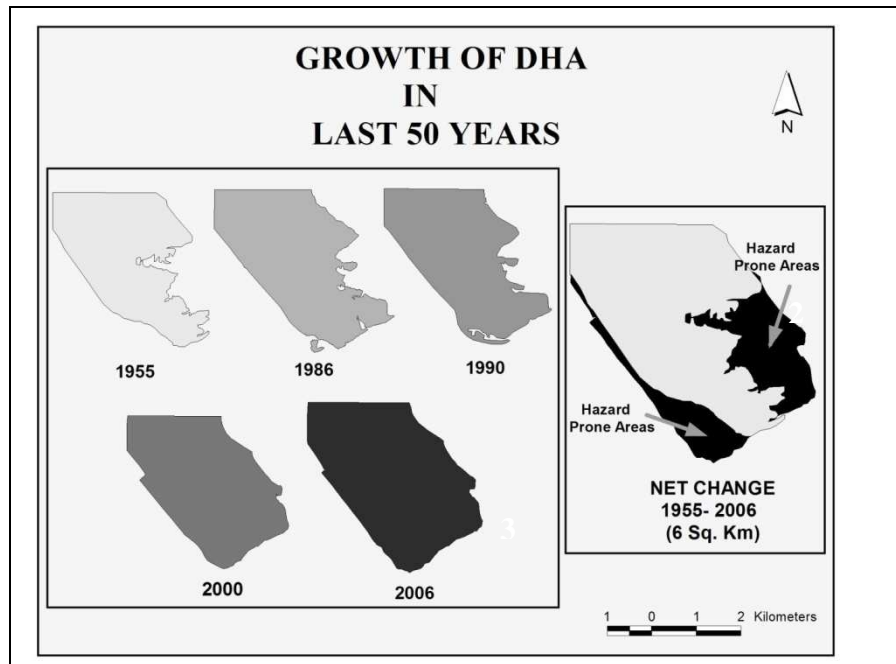**Figure 1: Urban Sprawl of Karachi**

After: (Sheeba, 2001)

Studies involving huge areas of urban development are greatly ease by the use of satellite remote sensing and GIS which would otherwise be a prolonged task continuing till years with probable results and may not be updated frequently. Basic information on urban areas – such as their location, physical extent, human population and rate of growth- is often dated, inaccurate or simply non-existent. In this context, the potential for satellite remote sensing systems to deliver timely, consistent and spatially comprehensive data sets seems clear (Barnsley *et. al*., 2001).

The study of Defence and Clifton Areas reveals that remote sensing and GIS techniques bears the potential for the risk assessment and hazard management along with urban planning. It is a normal observation that while planning for urban infrastructure, the hazard prone areas are not considered which results in mass destruction at the time of any natural disaster as in the case of Islamabad.

Now 3D virtual GIS is being used in City modeling to evolve real-time scenario (Hala and Kada, 2009). Recently, Defence Housing Authority (DHA) is using this technology for the Development DHA City on Superhighway, Karachi.
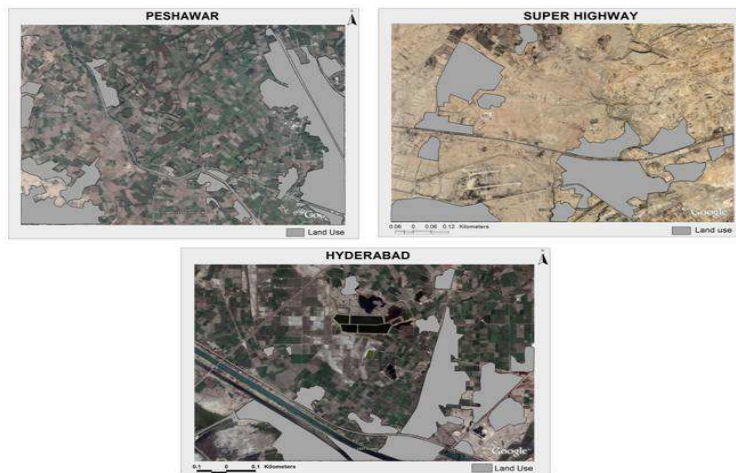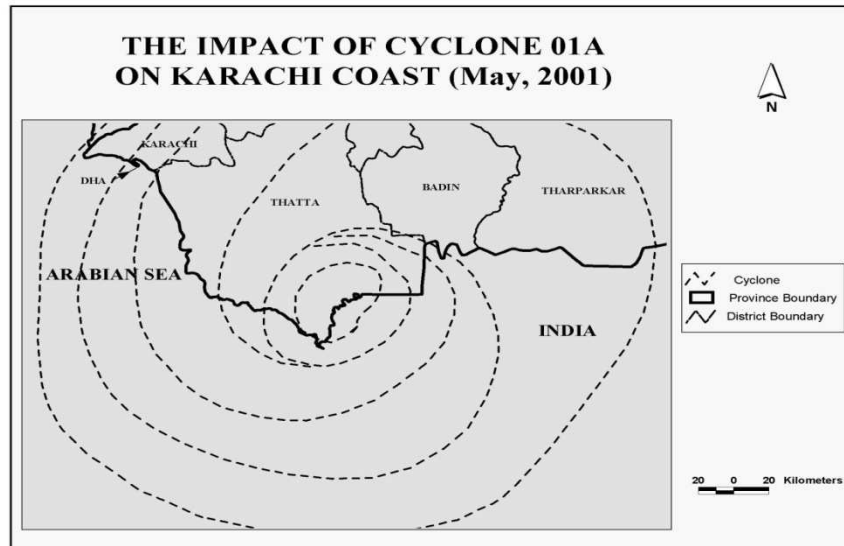
Figure-2: Defence Phase VII and Clifton Area

TABLE-2: Area reclaimed for Defence Phase VII and Clifton

YEARS	AREA	
	Acres	**Sq.Km**
2006	4857.735	19.6587
2000	4754.048	19.23896
1990	3796.469	15.36378
1986	3604.589	14.58726
1955	3469.069	14.03883

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Figure-3: The Impact of Cyclone on the Karachi Coast.

Figure 4: Expansion of Urban Areas in Peshawar, Hyderabad and Karachi.

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## 4.	Conclusion:

This study reveals the use of geo-informatics in the urban and regional planning. Especially, developing countries like Pakistan where tremendous population pressures evolving new cities at very high peace. This development requires efficient means which could be achieved through the use of remote sensing and GIS. This technology is proved to be highly cost-effective, less labour intensive and time saving. Several of the High Resolution satellite data are now available at cheaper cost and the implementation of these technologies now greatly expedites the planning process that may take years in creation and implementation. Few City Districts Governments and Utilities Agencies are using this technology in Pakistan and with the coming years it is going to grow larger in size. There is an emergent need to introduce Geo-informatics at various curricula of the Universities and diffuse tool at the local bodies level.

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