SPATIOTEMPORAL MONITORING OF URBAN SPRAWL AND ITS IMPACT ASSESSMENT IN DISTRICT SHEIKHUPURA THROUGH REMOTE SENSING AND GIS USING SATELLITE IMAGES FROM 1976-2014.

S M H Raza[1*], S A Mahmood[2], Fauzia S Alvi [3], M Atif[4], S Yahya[5], J Ahmad[6], A Hanif[7]

[1,2,4,6,7] *Remote Sensing Group, Department of Space Science , University of the Punjab, Lahore, Pakistan*

[3,5] *Institute of Social & Cultural Studies. University of the Punjab Lahore Pakistan.*

*CONTACT: (smhn72@gmail.com)

ABSTRACT: *Sheikhupura is well known city of Pakistan. It is sprawling rapidly, which is causing several socioeconomic and environmental problems. Sufficient knowledge about trend of this spread is required for satisfying needs of residents by managing available limited resources. It is also required to have knowledge about land cover and land use(LCLU) changes over the time and, to detect growth patterns across the city. To accomplish these tasks with greater accuracy and easiest way, techniques of remote sensing and Geographic information system (GIS) proved to be very advantageous. This study makes an attempt towards mapping spatio-temporal changes using LANDSAT satellite image for urban sprawl of Sheikhupura, Pakistan. In this study, four different time periods viz. 1976-1994, 1994-2000, 2000-2014 are chosen for the analysis. The results show that high-density urban area had grown during 2000-2014 and eaten up fertile agricultural land pieces which is due to growth in industrial progress seen in Sheikhupura city.*

Keywords: LULC (Land use and Land cover) mapping, Change detection, Spatiotemporal analysis, GIS, GPS, Remote Sensing.

INTRODUCTION

1.1 Background

The process of Urbanization is defined as a development that involves growing ratio of total inhabitants existing in cities and the surrounding areas. It also refers to change of agricultural land into buildings for living of people, markets and industries. The progression of urbanization is due to explosion of population, conversion of rural localities into urban areas and migration of people towards cities [1]. People view cities, a source of economic growth and, a source of employment that draws more and more population towards it [2]. Growing population and urban sprawl are posing challenges to urban planning, especially for developing countries [3]

1.2 Urban Sprawl in world

Worldwide number of people living in urban areas is larger than rural areas. About 54 percent of world's human population is living in urban areas. In 1950 about 30 percent of world human population lived in urban areas and it will be increased up to 66 percent in 2050 [4], World urbanization Prospects (2009) stated that 50 percent of world population started living in urban areas in 2008 which, if this trend persists, then world population will be increased by 72 percent between 2000 and 2030, as a result of which built up area will grow up to 175 percent [5]. This urbanization trend is seen in developing countries like Northern America, which has an urban population of 82 percent, Latin America and the Caribbean have 80 percent and Europe 73 percent. Africa and Asia are faster than other regions in this race of urbanization. By 2050; Africa will grow to 56 percent and Asia 64 percent. Three major countries, India, China and Nigeria collectively are expected the main reason for 37 percent of expected growth of world's urban population between 2014 and 2050. India is likely to increase 404 million urban inhabitants besides China 292 million and Nigeria 212 million. [6]

1.3 Objectives of Study

The goal of this study is to analyze urban growth by using satellite data of different years to define the rate of sprawl.

Furthermore, suggestions and recommendations will be given to city planners and decision makers to control and manage urban sprawl. Under this goal, this study has the following objectives:

1. To figure out Temporal changes of urban sprawl in the study area.
2. To explore the impacts of urban sprawl in thestudy area.
3. To make recommendations in terms of urban planning process to mitigate the adverse impact of urban sprawl.

1.4 Sociological Relevance of the study

Urbanization is a social issue as it has an impact on the society. The process involves migration of people from rural to urban areas. The reasons may be many like education, in-search of jobs, social mobility (shift from one economic class to another). Increasing population and demand of more resources may also increase the impetus of urbanization causing urban sprawl. Urban sprawl decreases the productive efficiency of development within the urban settings. Moreover, it is important to identify the socio-economic and environmental impacts of urbanization.

1.5 Study Area

Sheikhupura is a renowned District of Punjab; Pakistan, which is located on coinciding boundary with Lahore and Hafizabad. Spatially it is located at the Latitude of 31°42′47″ N and Longitude of 73°58′41″ E and elevated about 685 feet above sea level. Sheikhupura is famous for its historical places, industrial and agriculture surroundings and best export-quality rice. District Sheikhupura bounded on North by Gujranwala and Hafizabad districts, on the North-East by Narowal district, on West and South-West by Nankana Sahib District and on East by Lahore District. District Sheikhupura covers an area of 3,280 square kilometers. Population in Sheikhupura was 22,300 in 1951 which has increased more than 6.5 million in half a century. In recent decades reason for this progression is agricultural and industrial activities. Current population of Sheikhupura is growing gradually and expected to exceed 7 millions in the year 2019.
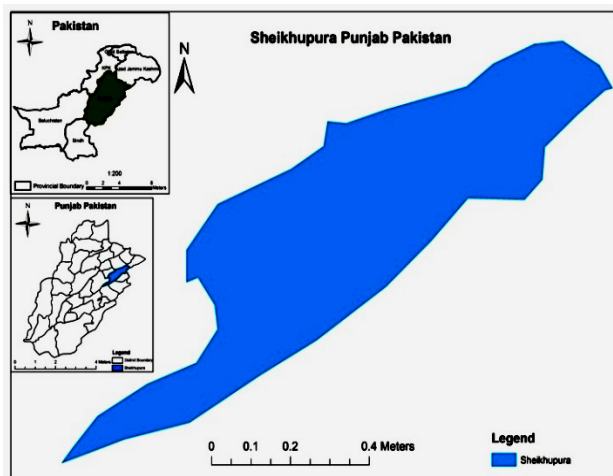
**Figure 1: Spatial Map of District Sheikhupura**.

2.1 Literature Review

Topography is closely associated with two distinct but interrelated attributes, land use and land cover. Land use may be classified as agricultural, residential, industrial, commercial, marshland and mining etc. categories. Land cover could be classified as cropland, forest, femland and grassland etc. Change detection is a process of finding changes in the state of an object or phenomenon by observing it at different times.

Urbanization is a process involving loss of agriculture, forests, and underground water bodies [7]. Urbanization occurs in radial direction around a well-established city and linearly beside the highways [8]. Sudhira observed that urbanization maintains a relationship with population [9]. Uncontrolled population leads to the scarcity of food, environmental problems, informal settlements and unemployment [10], which affects the management of available natural resources in cities, that cannot grow as fast as the human population [11]. This creates a stress on authorities to provide public the basic needs of life, including water, sanitation and transportation, etc [12]. Many forces behind changing land cover patterns affects climate and biosphere, water and radiation budget Commendable work has been done to map the process of urbanization.

Many methods have evolved for change detection with satellite imagery with the increasing power of computers to manipulate the digital data. Many studies used Remote Sensing (RS) and Geographic Information System (GIS) for change detection. RS data provide the key information for land use patterns . RS and GIS extensively integrated and known powerful tools for urban analysis.

RS provides algorithms for observing, forming, and examination of urbanization processes, and up-to-date maps [13]. Satellite imagery technique offers historical data and where as the GIS is useful source for recording and studying the patterns of urban sprawl. The methods widely used for finding changes in urban environments comprise image differencing [14], change analysis, direct multi time classification [15]. RS and
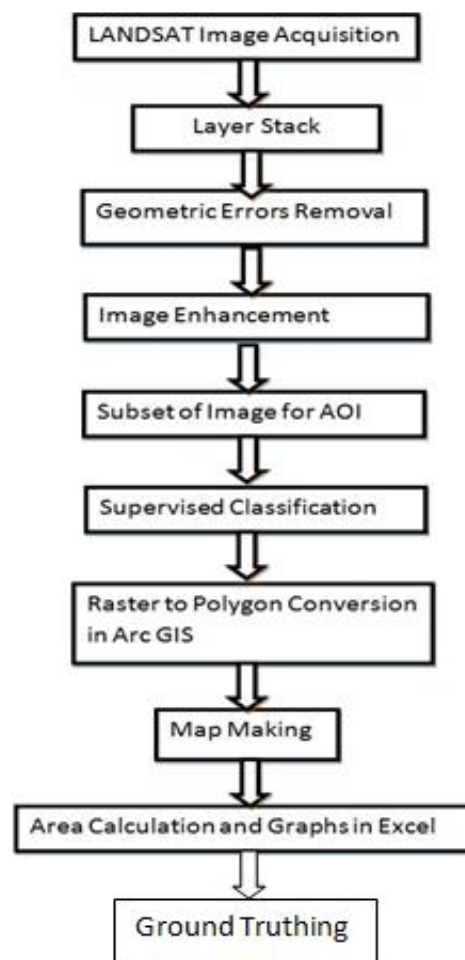
GIS has proved highly time and cost effective and less labor intensive. High resolution satellite data are now available at cheap cost and implementation of RS and GIS has accelerated the planning process.

Apan *et al* studied landscape structural changes at Lockyer Valley Catchment in Queensland, Australia [16]. They used two thematic maps of Lockyer Vallery and processed them using Arc GIS and measured the nature landscape structural changes within catchment areas. Yeh described Shannon's entropy to differentiate different types of urban sprawl which reflects the concentration of dispersion of spatial variables in a specified area [17]. Alados, studied vegetation cover and landscape patterns of semiarid and Mediterranean land in land cover changing aspects. To assess and compare changes from 1957-1994, aerial photographs were taken for the year 1957, 1985 and 1994. They used GIS software to conduct overlay analysis and also verified the results by conducting ground surveys [18].

Ye's study is based on Hierarchical Regional Space (HRS) model to analyze land changing patterns in Beijing Municipality [19]. He used GIS technique to detect landscape changing patterns and performed landscape change trajectory analysis by using spatial and temporal data and performed ground truthing. Ayad studied urbanization processes in coastal area of Egypt using remotely sensed data and proposed RS effective in decision making regarding urban planning [20]. Bhatta used GIS and RS techniques for

analyzing urban growth patterns of Kolkata. He verified remotely sensed data with topographic sheets of that area. He used maps with different resolutions and also described economic growth a cause of urbanization [21].

Pocas extracted area for vegetation and barren land using satellite images to describe spatial heterogeneity, disintegration and complexity of landscape and identification of decrease of annual crop yield [22].

This research aims to monitor urban sprawl in district Sheikhupura over a period of about 40 years using Landsat satellite imagery from 1976 to 2014 to analyze the socio-economic impact of urban sprawl across the study area. It is also aimed to define the patterns of urban sprawl and certain recommendations for decision and policy makers, given at the end for better management of available natural resources to overcome the problems of huge population.

MATERIALS AND METHODS
3.1 Data source: www.Earthexplorer.com
3.2 Software employed:
Software's which are mainly employed to complete the task is presented as following.

Table: 1 List of software used for this study.

Software Name	Application
ERDAS 9.2®	For classification and image processing
Arc GIS 9.3®	For Map making
Microsoft Excel	For making graph
Microsoft World	Final presentation of research

3.3 Methodology
Major steps followed in this research.
3.3.1 Image acquisition
The first step is the acquisition of an appropriate image. In order to study change detection in Sheikhupura , four Landsat satellite images of Sheikhupura district are acquired which are as following 1976, 1994, 2000 and 2014.These four images are downloaded freely from Earth explorer webserver. Landsat satellite images and their characteristics have been presented as follows.

Table 2: LANDSAT satellite images and their traits

Year	Sensor Type	Spatial Resolution	Spectral Resolution	Date of acquisition
1976	LANDSAT 1-5 MSS	30*30	4 band	09-04-1976
1994	LANDSAT 4-5 T.M	30*30	7 band	29-04-1994
2000	LANDSAT ETM+	30*30	8 band	07-09-2000
2014	LANDSAT 8	30*30	11 band	18-09-2014

.**3.3.2 Band stacking**
Band stacking is the process of combing the spectral layers to get a multispectral image, actually it ties up the spectral layer to comprise an image. The process of band stacking is executed using Erdas Image, Band Staking utility.
3.3.3   Removal of geometric errors
Remotely sensed images contain certain geometric errors which can distort the results. These errors may be due to attitude of sensor, curvature of earth, atmospheric refraction,

and nonlinearities in the sweep of the sensor's instantaneous field of view. These factors are removed by applying algorithms of Geometric correction in Erdas Imagine 9.2 to make the image error free.
3.3.4 Image Enhancement
Remotely sensed images contain noise which makes the image difficult to interpret. Image enhancement is a technique which increases the visual distinctions between the features in an image. Objective of enhancing image is to make new images from original image so that more information can be obtained. This task is performed using image enhancement utility of Erdas Imagine 9.2 for all the images from 1976 to 2014.
3.5.4 Sub Setting
Sub setting utility is a useful mechanism of extracting area of interest from a large dataset but it is application dependant. In case of Sheikhupura, Lansat satellite one scene preserve an area of $185*185$ km^2 , which is relatively larger than our area of interest. Subsetting utility in Erdas Image 9.0 is executed for satellite images to get rid of hectic job of processing for a large dataset of $185*185$ km^2.
3.5.5 Image Classification
Classification is amethod of classifying an image to its constituents. Remotely sensed images can be digitally classified through Supervised or Unsupervised approaches. Supervised classification is more precise for mapping information, largely depends on the intellect and expertise of image analyst [23], whereas unsupervised classification is performed by computer automatically. The first step in the process of supervised classification is to locate the representative training sites for each land-cover type that can be identified in the image. The task of supervised classification is performed using the Classification utility of Erdas Imagine 9.2. and satellite image are classified into two major land use classes Build up and Vegetation relatively.
3.5.6 Raster to polygon conversion
After classification images are digitized and polygons are drawn around each training site and a unique identifier is attached to each cover type. ArcGIS is used for converting raster data into vector data. Shape files are made for each image which is a simple process of conversion of raster data into vector form. According to nature of features, characteristics defined as national highways, roads, railways digitized as polyline, while urban area, river, vegetation cover, soil type etc. digitized as polygon. Finally built up area and vegetative area calculated for Sheikhupura for different years and results interpreted.

4.0 RESULTS AND DISCUSSIONS
This study focused on utilization of remote sensing and GIS techniques, analyzing land use pattern of Sheikhupura. It demonstrated the importance of digital image processing and GIS in producing accurate land use maps of Sheikhupura over past 40 years. Urban land use change of Sheikhupura is detected by careful study of maps created with help of ERDAS Imagine and GIS software. Maps containing two major land use classes, including built-up area and vegetation obtained temporally. These maps verify the progression of urban sprawl and confirmation of urban extent and growth

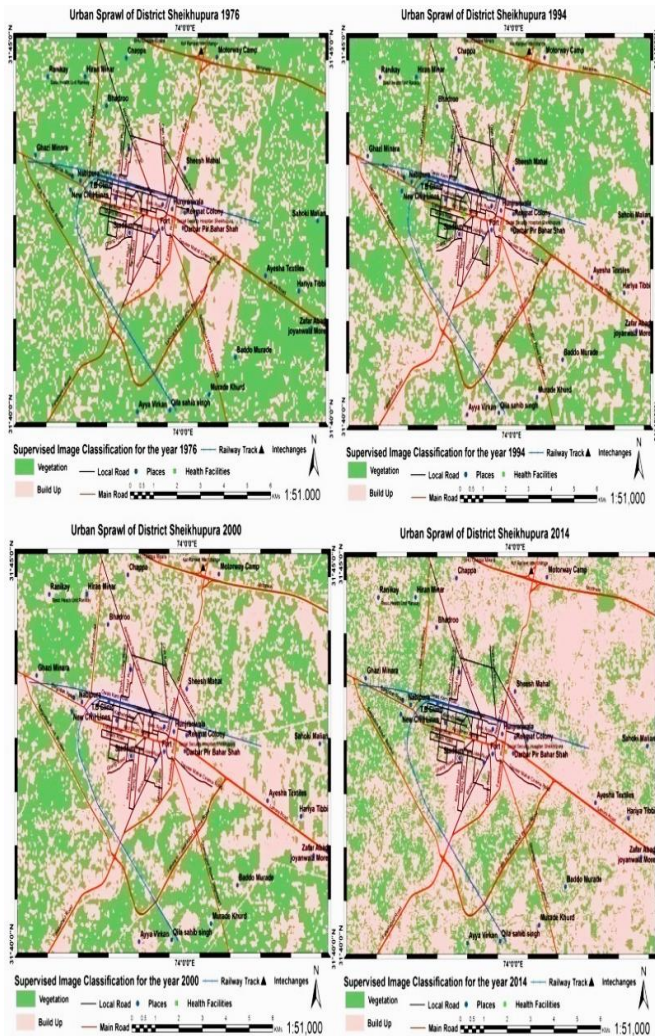patterns. Classified images show expansion of urban sprawl in certain areas and the results are as follows.

**Fig 2. Supervised Classification results for the year 1976-2014.**

The supervised land use classification provided following results,

Table 3: Urban sprawl Sheikhupura

Land Cover Categories	1976	1994	2000	2014
	Area (km^2)	Area (km^2)	Area (km^2)	Area (km^2)
Build Up	45.42	58.31	66.17	83.36
Vegetation	83.06	70.13	62.17	44.97

Graph 1: Urban Sprawl Sheikhupura 1976-2014

Above data represents built up and vegetative area for each study year. The figures shows built-up area in 1976 occupies $45.42km^2$, followed by vegetative cover 83.06 km^2.Built up area increased to $85.31km^2$ in 1994 and vegetative area decreased to 70.13 km^2 in year 1994.In year 2000 buildup area was $66.17km^2$ and vegetative area was $62.17km^2$. Boom of Sprawl can be seen in the year 2000-2014 with built up area 83.36 km^2 and vegetative area $44.97km^2$.
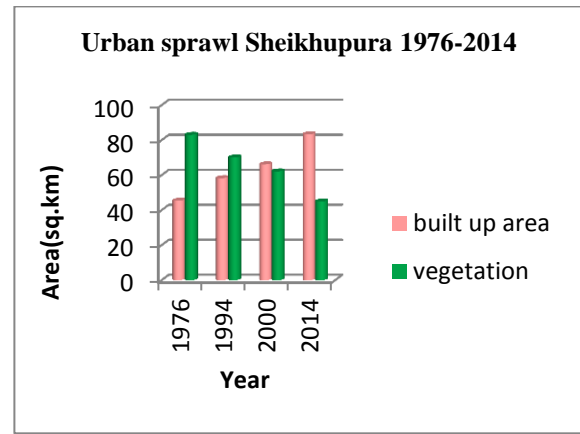
Graph No 1. Urban Sprawl Graphical Representation

4.2 DISCUSSION

Metropolitan area of Sheikhupura is divided to two categories: built up zone, vegetative area. Built up zone includes residential area, commercial area ,industrial zone, educational institutes ,transport terminals, railway lines, public buildings and hospitals .vegetative area includes agricultural area , orchards, open spaces , parks and graveyards . People rush to urban areas and needs for social facilities increases. Data shows that trend of urban sprawl is mostly seen where these facilities are likely available along the road network. Sheikhupura is industrial area which provides people opportunities for employment. More urban sprawl is seen around hospitals and industrial areas.

4.3 Impacts of urban sprawl

The concept of urban sprawl and its impact on human life is not new as it has been prevailing since many years. Towns and cities are growing larger and becoming overcrowded. It is important to look into its impacts. Major effects of urban sprawl are increasing traffic hazard, pressure on indigenous resources, and destruction of open space. It effects physical environment and spatial structure of cities. Poorly strategic urban development is also threatening natural environments. These physical impacts also influence human emotions and behavior. Different sociologists have explained the social impact of urban sprawl. Ferdinend Tonnies (1855-1937) a German sociologist discusses by his concepts of Gemeinschaft (used for traditional rural life) and Gesellschaft (used for urban life where people come together on the basis of individual interest) that as societies experience a spread of urban population they experience an erosion of close, enduring social relations and impersonal business ties become the foundation of society. Similarly, Emile Durkheim, a French theorist explains that as small towns change to become large cities they experience a lack of shared moral standards and sentiments. Another German sociologist Georg Simmel (1858-1918) explains that as cities grow larger, individuals perceive the city as a crush of people, objects and events and develop an individual detachment to their surrounding which he terms as '*blasé attitude*'. This makes people less compassionate about the

unpleasant happenings around them [24]. So it is important to understand that urban sprawl, not only influences human life externally, but it also has a strong impact on their behavior and emotions as well.

4.3.1 Environmental impacts of urban sprawl

Johnson identified four classes of environmental effects recognized to urban sprawl, which are air, energy, land, and water. Loss of farmland, open space, forest, and habitat are the most common issues attributed to urban sprawl. As population increases in the cities agricultural land, forest land and open spaces are converted into buildings to accommodate the increasing population [25]. Transformation of agricultural land to urban sprawl means loss of fresh local food sources and loss of habitat and diverse species, since agricultural farms comprise of both plants and animal's environment. Presence of farms on rural landscape provides benefits such as green space, rural economic strength, and protection of traditional rural life. The increase of population in cities leads to construction of more industries, increase load of traffic which causes emission of harmful gasses causing harmful impact on the health of people. Increased population not only effects quantity of water resources, but also quality of water. Poor sanitation system pollutes the water which causes out brake of water-born diseases. Urban sprawl results in the decrease of productive agricultural land within and around the cities [26]. Farm land conversion into residential land causes the loss of agricultural production. Another reason may be the migration of people from rural to urban areas due to which a deficit of agricultural labors is created within the rural areas causing loss of agricultural production. The augmented consumption of automobiles emits chemicals and noxious gasses like hydrocarbons, carbon monoxide, nitrogen oxides causing air pollution and smog. Building place destruction, fuel leaks, oil drips, paint falls, lawn chemicals, pet litters add water pollution. This also results in soil pollution. The pleasing, attractive green spaces are threatened and are being substituted by houses and infertile urban land. Large areas of land are being enclosed by roads, concrete and cement. There are large bulks of water overflow because road and cement do not absorb rain water as best as planted areas. There has also been a decrease in effective absorption of rainwater into rocks.

4.3.2 Economic impacts of Urban Sprawl

4.3.2.1 Impacts on Transportation

The inhabitants of sprawls expend higher amount of their income on transportation than inhabitants living close to center of cities. The unforeseen growths often lead to loading of road capabilities, power lines, etc. The town that was intended to cater small group of people is often forced to provide sprawling populations resulting in overloading of services and infrastructure leading traffic blockings, irregular water supply and burden on sanitation system, etc. In developing countries results can be much serious like development of slums and substandard living environments, lack of hygiene and sanitation. As open structure prices surges for outskirts, it becomes problematic to explain costs of big investments for low density populations. This becomes problematic for governments funding for services as such people are frequently deprived of vital amenities.

4.3.3 Social impacts of urban sprawl

Besides the visibly physical impacts of urban sprawl like scarcity of food, environmental problems, generating unplanned settlements, unemployment and most importantly the mismanagement of the basic delivery of human services, urban sprawl has also significant social impacts. Some of the literature given in 'Impacts of urban Sprawl' is already discussed. Other implications include destroying social capital, effecting people of all ages and feeling of anomie among the members of a society opportunity to have a sensible well life, destroying neighboring natural environment, increasing stress negatively effecting mental and physical health of people.

4.3.3.1 Social Fragmentation

It has been detected people residing in stretches or outskirts use a lot of time traveling longer distances to reach their jobs, schools, shopping facilities. There is scarcely any time or chance to see their fellow citizen. Even people do not know their neighbors. There is no civic feeling.

4.3.3.2 Impacts on security

As social communication decreases, observation of adjacent belongings reduces. This leads to rise in crime rate. The offenders find themselves at the minor chance of being arrested as they often mistaken as a part of the resident's family. We repeatedly get news of robbery and murder nearby after many days of event when police or inspecting organizations blow our door for evidence.

Urban sprawl has many implications as discussed earlier. Therefore, it is recommended to develop a wise policy to regulate the spread of population in Sheikhupura in an uncontrolled manner. Such studies can help to facilitate policy makers as well as city planners to emancipate a sustainable, environment friendly road map for the growth of cities like Sheikhupura city which in future can also be a major contributor in the economic growth of Pakistan.

5.1 CONCLUSION

Urban sprawl has turned into a worldwide problem, and is being confronted by both developed and under-developed nations. In developing nations results can possibly be life intimidating owing to problems of health and hygiene. Developed nations, are certainly in a better situation as compared to the underdeveloped countries. However, with increasing growth of urban population day by day, occupying the agriculture land at an ever increasing speed, there is a threat to sustainable development and quality of life. The results can be disturbing for future generations.

This study shows that process of urbanization can be analyzed effectively using GIS and remote sensing. The easily available Temporal Landsat TM and Landsat ETM data has helped detecting of land use and cover changes over the years for District Sheikhupura. It shows the total urban built-up area of the city and explains the growth of urban settlements in Sheikhupua from 1976 to 2014.The shift shows an increase from low density of 45.42 km^2 to a high density area of 83.36km^{2}in this period. Vegetative areas which include agricultural land, orchards, open spaces, parks and graveyards are categories which are mostly affected by urban growth. During the period 1976 to 2014, the low-density urban areas have rapidly contributed to the growth of

high-density urban areas. Studying temporal trends of urban growth it is obvious that urban growth is spreading in all directions. However, the regions where more industries are located are experiencing more dynamic activities of transformation into urban areas. Urban sprawl has posed many serious effects, especially on environment. So there is an immediate need of sustainable planning to provide basic amenities to the growing population in these regions. This analysis of urban growth can provide basis for better sustainable urban planning for regions which are dynamically active.

5.2 RECOMMENDATIONS

Main focus of present study is detecting urban land use change of Sheikhupura. Results and analysis of present study is calling for making a joint strategy for the spatial arrangement of these urbanites. This study can also be helpful in detecting various problems related to urban environment. It is strongly recommended for urban scholars that same types of studies must be revised after the nominal time intervals so that settings of urban spatial patterns may be revealed timely and future planning may be managed in a better way.

REFRENCES

[1]. UN. Report "World Urbanization prospects" (2009).
[2]. UN, "United Nations Human Settlement," (2010).
[3]. Putra, B. R. "*Impacts of urbanization on groundwater recharge*". Nanging, China United Nations settlement programs (2008).
[4]. UN, "United Nations Human Settlement," (2014).
[5]. Shlomo Angel, S. C. "*The Dynamics of urban expansion*". Washington D.C: World Bank. (September 2005).
[6]. UN, "United Nations Human Settlement," (2008).
[7]. S K Pathan, V. K. "*Urban Land using Mapping, A case Study of Ahemedabad City and its Environs*". Journal of Indian Society for Remote Sensing, 95-112 (1991).
[8]. Sudhira, H. S. "*Urban Sprawl metrics, analyzing and modeling using GIS*". International Journal of Remote sensing (2003).
[9]. Sudhira, H. S. "*Urban Sprawl Metrics ,dynamics and modeling using GIS*". International Journal of Applied Earth observation Geoinformation. (2004).
[10]. Maktav, D. A. "*Analysis of Urban Growth Using Multi Temporal Satellite data*". International Journal of Remote Sensing (2005).
[11]. UN Report "*United Nations World Commission on Environment and development*", Oxford University Press (1987).
[12]. Uitto JI, B. A. "*Water for urban areas: challenges and perspectives Tokyo*" United Nations University Press (2012).
[13]. Gadal S., S. F. "*3D dynamic representation of urban sprawl modeling: Example of Delhi-Mumbai corridor.*" India Surveys and Perspectives Integrating Environment and Society (2009).
[14]. Toll, D. J "*Urban areas update Procedures using Landsat Data*". Proceedings of American Society of Photogrammetry (1981).
[15]. Li, X. "*Principal component Analysis of stacked Multi-temporal Images for the monitoring of rapid urban expansion in the Pearl River Delta.*" International Journal of Remote Sensing, 1501-1518 (1998).
[16]. Apan. "*Mapping and analysis of changes in the reparian land scape structure of Lockyer Valley catchment in Queensland Australia*" (2001).
[17]. Yeh, L. "*Measurement and monitoring of urban sprawl in a rapidly growing region using entropy*". Photogrammetric Engineering and Remote Sensing, Pg 83. (2001).
[18]. Alados, C. P. "*Variation in landscape patterns and vegetation cover between 1957 and 1994 in a semiarid Mediterrerian ecosystem*" (2004).
[19]. Yeh, L. "*Measurement and monitoring of urban sprawl in a rapidly growing region using entropy*". Photogrammetric Engineering and Remote Sensing, Pg 83. (2001).
[20]. M. Ayad. "*Remote sensing and GIS in modeling visual landscape change: a case study of the northwestern arid coast of Egypt*" (2004).
[21]. Bhatta. "*Analysis of urban growth and sprawl by Remote Sensing*". Springer. (2010).
[22]. Pocas, I. C. "*Remote sensing based indicators of changes in a mountain rural landscape of Northeast Portugal*". Applied Geography , 871-880. (2011).
[23]. Bhatta. "*Analysis of Urban Growth and Sprawl from Remote Sensing Data*" *Springer*. (2010).
[24]. Macionis, J.J. "*Dorling Kindersley (India) Pvt.Ltd, licenses of Pearson Education in South Asia*". (2013).
[25]. Johnson. "*Environmental Impacts of Urban Sprawl*". A Survey of the literature and proposed research agenda (2001).
[26]. Bhatta B, G. "*Application of Remote Sensing and GIS for detecting land use changes: A case study of Vadodara*" (2005).