

URBAN POPULATION GROWTH MONITORING AND LAND USE CLASSIFICATION BY USING GIS AND REMOTE SENSING TECHNIQUES: ACASE STUDY OF FAISALABAD CITY

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ABSTRACT

In light of rapid global urbanization, monitoring and mapping of urban and population growth is of great importance. The investigation of various attributes of demography plays a vital role in social and economic profiling of the city. To realize the forthcoming policy levers to manipulate the future size, structure and distribution of population, it is essential to understand factors responsible for population dynamics. Moreover, to study the demographic aspects and knowledge about the dual population size of Faisalabad city contributes a tremendous part in future urban planning of the city. Identification and Analysis about the population growth of Faisalabad city can also be productive in effective infrastructural & urban planning. The Population study endorses planners to design the better strategies for future planning. Consequently, population aspects with all their perspective marked deep effects on society. The study of urban population growth in Faisalabad city reveals the total number of city dwellers simultaneously demonstrates the development of urban clusters from the last 20 years.

Keywords: Faisalabad City, GIS and Remote Sensing, Growth Monitoring, Spatial Analysis, Urban population

INTRODUCTION

Today urban growth all over the world is one of the most significant geographic phenomenon. This is particularly true for developing countries like Pakistan where number of urban centers are increasing with the passage of time(Bhalli 2011). There is a threatening situation of Rapid urbanization, especially in the developing countries(J. Antony Vinoth Kumar, S.K. Pathan et al. 2007)like Pakistan. Urbanization may be defined as a process in which agricultural landscape, forests, water bodies of the surface and underground water level is irretrievably lost(Pathan, Jothimani et al. 1989; Pathan, Shukla et al. 1991). This is mainly due to uncontrolled population growth resulting in serious problems with regards to informal settlements, scarcity of food, environmental pollutions, destruction of ecological structure, unemployment, and so on (Maktav and Erbek 2005).Urbanization, in this study is conceived as characteristic of the population, as a particular kind of land uses and land covers and a characteristic of social and economic processes interacting and affecting both population and land(McIntyre, Knowles-Yánez et al. 2000).Urban places in particular are also defined as concentrations and recommendations of the people who are engaged in non-agricultural activities. Urban growth maintains a different relationship with population and socio-economic data(Sudhira, Ramachandra et al. 2004).

Urban growth history shows that urban areas are the most dynamic areas on the surface of earth. In spite of their regional economic importance, urban population growth has a substantial impact on the neighboring urban ecosystem (Yuan, Sawaya et al. 2005). For the first time in history, in 2008, the world has reached an important milestone that is half of the world population is living in urban areas (United Nations 2002). Urban Population growth is a common phenomenon in almost all countries over the world though the rate of growth varies. The latest census reports were utilized for population figures for intermediate years. The area of the city was taken as the smallest unit for measuring population distribution and population growth (Martin P. Brouckerhoff 2000). The resulting urban population and growth patterns of Faisalabad are useful information for sustainable and reliable urban planning in order to provide the appropriate urban service infrastructure. In the present attempt, census data has also been attributed to the respective point location of urban union councils to make various analyses of social significance. Based on the aggregate census data, scholars have used population density functions either mono-centric or polycentric models, to analyze urban population distribution (Baumont, Ertur et al. 2004).

GIS provides a technique in which the statistical consequences can be represented spatially on the map and spatial patterns can be familiar. In the absence of conventional maps showing details on infrastructure, high resolution satellite images can be used to effectively monitor and implement changes in land use through detailed street level mapping. The integration of remote sensing and GIS has been widely applied and been recognized as a powerful and effective tool in urban analysis (Paul M. Treitz, Philip J. Howarth et al. 1992). Planners therefore, need to sue more advanced than the present techniques for spatial analysis. The availability of spatial datasets those might be routine applications of GIS in developed countries often become pioneering ventures when used in developing countries.

OBJECTIVES OF THE STUDY

1. Supervised image classification of Land sat imagery for major exterior features, predominantly with reference to population growth, within the limits of Faisalabad city
2. To assessing population sprawl and study of ensuing environment implication
3. To assess the trends of urban population growth and its distribution.

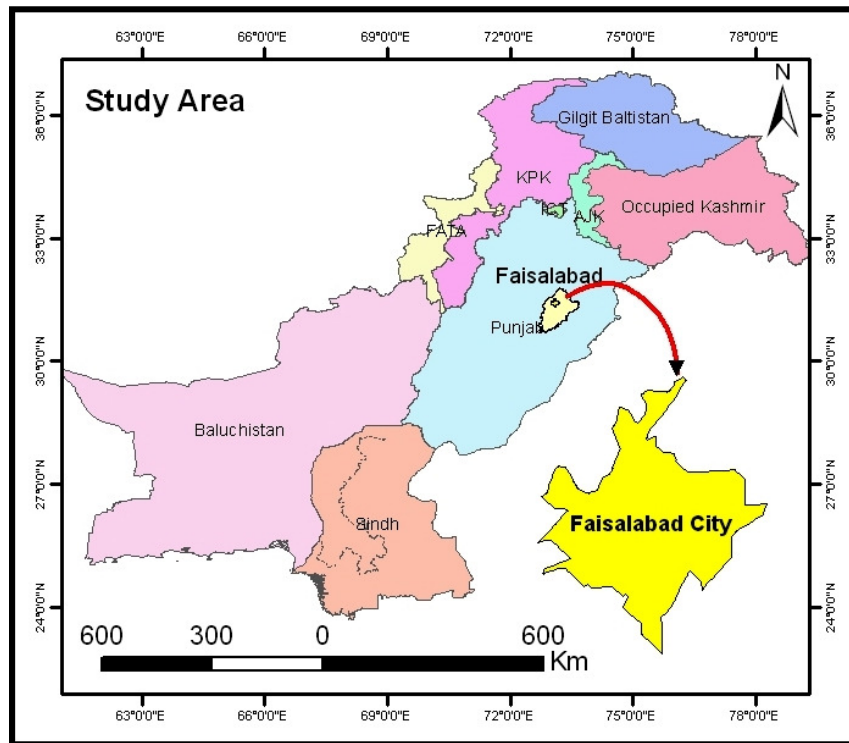
STUDY AREA, DATA SOURCE AND METHODOLOGY

A tiny town founded only for the purpose of grain market, has now grew into a gigantic size metropolitan city, which enjoys the status of third and second largest city in Pakistan, respectively population and industrial growth is concerned (Bhalli 2011). Faisalabad district has an area of 5,856 Sq. Km. its metropolitan area nearly 1295 Sq. Km. Area under observation (Figure 1) Faisalabad City is 213 sq. km. Faisalabad city is located in central Punjab, Pakistan. Faisalabad lies between 30°42' and 31°47' north latitudes and 72°40' and 73°40' east longitudes, at an altitude of 605 feet above sea level (Govt. of Pakistan 2000; Bhalli 2011).

In this study spatial data regarding the chronological nature of urban land has been acquired from the satellite images. To accomplished the desired objective of the study, images datasets of the Landsat system in TM, ETM and ETM+ modes were acquired for Sep 20, 1992, Nov 10, 2000, sep 16, 2005 and Mar 10, 2010 correspondingly. The image was downloaded in “.Tiff” format initially and was converted into “.img” format. First of all, different bands of the imagery

were stacked for the production of a false color composite image(Bhalli 2011). All the Landsat imageries were Geo referenced on a familiar coordinate system UTM43 Projection & WGS84 datum and then the vector layer of Faisalabad city was utilized for clipping and sub setting the satellite images from the complete scene. Other supplementary data such as Landuse maps, topographical sheets, municipal boundary maps, and census data were also used either as references or for analytical purposes(Bhalli 2011).

Figure 1: Location of Study Area, Faisalabad City, Pakistan



Source: (Bhalli 2011)

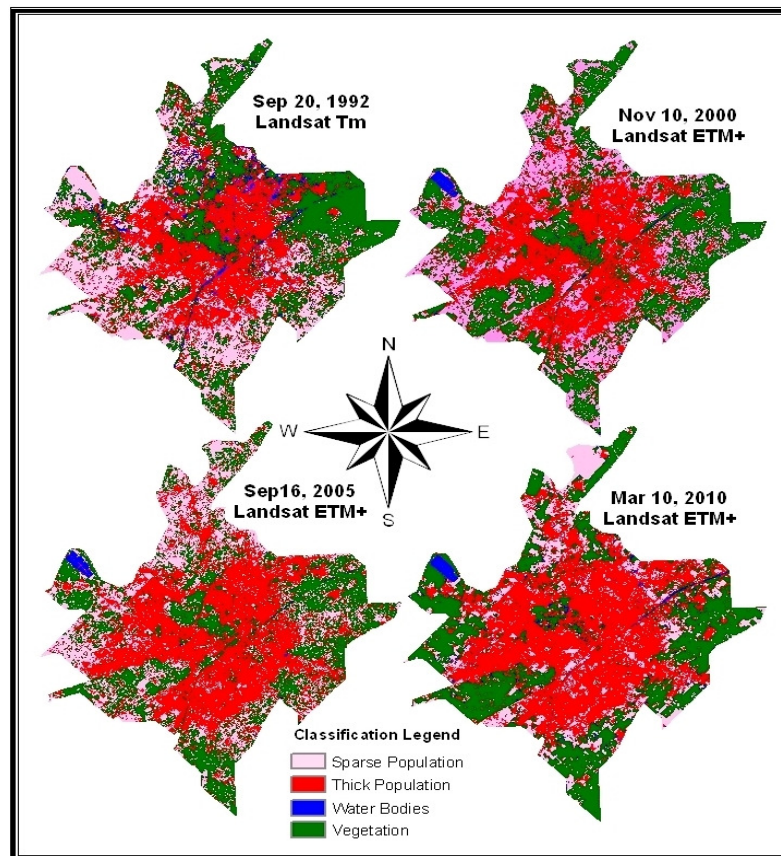
Digital image classification is process whereby all the entire pixels in the image are categorized into a landuse classes or theme (Thomas Lillesand, Ralph W. Kiefer et al. 2008). The spectrally enhanced images were used for the supervised. The training samples were then taken for each of the 1992, 2000 and 2010 enhanced images. Supervised classification from training areas was distinct with the assist of field-acquired data. The exterior skin tone classified from the image datasets comprised Thick Population, Sparse Population, Water Bodies and Vegetation. Monitoring of extension in residential areas with population growth in past 20 years was the main focus of image classification. Plentiful information has been published representative the aptitude to extract population information either directly from remotely sensed data, or indirectly by analyzing information resultant from the imagery (Victor Mesev 1998). The resulting classified image datasets show a very prominent expansion in population regimes. Supervised images classification accuracy assessment was carried out for each of three datasets. Confusion matrices were developed to highlight the classification accuracy (Lu and Weng 2007).The consequences derived after temporal maps of Landsat land use/cover about the five years 1992,

2000 and 2010 images ensured overall accuracy of 76%, 75%, 85, and 86 % respectively was achieved and agreed to proceed with(Bhalli 2011).

RESULTS AND DISCUSSION

The classification of the satellite images for five time instants has helped in gaining formation of speculative and extremely simplified visual images of the study area (Figure 2). These maps are proof of the verification about the dynamics population direction and which important evidence of urban extent and growth pattern are. The resulting classified image datasets show a very prominent expansion in populated regimes(figure 2). Rapid growth and development resulted in a very congested central area that has an unhealthy mix of land uses, with uncontrolled pollution and contamination from industrial exhausts. The spatial organization of Faisalabad around the historic core, without adequate open spaces, has meant the development of residential areas very close and intermingled with industrial development. The ultimate expansion of the industry and installation of small cottage industry failed to receive adequate systems of disposal and wastes. Facilities for the community were provided, occupying residential structures, lacking any open space for playing and social purposes. The provision of bridges and railway crossings meant that the canal and the railway line acted as obstacles in development and extension of the city to the South and the West.

Figure 2: Extent and Direction of Population Growth of Faisalabad City



Source: (Bhalli 2011)

The rate of urban population growth and expansion was observed regardless of time and space. There are numerous factors responsible for the growth rate and the growth is persistent in a specific direction. It is apparent that the growth of the city has more natural trends towards North-West, and South-West directions. Development of linear infrastructure such as Motorway, and the roads along the canal, contributed the shifting of modern trend of urban growth towards ribbon growth and corridor of opportunity running from Northeast-Southwest across the district and through the city center has created an opportunity for further development and with it also changed the past pattern of urban growth. Future development is likely to be influenced by the provision of major roads, especially the M4 motorway, and the links to it off the Narawala and Jhang roads to the West.

Faisalabad City is ranked the third amongst the big cities of Pakistan after Karachi and Lahore with a population of 2,008,861 in 1998 Census and 2,553,000 in 2010 according to Punjab development Statistics. The population of the city grew at an average annual growth rate 3.58 percent during the intercensal period 1981-98 (17 year) and registered an increase of 81.93 percent over 1981 when its population was 1,104,209. The Population of Faisalabad city grew at a fast rate i.e., 9.10 percent during the intercensal period 1951-61 when substantial influxes of migration took place due to attraction of small industrial environment of working population from other parts of the province/country and extension in boundaries of the city during intercensal period (1951-61). The growth rate of the city, however, decreased to 6.19 percent during 1961-72 and 3.32 in 1972-81. The overall increase in population of the city has been about eleven times during the last 47 years i.e., 1951-98. If the population of the city continues to grow at its present rate i.e., 3.58 percent (Table 1), it is likely to be doubled in the next 18 years. Estimated and analyzed average annual growth rate of Faisalabad city by Punjab development statistics, 2010 is 2.01%. The table 1 gives population, intercensal increase and average annual growth rate of the city since 1951.

Table 1: Population Size & Average Annual Growth Rate

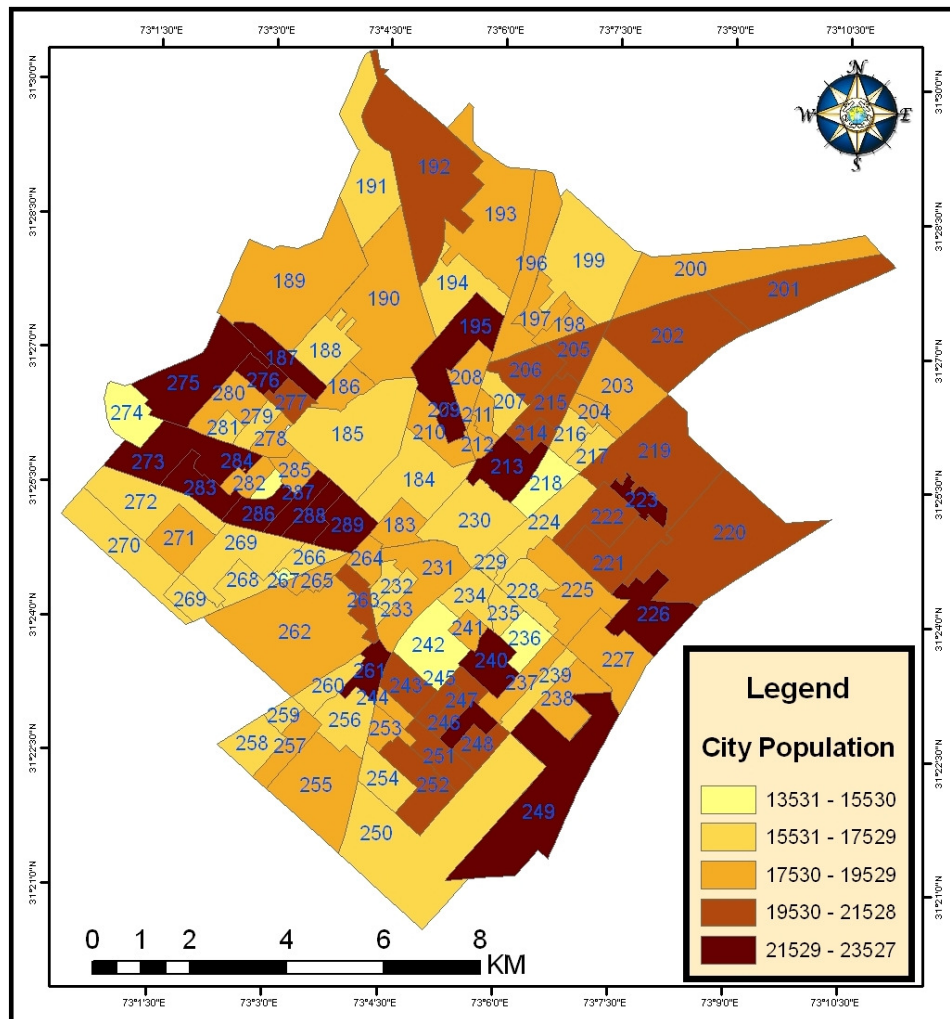
S. No	Year	Urban Population	Growth Rate % AGE
1	1951	179,127	9.86
2	1961	425,248	9.03
3	1972	823,343	6.19
4	1981	1,104,209	3.32
5	1998	20,08,861	3.58
6	2010	25,53,000	2.01

Source: (Govt. of Pakistan 2000; Govt. of Pakistan 2005; Planning Commission of Pakistan 2010),

To achieve the third objective, urban Union Councils falling within the limits of Faisalabad city were digitized as point locations using reference data from paper layouts developed by Faisalabad development authority and urban unit Lahore. Later on the most recent population census was appended as attributes to each demarcated on entity location (Govt. of Pakistan 2000). The general pattern of population distribution within Faisalabad city is shown in Figure 3. It is demonstrated through the map that the union councils number 187, 195, 209, 213, 223, 226,

240, 245, 249, 26, 275, 273, 276,, 275, 283,285 286, 287, 288 and 289 are experiencing extremely high population distribution. These union councils are having the major clusters of population. Whereas the union councils number 191, 201, 202, 205, 206, 214, 215, 219, 220, 221, 222, 243, 245, 251, 252 and 263 are having less number of urban dwellers as compared to the earlier mentioned union councils. Furthermore, the moderate population distribution is observed in the union councils numbers 183, 186, 189, 190,193,196, 197,198, 200, 203, 204, 208, 210, 211, 212, 225, 227, 231, 233, 255, 257, 262, 264, 271, 278, 280, 282, 284, 285. These areas are even less populated as compared to the previously mentioned union council areas and occupying the larger area of map. On the other hand 184, 185, 188, 191, 194, 199, 228, 229, 230, 232, 234, 235, 250, 254, 256, 260, 258, 259, 266, 268, 269, 270 and 272 union concils are among the second least population clusters. Moreover, 274, 218, 236, 242 and 282 are very few and sparsely populated union councils with exteremley low population as compared to all above described areas.

Figure 3: Map of the Spatial Distribution of Population, Faisalabad City



Source:(Bhalli 2011)

Housing and population growth

The standards of residence can be checked through the housing infrastructure which is among the basic needs. House is the facility that makes sure the provision of the protection and amenities for maintenance of privacy, family health and desirable living conditions. Consequently, the adequate knowledge about the housing facilities is very effective in efficient planning of the urban center. The changing mechanism and data regarding the housing units played a vital role in efficacy of planning and policy formation about the city.

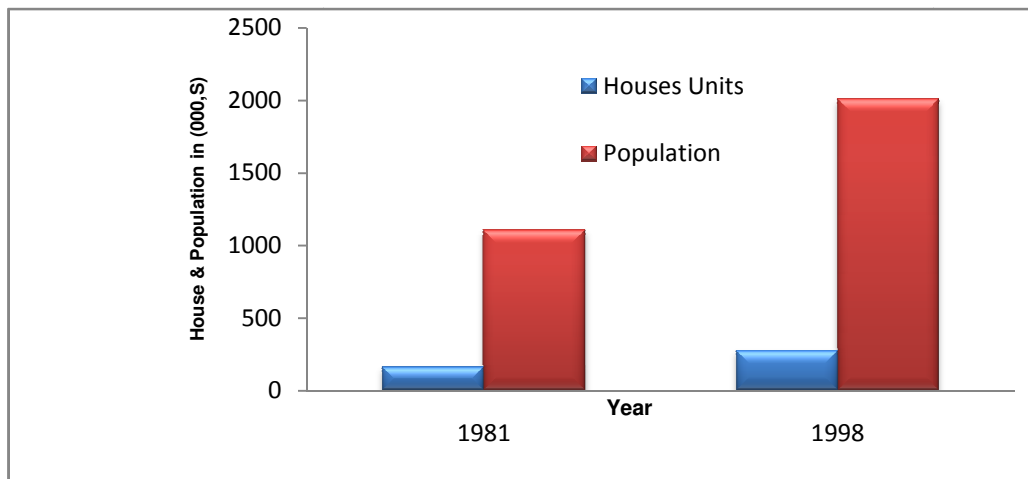
In the city of Faisalabad, there is an emerging trend of developing new housing colonies and schemes in order to upgrade the standards of living and to meet the demand of city dwellers. In 1981, the statistics reported that there were 161,821 housing units and the number was increased to 247,027 in the 1998 census data, while population was 2008861 in 1998. It was reported that during the intercensal period of 1980-98, 69.34 percent increase has been observed (Figure 7) in the housing units (Bhalli 2011).

Table 2: Indices of Congestion 1981 and 1998

Index	1981	1998
Persons per housing Unit	7	7.3
Persons per room	3.5	3.17
Rooms per housing unit	2	2.3

Source:(Govt. of Pakistan 2004; Govt. of Pakistan 2005)

Figure 4: Comparative Growth of Population and Houses, 1981-98



Source:(Govt. of Pakistan 1984; Govt. of Pakistan 2005)

The urban areas in Pakistan are characterized by congestion, haphazard growth, pollution and urban sprawl, including informal settlements along major national highways adjacent to metropolitan areas. This has put increasing burden on an already inadequate infrastructure and contributed to environmental harms including pollution traffic congestion and problems

associated with inadequate provision of water supply, sanitation, drainage, solid waste management, and urban flood protection. The situation has been further compounded by the inadequate technical and financial capacities of the local governments and other involved agencies, and the lack of an integrated urban development approach without integrated urban planning and zoning resulting in disintegrated development of services like electricity, natural-gas, and telephone(Planning Commission of Pakistan 2010).

CONCLUSION

The present research focused on using geospatial techniques for combining geospatial themes and population census data to study various surface features in the environs of Faisalabad city, the dynamics of urban expansion with reference to population growth, and analyses different population aspects with reference to the spatial distribution of urban population. The potential direction of population expansion in the district can be predicted by carefully examining the existing growth. Further to this, attributing population census data to respective features, digitized as thematic layers of geo-spatial information, developed into useful information for carrying out various demographic analyses corresponding to spatial distribution of urban localities. It is recommended that such studies may be repeated after a regular agreed-upon time-intervals, so that not only the activity of keeping the statistical/census data updated continues but also the maps, both cadaster and physical, could be improved for new features using satellite images at high spatial detail. The city of Faisalabad is facing a high population growth rate, and proper steps should be taken to prevent possible problems in policy making as well as implementation. The area is divided into 8 towns for administrative and management purpose in accordance with the Punjab local govt. ordinance 2001(The Punjab Local Government 2006). Not only the population has increased naturally, but the trends of migration towards this area have also been increased.

REFERENCES

- Baumont, C., C. Ertur, et al. (2004). "Spatial Analysis of Employment and Population Density: The Case of the Agglomeration of Dijon 1999." Geographical Analysis 36(2): 146-176.
- Bhalli, M. N. (2011). A GIS Based Analysis of spatial patterns of urban Growth in Faisalabad city 1981-2010. Geography. Faisalabad, GC University Faisalabad. M.Phil.
- Govt. of Pakistan (1984). Comparative Growth of Population and Houses, 1981-98. Islamabad, Population Census Organization, Statistics Division.
- Govt. of Pakistan (2000). District Census Report of Faisalabad 1998. Islamabad, Population Census Organization, Statistics Division.
- Govt. of Pakistan (2004). City Report of Faisalabad 1998. Islamabad, Population Census Organization, Statistics Division.
- Govt. of Pakistan (2005). Basic population and housing data by union councils 1998. Islamabad, Population Census Organization, Statistics Division.
- J. Antony Vinoth Kumar, S.K. Pathan, et al. (2007). "Spatio-Temporal Analysis for Monitoring Urban Growth - A Case Study of Indore City." Journal of the Indian Society of Remote Sensing 35(1): 11-20.

- Lu, D. and Q. Weng (2007). "A survey of image classification methods and techniques for improving classification performance." International Journal of Remote Sensing 28(5): 823-870.
- Maktav, D. and F. S. Erbek (2005). "Analysis of urban growth using multi-temporal satellite data in Istanbul, Turkey." International Journal of Remote Sensing 26(4): 797-810.
- Martin P. Bockerhoff (2000). "An Urbanizing World." Population Bulletin 55(3): 1-48.
- McIntyre, N. E., K. Knowles-Yáñez, et al. (2000). "Urban ecology as an interdisciplinary field: differences in the use of "urban" between the social and natural sciences." Urban Ecosystems 4(1): 5-24.
- Pathan, S. K., P. Jothimani, et al. (1989). "Urban land use mapping and zoning of Mombay Metropolitan region using remote sensing data. ." Journal of Indian Society of Remote Sensing, 17(0): 11-22.
- Pathan, S. K., V. K. Shukla, et al. (1991). "Urban land use mapping-a Case study of Ahmedabad city and its environs." Journal of Indian Society of Remote Sensing, 19(0): 95-112.
- Paul M. Treitz, Philip J. Howarth, et al. (1992). "Application of Satellite and GIS Technologies for Land-Cover and Land-Use Mapping at the Rural-Urban Fringe: A Case Study." Photogrammetric Engineering & Remote Sensing 58(4): 439-448.
- Planning Commission of Pakistan (2010). Task Force on Climate Change, Final Report. Islamabad, Planning Commission of Pakistan: 1-118.
- Sudhira, H. S., T. V. Ramachandra, et al. (2004). "Urban sprawl: metrics, dynamics and modelling using GIS." International Journal of Applied Earth Observation and Geoinformation 5(1): 29-39.
- The Punjab Local Government (2006). The Punjab Local Government Ordinance 2001,(Ordinance No XIII of 2001). Lahore, The Punjab Local Government.
- Thomas Lillesand, Ralph W. Kiefer, et al. (2008). Remote Sensing and Image Interpretation, Wiley, New York, USA.
- United Nations (2002). World Urbanization Prospects;The 2001 Revision Data Tables and Highlights Population Division, Department of Economic and Social Affairs; United Nations, New York 10017, USA.
- Victor Mesev (1998). "The Use of Census Data in Urban Image Classification." Photogrammetric Engineering & Remote Sensing 64(5): 431-438.
- Yuan, F., K. E. Sawaya, et al. (2005). "Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing." Remote Sensing of Environment 98(2-3): 317-328.