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Monitoring of Urban Sprawl and Land Use Pattern Using Geographic Information System (GIS) and Remote Sensing:

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Abstract:

Land is an essential resource on which all the activities of life are based. Land use is dynamic and is one of the main driving forces of the global environmental changes. Urban growth has increased the utilization of the natural resources and it has remarkably changed the land use land cover pattern. In this research an attempt has been made to study the impact of urban sprawl on land use changes on Warsak Road Peshawar between 1995 and 2015 by using GIS and Remote Sensing. Supervised classification techniques (maximum likelihood) were employed for land use land cover classification. The result shows that a tremendous increase in built-up area, population, and decrease in vegetation cover in 2015 as compared to 1995 were examined. The built-up area increased by 574.6 hectares throughout the study period, and vegetation coverdecreasedby610.17 hectares. The information collected on the urban growth through the land use and land cover change detection is very beneficial to the local government and urban planners for betterment of the future plans of sustainable development of the city.

Keywords: Land Use/Land Cover, Urban Sprawl, GIS and Remote Sensing, Change Detection

Introduction:

The isolated development along main road in linear direction or adjacent to the city and in rural area in radial direction is normally mentioned as urban sprawl. (Jain, 2008). The continuous expansion of cities has been noted for many decades, this expansion and conversion of prime vegetation cover into built-up is mostly taking place in the developing world. (Taubenbock, et al. 2009). In the international planning

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deliberation during 1990's, urban sprawl received growing attention. Sprawl is multidimensional phenomena and can be measured with the help of multi indicator approach using GIS-based tools (Sidentop and Fina, 2010). The most advantageous source for land use /land cover information is remote sensing data. A high resolution remotely sensed data can be used for identification and mapping of urban land cover (Jensen, 2004). The integration of remote sensing and GIS has been extensively applied and recognized as an effective tool for examining and mapping urban growth and Land Use Land Cover(LULC) changes.
(Epstein et al. 2002).

Remote sensing is a cost-effective technology and is widely used for urban growth and land use change detection assessment (Kaya and Curran, 2006). LULC is one of the most visible results of modification of the terrestrial ecosystem by humans (Weng, 2001). Increase in population, employment opportunities, health and educational facilities etc. are some of the factors responsible for city expansion which is also known as urban sprawl.
(Inallah et al. 2016). Environment is harmfully effected by the anthropogenic activities. Land use land cover has been changed because of the uncontrolled city expansion. Due to the rapid urbanization vegetative land cover is reduced, it destroys the nature and pollutes the water (Shalabi et al. 2013). The rapid rate of urbanization causes conversion of land from agriculture to built-up land (Weng, 2007). According to the UN Projection in 2006 there were about 50% of whole population of the world residing in the urban area and in 2020 it would be almost 60%. Most of the growth occurs in the developing countries. The abiotic environment and living organisms of the cities both were influenced by urbanization; it plays a major role in changing land use pattern (Dadras et al. 2014). The changes in the demographic and economic factors has influence on the land use demand. The intraregional and interregional migration towards cities results in expansion over the rural land and suburbs are the causes of increase in built up area and decrease in agriculture area. The residential demand increases as the population increases in that area (Hoymann, 2011).

Land use refers to the assessment of land according to various natural characteristics and the way how man has put the land for utilization. But land cover gives a detailed account of cultivated area of the land. The decision makers and planners need land use and land cover data for the better land resource management (Ndukwe, 1997). Land cover is the pragmatic bio physical or physical account of the earth's surface. It is defined by the features of earth's surface picturing a map vegetal distribution, water, ice cover and desert (Baulies and Szejwach, 1998).

With the advancement of satellite remote sensing and approach to high resolution data, one can generate detailed maps of land use changes. In planning and decision making the application of GIS is very helpful. (Samjullah, 2013).

In general, geographic informatics provides very effective tools for gathering and analyzing the information required to detect changes in urban areas that conventional survey technology cannot provide in a timely and cost-effective manner (Saleh and Rawashedeh, 2007). Remote sensing and geographic information system can be used to identify, mapped and examined urban sprawl (Barnes et al. 2001). Accuracy assessment is an important step in the process of remote sensing data. It determines the value of information from the resulting data to the user. The total accuracy of the classified image compares how each and every pixel can be classified against specific land cover types. User accuracy computes commission errors, which represents the probability of pixel classification matching land cover types from their corresponding real-world location (Campbell and Wynne, 2011). To evaluate image classification accuracy, the error matrix and the Kappa coefficient have become a standard way. Furthermore, the error matrix was used in many land use classification studies and it was a critical element of this research (Rawanga et al. 2017).

The aim of this paper is to investigate the impact of urban sprawl on land use/land cover pattern of Warsak road Peshawar city from 1995-2015. Satellite imageries of the required time periods were used to detect the land use/land cover changes in the study area. An attempt was made to investigate the changes in built-up and agriculture area as well as the prediction of future pattern of land use has been done.

Study Area:

Peshawar is the Provincial Capital of Khyber Pakhtunkhwa and is also the largest metropolis in Province. Warsak road is one of the major arteries in the northern part of Peshawar which runs from Peshawar cantonment/ Khyber road to Warsak dam. It crosses Kabul River and connects Shabqadar to Peshawar. The study area comprises of four union councils; namely Mathra, Dag, Hassan Ghari-2 and Tehkal Payan-1 as shown in the figure 1. The study area covers $45km^2$ (4500 hectares). In general, it covers the residential as well as commercial land uses, especially education institutions due to which it is sometimes called education corridor of the city. Along the road most of the land is occupied by educational institutions. In the late 80’s one of the private education institution initiated the current trend of converting prime vegetation cover to educational/ commercial land use. The people started moving towards the Warsak road area which functionally converted from sporadic development to ribbon development.

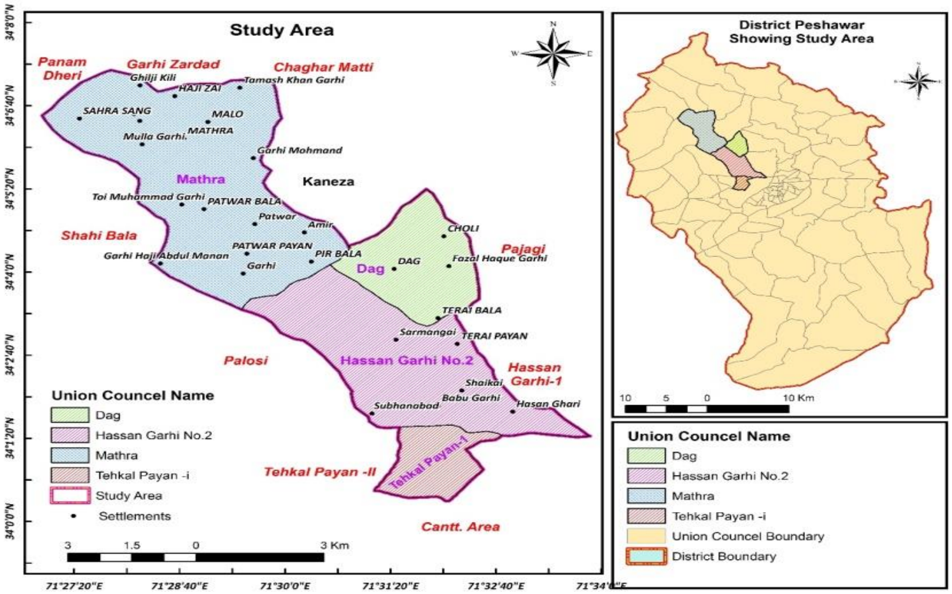

Figure 1. Location Map of the Study

Methodology:

To achieve the objectives following methodology was followed.

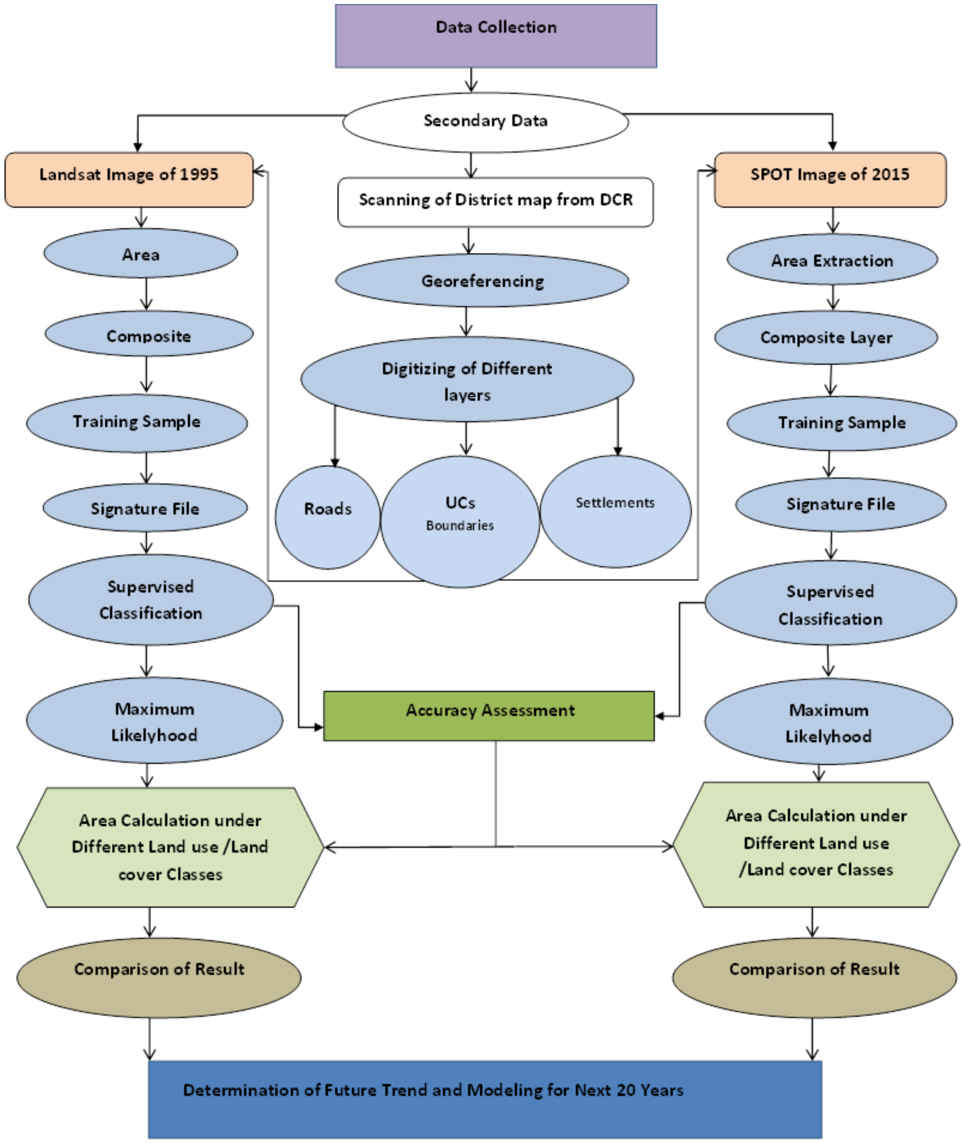

Figure.2. Research Methodology

Two imageries were acquired for the years 1995, 2015. The image of 1995 was downloaded from United State Geological Survey, Center for Earth Resources Observation and sciences USGS-EROS Landsat look viewer website. While the Spot-5 image of 2015 has been taken from Regional Office of SUPARCO. Vector data used in this study, includes district boundary, union council boundaries, road data and settlements. All of these were digitized from georeferenced scanned map of District census report 1998 (DCR).

Satellite images were put for atmospheric correction. In Quantum-GIS (QGIS 2.14) a tool named “DOSI Atmospheric Correction” was used for removing atmospheric errors. After atmospheric correction, the process of composite image was executed for all images.

In this study supervised classification technique was used in the research to classify the images. The first step in the process of supervised classification was to make training samples for different types of land cover in the image. Images were put for supervised classification and almost 100 training sample were collected from composite images and some from Google earth pro for each land cover class. The second step was to create signature file for those training samples based on the image to be classified. The task of supervised classification was performed using Maximum Likelihood technique in the classification toolbar of Arc-Map 10.2.1 and satellite Landsat image of 1995 and satellite SPOT image of 2015 classified in to four major land use classes i.e. Built-up, Vegetation cover, Barren land and Water. After successful image classification the classified images were then put for accuracy assessment to check the accurateness of the classification. The result of the accuracy assessment was satisfactory for all images so area was calculated for each land cover class, and maps were developed for year 1995, and 2015. Land use changes were observed between these 20 years. By analyzing of these classified images one can understand the land use of the study area. Table 1 shows the land use land cover classification scheme.

Table.1. Land-Cover Classification Scheme.

S. No	Land use Land Cover Classes	Description
1	Vegetation	All crops and orchards
2	Built-up	Residential, commercial, industrial, and road network
3	Barren Land	Land that is not suitable for agriculture
4	Water Bodies	River and lakes etc.

4.Accuracy Assessment:

In this study, the classified images have been justified by ground truth data and available open source Google earth (level of agreement between remotely sensed data and referenced information). The qualitative and quantitative accuracy assessment has been done for these classified images. For quantitative assessment a stratified random sampling technique was used whereas the qualitative assessment was carried out by visual interpretation technique through Google Earth Pro (open source). It is assumed that these ground truth points and Google Earth Pro images are the most accurate data available to measure the accuracy of the prediction. For each land use class 40 reference points were taken and then overall accuracy, user accuracy, producer accuracy and kappa coefficient were calculated for the two classified images.

Landsat Satellite TM 1995 (classification accuracy: 92.5%)

Predict	Built-up	Vegetation	Barren Land	Water	Ground Truth
Built-up	37	0	2	0	39
Vegetation	3	38	0	5	46
Barren Land	0	1	38	0	39
Water	0	1	0	35	36
Total	40	40	40	40	160

Table.2. Accuracy analysis (percentage) of land cover maps derived from Landsat data.

SPOT 2015 (Classification accuracy 95%)

Predict	Built-up	Vegetation	Barren Land	Water	Total
Built-up	39	0	3	1	43
Vegetation	0	40	1	3	45
Barren Land	0	0	37	0	37
Water	0	0	0	36	36
Total	39	40	41	40	160

Table.3Accuracy analysis (percentage) of land cover maps derived from SPOT Satellite data.

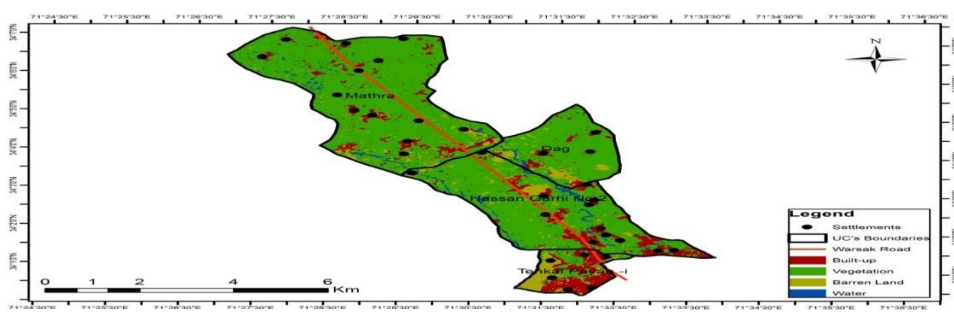

Figure.3. Land use\land cover of the Study Area 1995

Figure 3 shows the land use pattern during 1995, from which it is clearly visible that Vegetation was spread over large area and built-up area was covering small area as compared to vegetation cover except Tehkal Payan-1 as shown in figure 3. In 1995 the Vegetation was3504.18 hectares (77.94%), built up covers the area of 553.71 hectares (12.31%), barren land was 347.39 hectares (7.73%) and water was 89.76 hectares (1.99%).

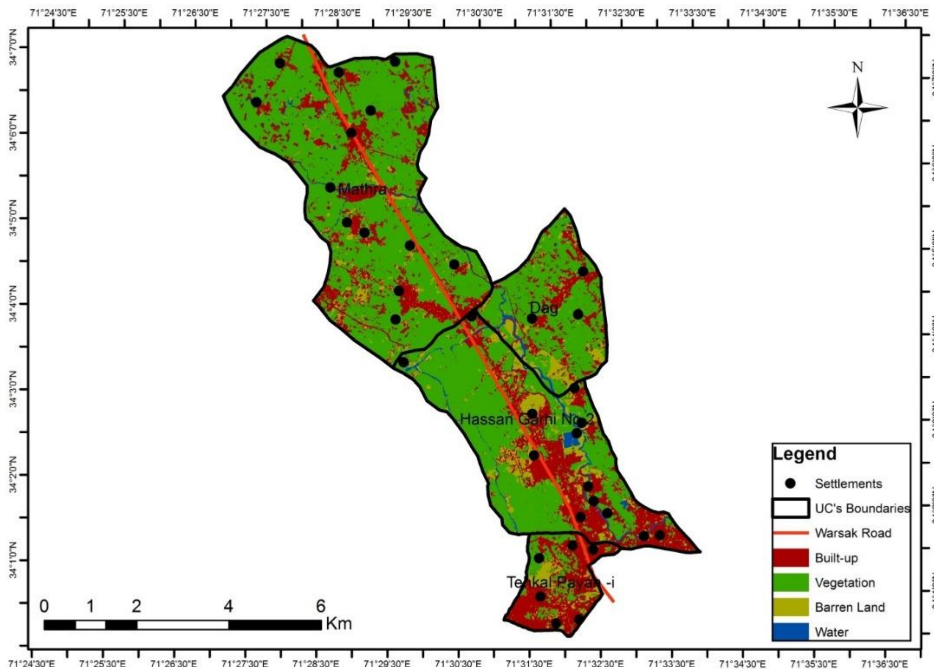

Figure.4**.** Land use\land cover of the Study Area 2015.

In the above classified image one can clearly notice the expansion of built-up area over vegetation cover, most of the in Mathra, Hassan Ghari-2 and Dag union councils have been converted to built-up area as shown in figure 4. In 2015 the area under Vegetation coverwas2894.01 hectares, the land under the cover of built-up area was1128.31 hectares, whereas the barren land covers 368.38-hectarearea. The water bodies cover the area of109.25 hectares.

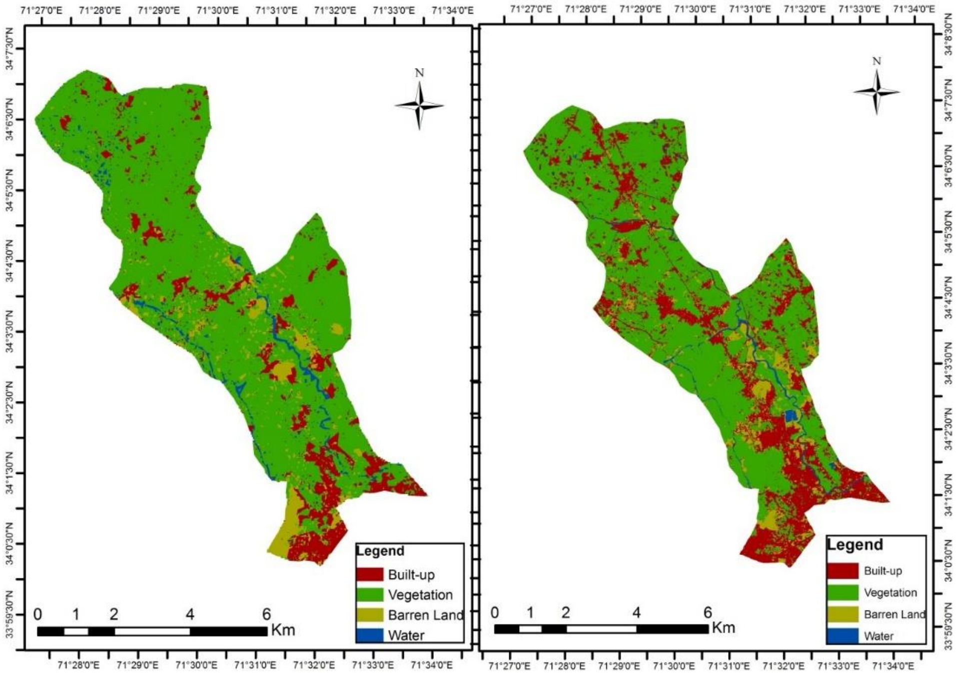

Figure.5. Land cover change detection 1995-2015.

Results and Discussion:

Table 4 and figure 5 indicates the changes in land use land cover from 1995-2015 in the study area. It is clear that there is a substantial increase in built-up area and decrease in Vegetation cover. In 1995 the area under Vegetation cover was 3504.18 hectares where as in 2015 it decreases to 2894.01 hectares. The total change in the Vegetation cover is -17.41%. In 2015 a remarkable growth of built up areas in the different areas of the study area has been noted i.e. Mathra, Chaura Khwar, Patwar Payan, Hijazai, Ghari Amir Khan and Ghari Abdul Manan of Mathra union council, Hassan Ghari, Irshadabad, Nawe Kalay, Barro Barhi, Darmangai, Pir Bala and Sindu Ghari of Hassan Ghari-2 union council, Choli Bala and Ghari Ghazali of Dag union council and Babu Ghari of Tehkal Payan-1 as shown in the figure 5. The built-up area in 1995 was 553.75 hectares and in 2015 it increases up to 1128.35 hectares, 103.76% increase in the built-up area have been noted. As compared to the other areas more changes have been noticed near to the Warsak road. The area covered by barren land in 2015 was 368.39 hectares, and in 1995 it was 347.95 hectares, the percentage of barren land which has changed was 5.87%. Whereas water in 1995 was 89.79 hectares (1.99%) and in 2015 it was 109.25 hectares (2.42 %).

S. No	Land cover categories	11th April 1995		12th Feb 2015		Change Area (1995-2015)	
		Area hectares	Area (%)	Area hectares	Area (%)	Area hectares	Area (%)
1	Vegetation cover	3504.18	77.94%	2894.01	64.36%	-610.17	-17.41%
2	Build-up area	553.75	12.31%	1128.35	25.09%	574.6	103.76%
3	Barren land/ open area	347.95	7.73%	368.39	8.19%	20.45	5.87%
4	Water bodies	89.76	1.99%	109.25	2.42%	19.49	21.71%
	Total	4495.60	100%	4495.95	100%		

Table.4. Land use Land cover change detection (1995-2015)

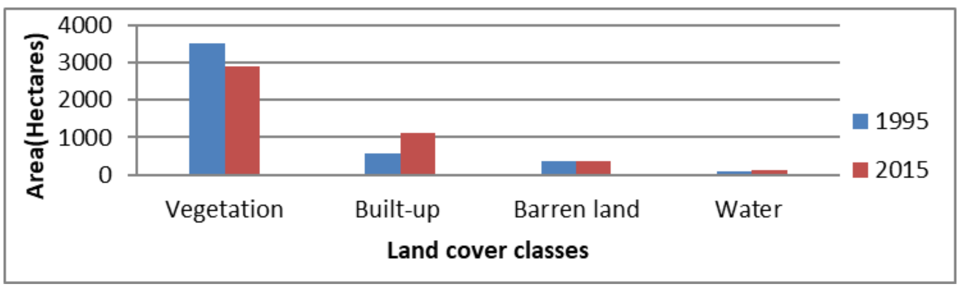

Figure 6. Area (Hectares) of LULC Features of Study Area 1995-2015.

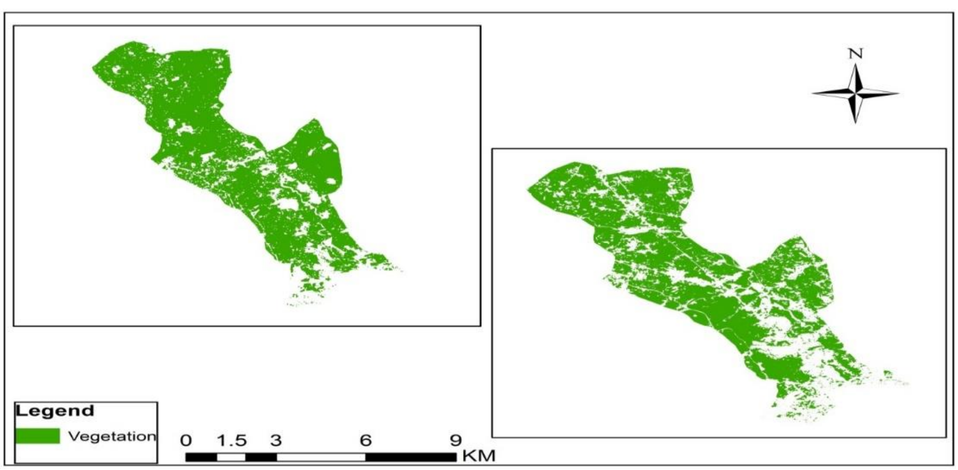

Figure.7. Vegetation cover change from 1995-2015

Figure 7 specifically focus on vegetation cover, in this figure it is clearly visible that vegetation cover has been decreased in the south eastern part of study area and the trend continues toward the north of the study area i.e. from Hassan Ghari-2 and Tehkal Payan-1 toward Mathra and Dag.

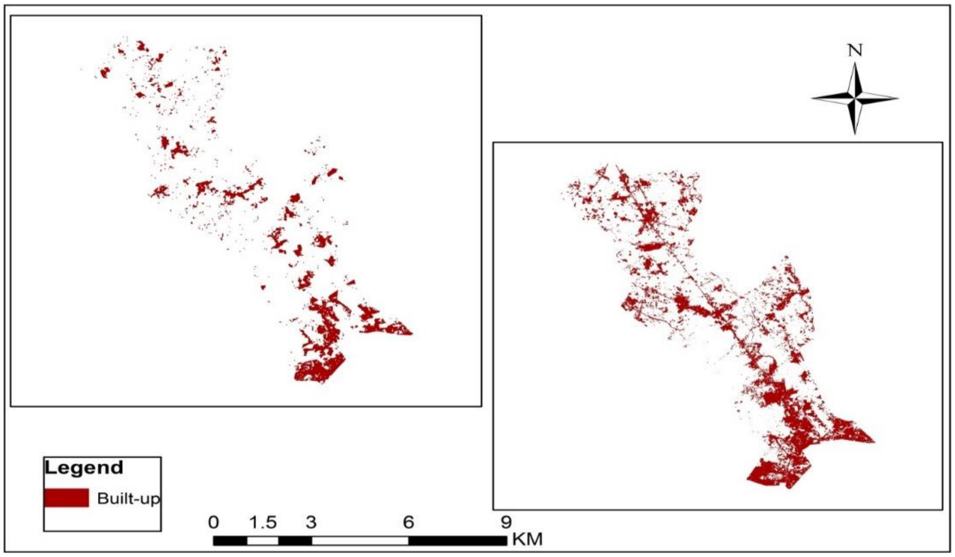

Figure.8. Built-up area changes from 1995-2015

In this figure the main focus is on built-up area, the expansion of built-up area can be seen in the above figure very clearly. Most of expansion occurred in the south eastern part of the study area where large area was under vegetation cover which have been later on converted into built-up area.

Determination of Future Trend and Modeling for Next 20 Years:

The table 5 shows future pattern of land use in which it is clear that if the vegetation cover is converted into new town schemes like Sabz Ali town Warsak road Peshawar, Arbab Shahbaz Ali khan town Warsak road Peshawar etc. and the process is still continuous, so from the above table 30.57 hectares' land per year would be converted into built-up, so in the next 20 years 610.17hectares of prime vegetation cover would be changed. As the trend of conversion of vegetation cover use to built-up area there would be ultimate shortage of food and there would be a trend of creation of haphazard development of built-up areas into slums. This would lead to low standard housing. The future trend in land use\land cover was calculated through following equation**:**

$$\frac{\text{Recent Year-Base Year* t}}{\text{N}}$$

Where "t" is Time interval and N is the Number of Years

Table.5. Future Pattern of Land Use Land Cover from 2015-2035

Land use Classes	AREA IN HECTARES				
	1995	2015	1995-2015	Change per year	2015-2035
Vegetation cover	3504.18	2894.01	-610.17	-30.57	-610.17
Built-up	553.75	1128.25	574.6	28.75	574.6

Source: Arc Map Analysis of Spot 2015/Landsat 1995

Findings:

In 1995 most of the area was under the Vegetation cover, 3504.18 hectares from the total area i.e. 4495.6 was under Vegetation cover. In 2015 it reduces and the area under the Vegetation cover decreases upto610.17 hectares i.e. 17.41%. From analysis it was found that the built-up area increases tremendously with the passage of time. In 1995 the built-up was553.75, hectares, in2015 it was 1128.35 hectares i.e. 103.76% increase occurred in built-up area from 1995 to2015.The changes in barren land have been also noticed during these 20 years. After analysis it was examined that in 1995 the area covered by barren land was 347.95 hectares i.e. 7.73% of the total area, but in 2015 the area covered by barren land was 368.39 hectares, the percentage of barren land which has changed was 5.87%. Water in 1995 was 89.76 hectares while in 2015 it was 109.25hectares, the total change from 1995 to 2015 was 19.49 hectares i.e. 21.71%.

Conclusion:

From the above findings it is concluded that the agriculture land is rapidly converted into built-up. The land was used for different town schemes, educational institute and for commercial purposes. As the city expands the land use pattern also changes. In this research it is found that a vast area of agriculture land is converted into built-up, there are several factors responsible for this rapid conversion of agriculture to built-up land. One of the major reason is population growth and population shift from the city core towards the suburban areas, accessibility, socio-economic factors like purchasing power parity increases, shift of education institutes, medical facilities, and new town schemes where people can get land for residential purpose on a very cheap cost as compared to the city core. As the prime agriculture land is squeezing/ shrinking at a high rate it is suggested that agriculture land should be conserved by creating counter magnets in southern part of Peshawar where agriculture is not very important. Green areas have also decreased as per findings so there must be a zone of green belt. Future trend estimated for the land use as discussed above, shows that in 2015 the decrease in vegetation cover was 610.17 hectares throughout the study period which means that 30.57-hectare land per year is converting from agriculture to built-up. which would be 610.17 hectares in 2035. Increase in built up area in the next 20 years would be 574.6 hectares i.e. 28.75 hectare per year increase in built up area. New town schemes like Sabz Ali town Warsak road Peshawar, Faisal town Warsak road Peshawar, Abshar colony etc. attracts people, if the process of converting vegetation cover to built-up by introducing new town schemes as mentioned above is continuous so in future there would be acute shortage of food. Haphazard development especially in private sectors has to be stopped by implementation of bylaws. The land should be used according to land capability classes suggested by soil survey of Pakistan.

All these results provide the information about the past and present dynamics of land use land cover change to the city planners and decision makers for better future planning.

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