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INVESTIGATING THE IMPACT OF 2010 FLOODS ON URBAN LAND USE LAND COVER CHANGE IN THE NOWSHERA CITY OF KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

The spatial and temporal pattern of Land Use Land Cover Change (LULCC) of a particular area is the expression of human-environment interaction. The important anthropogenic agents of LULC are rapid population growth and urbanization. However, several natural processes such as floods, earthquakes, desertification, etc. are also responsible for LULC. The present study utilizes the geospatial technologies to map and compute the LULC that took place in the study area resulting from 2010 floods. Landsat 5 image of 1998 with 30m resolution and 2008 image of SPOT-5 with 5m and 10m resolutions were used in this study. The analysis of the classified image of 1998 reveals that a decrease of only 1.39% in agriculture/vegetation cover was recorded in 10 years during 1998-2008. An increase of 2.7% was found for the built-up environment during 1998-2008. Similarly, an analysis of the 2018 classified image reveals a decrease of 2.22% for agriculture/vegetative during 2008-2018. This decrease is attributed to a corresponding increase in the built-up area. The built-up area shows a remarkable increase of 9.38% of the total area in 2008 and 18.05% in 2018. This study showed a rapid LULCC in Nowshera city in the last 20 years during 1998-2018. Furthermore, the present study found a strong connection between LULCC and the 2010 floods in the Kabul River where the land use land cover patterns were influenced to a greater extent by July 2010 floods. In 2008 the built-up area show increase in the area located close to river Kabul in booth Nowshera Kalan and Nowshera Cantonment. But after the 2010 floods, the extension of the built-up area is mostly on barren land in the south of the city. It is recommended that agricultural land protection must be comprised at all levels of land use plans and the farmland boundary must be identified and defined in town level land use plans.

INTRODUCTION

Urbanization is the transformation of land which occurs mainly as a result of urban rural migration (Abbas, 2016; Samat, Hasni, & Elhadary, 2011). The degree of urbanization in a country is shown by the proportion of the total people living in cities which in terms of Pakistan, have inhabitants of 5,000 or above people, which overlap with certain criteria in terms of providing basic facilities and social infrastructure base Economic etc. The population of urban regions increases more rapidly than the total population of a country due to a number of factors that mainly include migration from villages to cities (Rahim, 2007).

Urbanization will pose a threat to sustainable urban development because it involves an increase in the use of resources i.e. energy, water, land etc. which in return increases pollution and waste products. The impacts of urbanization on environment is increasing concerns among the planners and other models of urban expansion such as "smart growth" encouraged (Gabriel et al., 2006; Litman, 2014; Turner, 2007).

According to OECD (2000), Urbanization has a number of adverse impacts. The repetitive consequences are green space consumption, high infrastructure, energy costs, increased social isolation and functional distribution of land use. In addition, the need to travel and rely on a private vehicle and thus increase traffic congestion, energy consumption and pollutant emission which is associated with the expansion. Glaeser et al., (2003) analyze the effects of urbanization in the form of traffic congestion, environmental consequences, social consequences and infrastructure costs. They concluded that cars produce external impacts in the form of crowding and pollution.

Floods are frequently recurring natural and hydrological phenomena that considerably affect human lives. The flash flood hazards are important for both human settlements and economical perspectives in urban regions. Due to urbanization, regional sustainable development is threatening by flood disaster. Human encroachment more worsen the situation by increasing the risk of flood in urban areas, which requires new strategies to decrease the risk of flood (Karki et, al. 2025). Hydrological behaviour of basin is also influenced by land use by changing the local hydrological cycle (Barredo & Engelen, 2010). In many countries flood and urban expansion relationship has been examined According to Rucinska (2015) in the River Agly in the city of Marseille, France the risk of flood is increased due to eventual

change in flood discharges which concluded that in connection with recreation activities or proximity of a large city, the development of urbanization resulted in increasing flood vulnerability.

Many scholars provide the connection between urbanization and spatial elements with the addition of Geographic Information system, remote sensing and statistical tools. The integration of Geographic information system and remote sensing approaches to urbanization should also be seen as an essential step in the expansion analysis. Remote sensing has the capability to provide consistent datasets which covers large areas with enormous details and time frequency. In 1990 the high-resolution satellite imagery was available to study urban expansion. Some research has been done on using remote sensing and GIS to measure and monitor urban sprawl (Gielen et al., 2018; Jain, 2002; Lowry & Lowry, 2014; Mohd Noor et al., 2018; Norzailawati Mohd Noor & Hashim, 2009; Terzi & Kaya, 2018; Weng, 2002; Zeng et al., 2015).

Floods are the most dangerous and disastrous natural phenomena in the world that cause injuries, loss of human life, material damage, communication line and infrastructure. (Khan et al., 2013) used a GIS-based approach for the identification of flood-affected areas and preparing a map to show the affected areas and rescue those affected people.

Recently, estimating the effects of flood risks and developing GIS-based flood maps has been a critical issue. (Sagala, 2006) carried out a comprehensive study on the vulnerability to find out the risks of physical flooding especially damage to buildings in a residential area dependent on mobile GIS. Similarly, remote sensing can play a major role in in risk assessment and management, particularly when several factors are present at the same time, such as natural disasters and urbanization, covering very sensitive areas. In this context, multi temporal analysis can provide decision makers with the tools and information needed to reduce the impacts of disasters (such as floods) and promote sustainable development. (Hussain et al., 2021).

Land Use Land Cover Change (LULCC) can be the result of land conversion from one land use land cover type to another or modification of LULC or even can occur as a result of land maintenance (Briassoulis, 2004). The LULCC analysis studies are mainly carried out to determine the causes/driver or agent of change or to assess the environmental and socio-economic impact of these changes. This study aims to

assess the LULCC of Nowshera city with special emphasis on the impact of the 2010 floods in the Kabul river.

STUDY AREA

Nowshera is one of the most peaceful and fertile region, which is located in Khyber Pakhtunkhwa, consisting of three military cantonments i.e. Nowshera Contonment, Cherat Contonment and Risalpur Contonment. It is one of the largest cities of the province. It is located on GT Road, 27 miles east of Peshawar (GoP, 2017). Nowshera city is situated on the bank of Kabul river, covering an area of about 1748 km^2 with two administrative parts i.e. Nowshera Tehsil and Pabbi Tehsil (Shah et al., 2018). In the West of this region lies Peshawar, Mardan to the North, to the Northwest is Charsadda, to the Northeast is Swabi, Kohat to its South, to the southwest is Orakzae agency and to the East is Attock (GoP, 1999).

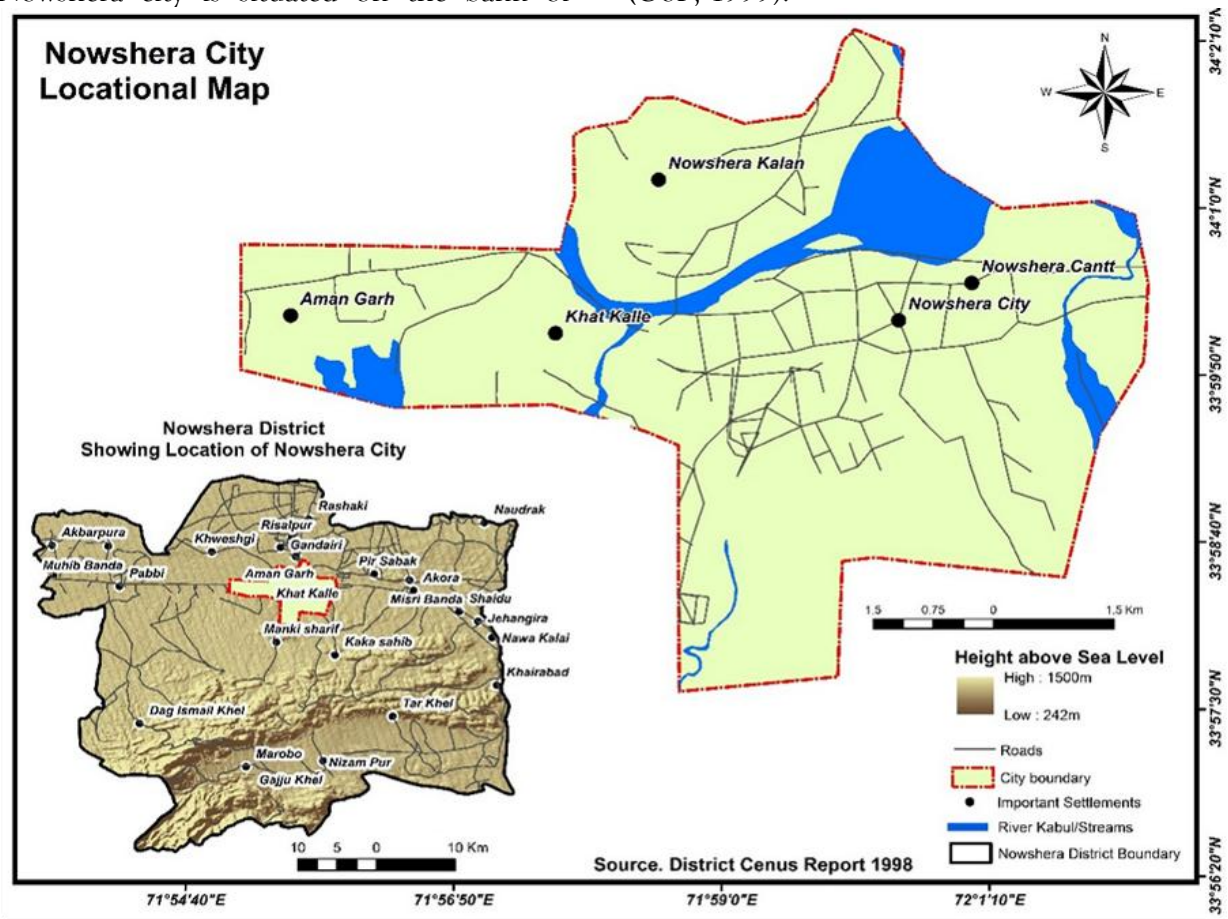

FIGURE 1: LOCATION MAP OF THE STUDY AREA AS DERIVED FROM DISTRICT CENSUS REPORT 1998

The terrain of study area is even and uniform with fertile and productive soil due to the depositional work of river Kabul. Therefore, the impact of the river is dominant in

shaping the landscape of this area. (GoP, 1999).

The climate of Nowshera is continental type with cold winters and hot summers. The Monsoon rainy season and winter spring-rainy season are the most prominent rainy seasons in the study area, which receives 50.8 mm and 18.2 mm rainfall but an unprecedented rainfall was recorded in the month of July, 2010, which was 20 times more than normal rainfall causing the destructive and disastrous flood (Mustafa and Wrathal, 2011).

Kabul and Indus are the two main rivers in the study area. There are two perennial streams namely Kalpani River and Bara River and many dry streams or "Khwars" which is the main cause for such large-scale devastation in the rainy season. According to the 2017 census, the population of district Nowshera was 1,518,540 which was 874,000 in 1998. The population density is 608 persons per square kilometre.

MATERIAL AND METHODS

To assess the impact of land use land cover change on land value, GPS waypoints were collected along with the land value in various periods. The data collected was retrieved in the ArcMap environment and displayed as an event layer which was subsequently saved as a point map. The point map was then interpolated to create various land value zones for both 1998, 2008, and 2018 and later the map showing the change in land value from 1998 to 2018 is created. This procedure is shown in figure 2.

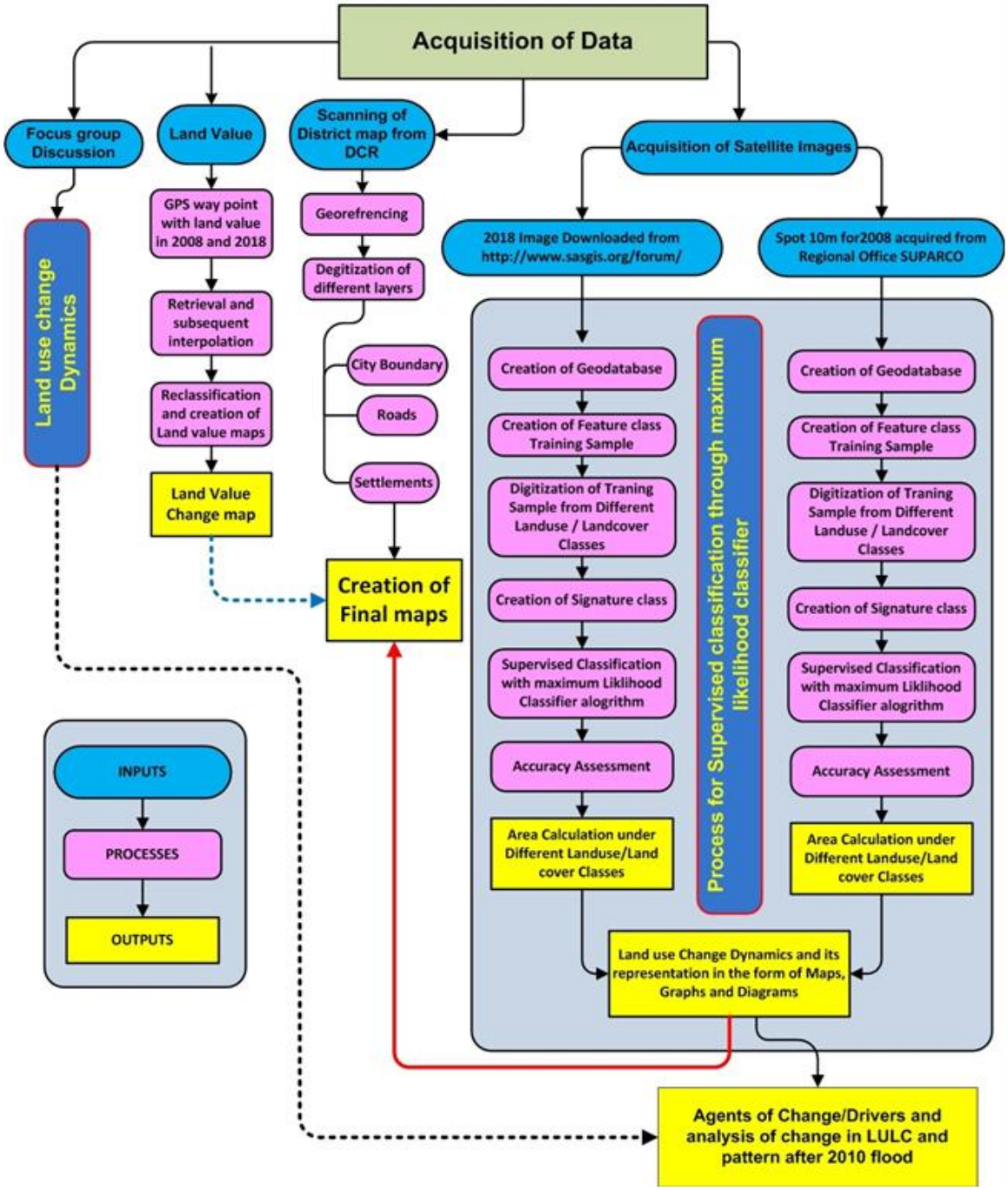

FIGURE 2: METHODOLOGICAL FLOWCHART

PRIMARY DATA COLLECTION

To determine the land value, urbanization trend, and associated problems, Focused Group Discussion (FGDs) has been conducted with urban authorities, politicians, estate agents, District revenue Office and elder people residing in the study area. Five sessions were conducted in which 10 peoples have been selected from the above-mentioned authorities. For this purpose, a formal list of questions in the form of a short questionnaire was designed and data

collected through focus group discussion has been compiled in the form of qualitative/quantitative figures, tables and were shown on maps and graphs. Besides, detailed interviews have been conducted with heads of line agencies to know about policies of the government about urban sprawl and their consequences. Data about land value is collected from the field through real estate agents and GPS way points.

SECONDARY DATA COLLECTION

The current study is mainly based on remotely sensed data obtained from various sources. The Landsat 5 image for 1998 with 30m resolution, 2008 SPOT-5 image with 10m resolution was acquired from SUPARCO, and the image of 2018 with the 5-meter resolution was acquired from SAS planet for Bing satellite.

Maps of Nowshera city were obtained from Nowshera Municipal Committee and Cantonment Board Nowshera. Population data has been collected from the District Census Report of District Nowshera for various years.

LULCC ANALYSIS

To distinguish the geographical distribution of built-up land expansion, the raster images were classified with the help of supervised maximum likelihood classification method using generated training samples. The images were classified into four major land-use classes including Agriculture/Vegetation, Built up Area, Barren Land/Open Spaces and Water Body/River classes.

Several methodologies are available to determine the percentage of annual land use land cover changes. However, in this study, the Single Land Use Dynamic Degree (SLUDD) of Quan et al., (2015) is used to compute and evaluate the percentage annual change in various land use land cover classes.

RESULTS AND ANALYSIS

The analysis reveals that agriculture and vegetative area account for 1430.08 hectares (28.69% of the total area of Nowshera city). Most of the agricultural area was concentrated along the Kabul River which passes through the middle of the city. The areas include parts of Pir Sabak and Nowshera Kalan etc.

The barren land/ open spaces were mostly located toward the south of the city in the form of undulating bad land topography and cover more than half of the city area. The analysis suggests that the area under barren land/open spaces accounts for 2867.35 hectares (57.53 % of the total area).

The built-up area in 1998 was only 332.87 hectares (6.68 % of total area). The built-up area was mostly concentrated along river Kabul from Amangarh, Khat Kilay Nowshera,

and Nowshera Kalan. The image analysis reveals lots of open spaces within the built-up area in Nowshera Kalan and Nowshera as well. Besides the area along river Kabul used to be a high-class residential area and land value was high too because of water front.

The area occupies by river Kabal and part of the river Kalpani course was 354.22 hectares (7.11% of total area).

TABLE 1: AREA AND PERCENTAGE UNDER VARIOUS LULC CLASSES IN 1998

Land use Land Cover Classes	Area in Hectare	Percentage of Total Area
Agriculture/Vegetation	1430.08	28.69
Built Up Area	332.87	6.68
Barren Land/Open Spaces	2867.35	57.53
Water Body/River	354.22	7.1
Total	**4984.52**	**100**

The agricultural land and vegetation cover account for 1359.9 acres (27.30 % of the city area compared to 28.69% in 1998). A decrease of only 1.39% in agriculture /vegetation cover was recorded in 10 years i.e. 1998-2008. Almost the same results were recorded for barren land and open spaces. The barren land and open spaces in 2008 covered an area of 2794.64 hectares (56.09 % of the total area), compared to 2867.35 (57.53% of total city area). A total decrease of 1.44 % took place from 1998 to 2008. The area under water bodies which were Kabul River and Kalpani River remain almost the same. 1n 2008 the area under the course of these rivers was 360.12 hectares (7.23% of the city area), compared to 254.22 (7.11 % of the total area).

As for as the area under built environment is concerned it record a gradual increase from 1998 to 2008. In 2008 the area under the built-up environment was 467.38 hectares (9.38 % of total area) compared to 332.87 hectares (6.68 % of total area). A net increase of 2.7 % during 1998 to 2008-time period. The net increase in a built-up area is mainly attributed to an increase in population from 1998 to 2008. Table 2 shows the estimated population of 2008 for Nowshera city including cantonment and other important localities within Nowshera city at a growth rate of 1.5% per year (1998-2017).

TABLE 2: AREA AND PERCENTAGE UNDER VARIOUS LCLC CLASSES IN 2008

Land use Land Cover Classes	Area in Hectare	Percentage of Total Area
Agriculture/Vegetation	1359.9	27.30

Built Up Area	467.38	9.38
Barren Land/Open Spaces	2794.64	56.09
Water Body/River	360.12	7.23
Total	**4982.04**	**100**

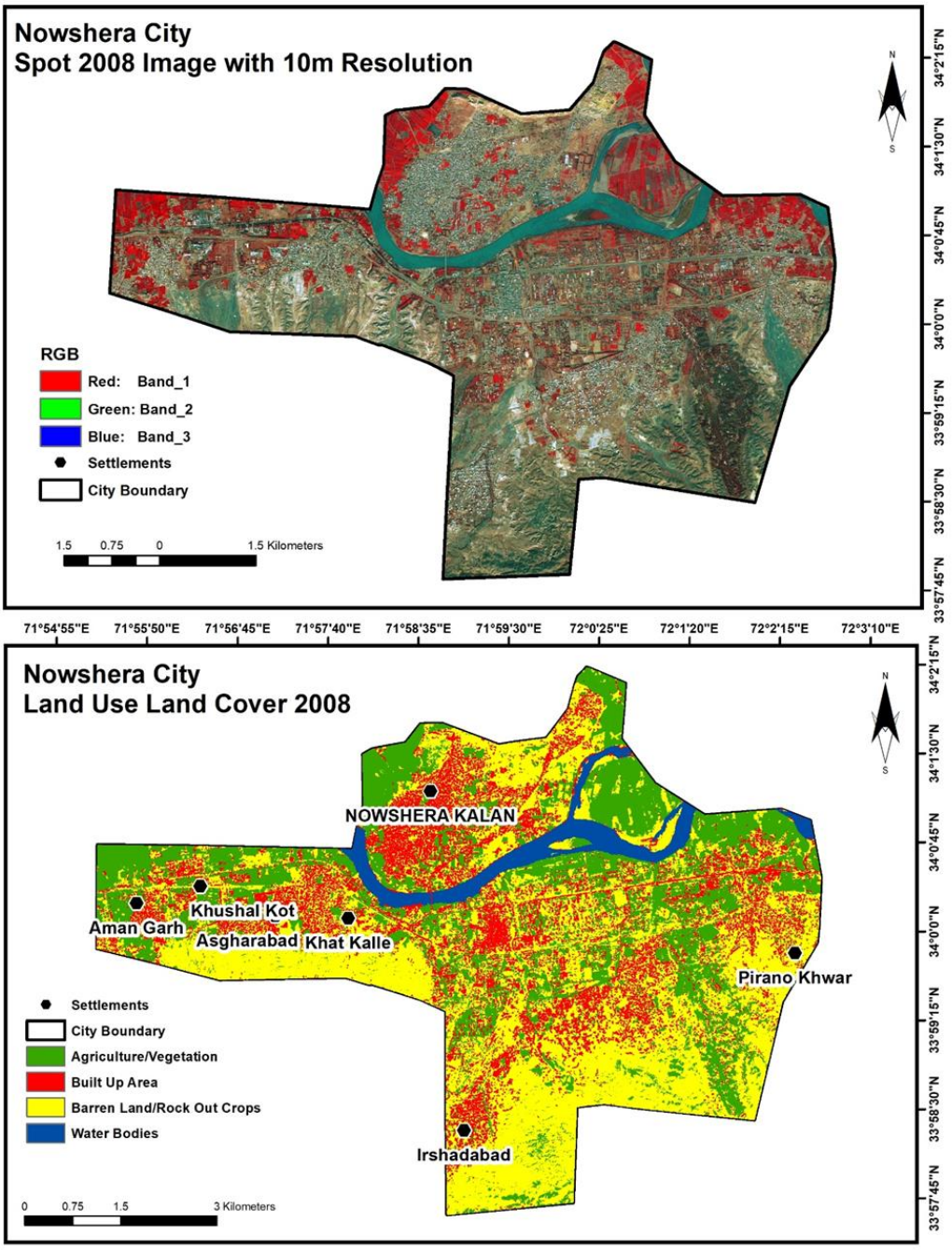

FIGURE 3: VARIOUS LULC IN 2008 (A) SPOT 5 IMAGE (B) SPOT 5 CLASSIFIED IMAGE

Table 3 summarise the analysis results of classification carried out on satellite image downloaded from the SAS website with 10-meter resolution. The analysis results are shown graphically in figure 4.7, while the spatial distribution of various land use land cover classes is shown in Figures 4.8 and 4.9.

The analysis reveals that the agriculture /vegetative area accounts for 1325.48 (26.59% of total city area). The comparison with the agriculture /vegetative area of 2008 reveals that the area under class shows a decrease of 0.7% during 2008-2018. This decrease is attributed to a corresponding increase in the built-up area. The decrease was mainly taking place in areas like Badrashi, Khat Kilay, Dheri Katti khil area, besides some decrease in the vegetative area also observed in the periphery of Nowshera Kalan.

In contrast, the Built-up area shows a remarkable increase from 9.38% of the total area in 2008 to 17.69% in 2018. The Built-up area accounts for 882.11 hectares (17.69 % of total city area) in 2018, which was only 467.38 hectares in 2008. This increase in the built-up area has taken place in agriculture / vegetative areas and open spaces. The increase is mainly observed in the two planned areas of Nowshera city i.e. ASC colony and Armour Colony. In the 2008 image (figure 4.5), the open spaces can be easily seen in contrast to congested built-up areas in 2018 (figure 4.8).

The open spaces account for 2410.02 hectares (48.34% of the city area), in comparison to 2794.64 hectares (56.09 % of the total area) in 2008. The extraordinary decrease is the result of the fast increase in the built-up area during the same period. These open spaces can be seen in a satellite image of 2008 which become built up in 2018 (figure 4.8).

The area under water bodies i.e. river Kabul and Kalpani show an increase of 7 hectares which may be the result of the 2010 flood in Kabul river, which cause the river channel to widen at places.

TABLE 3: AREA AND PERCENTAGE UNDER VARIOUS LCLC CLASSES IN 2018

Land use Land Cover Classes	Area in Hectare	Percentage of Total Area
Agriculture/Vegetation	1325.48	26.59
Built Up Area	882.11	17.69
Barren Land/Open Spaces	2410.02	48.34
Water Body/River	367.23	7.38
Total	**4984.84**	**100**

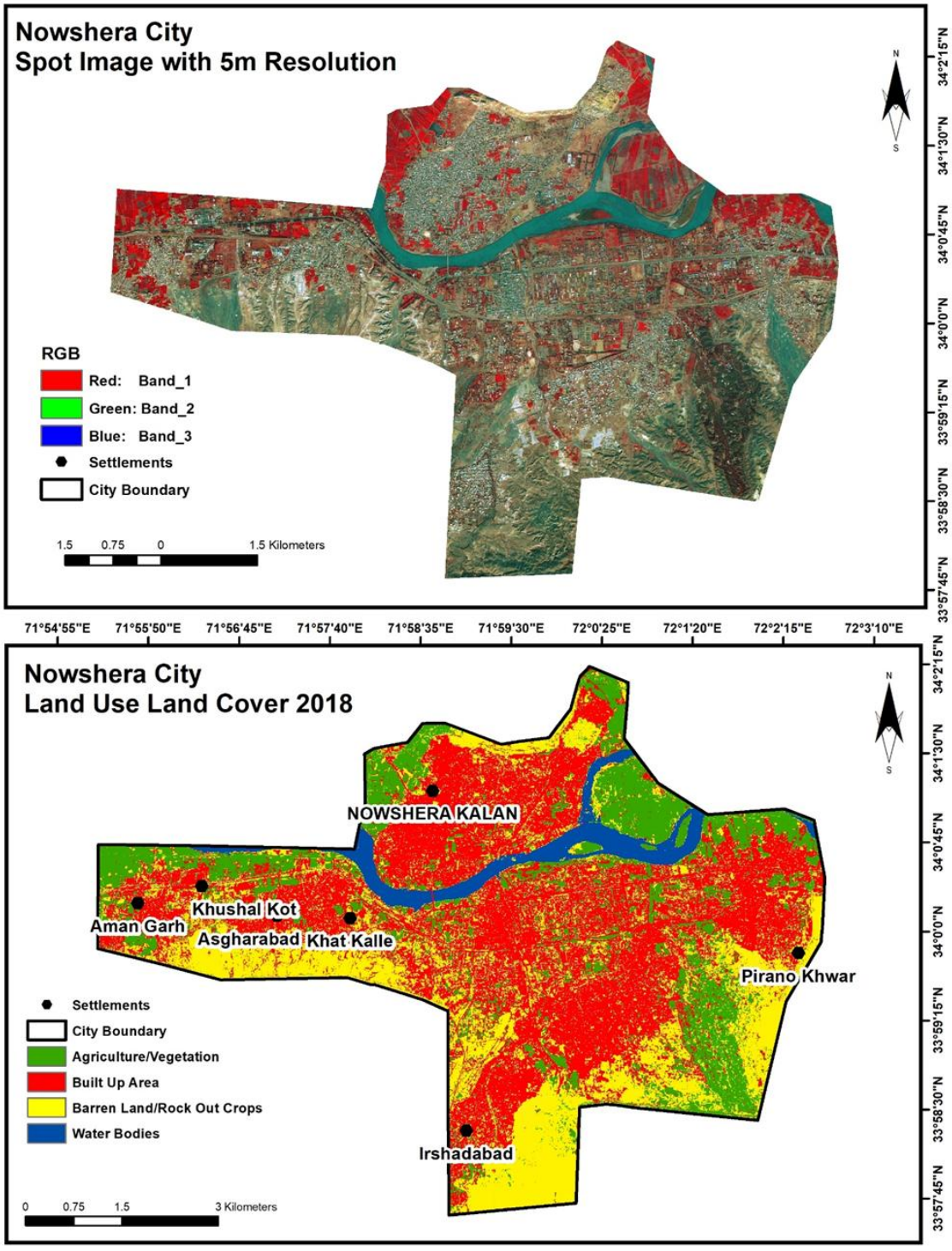

FIGURE 4: VARIOUS LULC IN 2018 (A) SPOT 5 IMAGE (B) SPOT 5 CLASSIFIED IMAGE

DISCUSSIONS

The study aims to determine the spatial and temporal land-use changes between the 2008 -2018 periods and to investigate the impact of the 2010 floods on land use patterns and land values in the study area. The 1998

image of Landsat 5 was also analysed to determine the change which took place from 1998 to 2008. The temporal analysis of satellite images reveals an increase in the built-up area with a corresponding decrease in agricultural land/vegetation and open spaces.

TABLE 4: AREA AND PERCENTAGE UNDER VARIOUS LCLC CLASSES IN 1998, 2008 AND 2018

Land Use Land Cover Classes	1998		2008		2018	
	Area in Hectare	%age of Total Area	Area in Hectare	%age of Total Area	Area in Hectare	%age of Total Area
Agriculture/Vegetation	1430.08	28.69	1359.9	27.30	1325.48	26.59
Built Up Area	332.87	6.68	467.38	9.38	882.11	17.69
Barren Land/Open Spaces	2867.35	57.53	2794.64	56.09	2410.02	48.34
Water Body/River	354.22	7.1	360.12	7.23	367.23	7.38
	4984.52	**100**	**4982.04**	**100**	**4984.84**	**100**

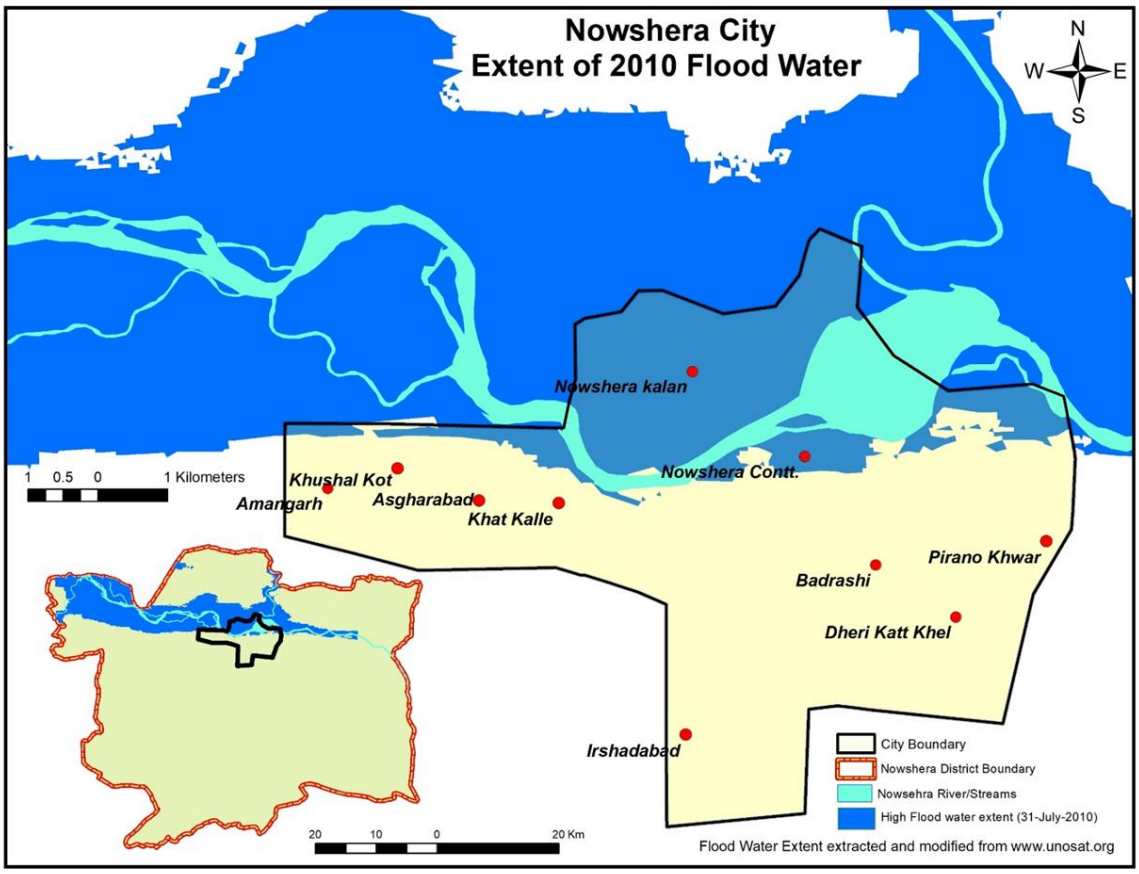

FIGURE 5: FLOODED AREA OF NOWSHERA CITY DURING JULY 2010 FLOODS

Because of the fear of the flood the new construction and extension of the built-up area took place on the higher ground located in the south of the city mostly in two colonies i.e. ASC colony and Armour colony. Figure 4.16 shows the Armour colony in both 2008 and 2018 images. The analysis reveals that there were wide open spaces between built-up areas which were converted into the built-up area in 2018.

Similarly, figure 4.17 shows the comparison of the Khat Kilay and Ashoreabad areas. In the 2008 image, there are open spaces that were eliminated in 2018. It also reveals the agricultural land in 2008 which is converted to built-up in 2018. Similarly, figure 4.18 shows the comparison of the Dheri Kati khel area. The analysis reveals that in the 2008 image there was a huge torrent namely Pirano torrent (khwar), which is converted into a built-up area in 2018.

Plate 4.1. Showing the undulation Bad Lands topography on Nowshera Kaka Sahib road, which is level down for the development into residential colony soon. Figure 4.19 shows the comparison of the area along the riverside which was agricultural in 2008 and converted to the built-up area in

2018. Besides the city witnessed, a mushroom growth of new colonies in the southern part of the city Figure 4.20 shows the development of a new colony close to the ASC colony. Figure 4.21. shows the 2008 image which reveals that the open spaces were converted into the built-up area and the development of the Gulberg model town.in the year 2018. Similarly, Plate 4.2 shows the newly developed Gulberg model city Nowshera city. The area was covered by undulating badland topography in 2008. Which is leveled for a new housing colony. And today the piece of the plot is between PKRs 4 to 4.5 million/Kanal (0.123 acres). Plate 4.3 is showing the glimpses of Gulberg model town Manki road Nowshera, the plot price is PKRs 2.0 million /Kanal (0.123 acres).

Photograph 4.4. Shows some glimpses of Paradise city Nowshera. The township started earlier but after the 2010 flood in Nowshera its starts development and today it's one of the fast-developing residential projects of Nowshera city. The price of the plot is PKRs. 2 million /Kanal (0.123 acres). Plate 4.5 showing some glimpses of New city Nowshera city. The town is started recently on Nowshera Kaka Sahib road and is developing fast, the price of the plot is PKRs 2.4 million /Kanal (0.123 acres).

The above discussion reveals that after the 2010 flood the land use pattern was completely changed and the new extension in the built-up area is mostly taking place in the south of the city on barren land. The area is safe from the flood and the developers are using this slogan to attract customers.

These newly established towns in the surrounding of Nowshera city are the result of the July 2010 flood in Kabul River. These newly established towns were barren lands, undulating badland topographies of no value even was not fit for cultivation but today on average the price of land per Kanal (0.123 acres) is more PKRs 2.5 million.

The prompt effect of riverine flooding is the loss of human life, damage to properties and infrastructure, etc. The damage caused to infrastructure causes long-term unavailability of clean drinking water, disruption of education and health facilities. The loss of livelihoods can reduce the purchasing power which ultimately causes the reduction in land value in the vicinity of rivers.

Besides the excess toll of relocation and rehabilitation can induce continuing tension and stress. The stress of overcoming these losses can be overwhelming and produce lasting psychological impacts (Khan, 2005). The July 2010 flood disaster in Nowshera city disrupt the smooth functioning of the

system because of the destruction of public utilities that caused fear and uncertainties among the public. The field survey and discussions with locals reveal that people still fear the flood. The majority of the respondents believed that if they were given the chance they would like to dislocate.

In Nowshera city, the Nowshera cantonment and Nowshera Saddar used to a high-class residential area with very high land value before the 2010 flood in Kabul river. The price of Kanal of land used to ranging from 2 to 3 million PKRs. The Saddar area is still the hub of economic activities. During the 2010 flood, almost all the cantonment and Saddar area were under up to 08 ft. of water for several days. After the flood even today the price is still almost the same. On the other hand, the area in the south of the city which was barren undulating and people use to go for hunting was slowly and gradually developed only because it located 100-200 meters above the present day bed of river Kabul and is located away from the fear of flooding.

The land developers used the slogan "live away from the danger of river". The land value in newly develop New city, Paradise city, Gulberg model town is hiking up fast. The land value in these areas is well above 5 million PKRs.

Figure 4.23 is showing the property value zone map of the study area for 2008 (before the 2010 flood). The analysis reveals that high-value property is mostly concentrated along both sides of the river in the Cantonment and Saddar area and on the other side of the Nowshera Kalan area. While the suburb and peripheral areas of the city. Even the first planned area of Nowshera city i.e. ASC colony and Armour colony were not densely populated. It can see in Figures 4.16 and 4.20.

Similarly, figure 4.24 is showing the property value zone map of 2018. The analysis reveals that the high-value property is concentrated in the South, peripheral areas of Nowshera city. The area was uninhabited and mostly constitutes low hilly areas with acacia species. After the 2010 flood in Nowshera district in general and Nowshera city in particular the pattern of land use development started toward the south and mushroom growth of housing colonies started and today its high-class residential area. The property value is ranging from 4 to 5 million PKRs /Kanal in some of the cities (Zammen.com, 2019).

CONCLUSION

The present study aimed to analyse the spatial and temporal LULC change in Nowshera city during 2008-2018, and determine the driving forces with special

emphasis on the impact of the July 2010 flood on land use pattern and land value.

Among all the anthropogenic activities, land use land cover change resulting in alteration of land cover is the most irreversible. In the last couple of decades' urban areas have expanded at an alarming rate. Human has changed the natural landscape for the construction of multi-story buildings, provision of drainage, sewage system, and other infrastructure. These changes in natural landscape contribute to environmental degradation both in urban and rural areas.

Urbanization is randomly continued and in the absence of proper and appropriate planning, the urban areas in developing communities are facing many problems in housing, education, health, transportation, etc. besides environmental degradation.

The present study observed rapid changes in land use in the land cover of the study area Nowshera city in the last 20 years from 1998-2018. The study noticed an accelerated transformation in the built-up area at the expanse of a decrease in agriculture / vegetative area and open spaces. The main driving force behind this accelerated growth of the built-up area is the increasing population resulting from both natural growth and migration. The built-up area increased at the rate of 4.04% per annum during 1998-2008, and 6.7% per annum during 2008-2018, suggesting faster conversion during the 2008-2018 period.

The present study finds a strong connection between land use land cover change and the 2010 flood in the Kabul river. The land use land cover pattern is seem influenced to a greater extent by July 2010 flood. Riverine flood is a recurrent phenomenon in Nowshera District especially in Nowshera city and Nowshera Kalan. The torrential rainfall in Upper Khyber Pakhtunkhwa generated unprecedented flood peaks in the Swat River. In Nowshera city, a high flood peak caused severe damage. A total of nineteen union councils of district Nowshera were affected. In Nowshera, city flooding caused damage to property and infrastructure. Roads, water supply, sewerage, and drainage systems were disrupted. Nowshera was among one of the most affected districts. Almost half of the Nowshera city was under 8-10 feet of water.

The south, South Eastern and South Western part of the study area is highly dissected and undulating barren land. Most of the area is 100 to 150 meters above the present-day bed of River Kabul. After the flood, the pace of development accelerated toward the South and the development of

several housing colonies and societies started immediately after the flood. And today the land value in these newly developed towns is among the highest in the study area. The study found that the land value in those areas was only a couple of hundred thousand but today it's in millions. The highest recorded in Paradise city 4.5 to 6 million per Kanal (0.123 acres).

The field survey suggests that the present trend may be continued in the future, and the majority of respondents in the close vicinity of river Kabul, which used to one the high-class residential area because of the closeness to the river want to move to the higher ground. The inhabitant still remembers and fears the 2010 flood. This fear is cashed by the new developers and their most important slogan is "come and live away from river Kabul Flood".

The study concludes that the adopted methodology is highly valuable and appropriate for change detection studies. The study suggests and encourages such studies in other urban areas as well, as such studies provide valuable data for land-use planners and urban developers.

RECOMMENDATIONS

It is recommended that agricultural land protection must be comprised at all levels of land use plans and the farmland boundary must be indicated and defined in both country and town level land use plans. Just like China, the conversion of prime agricultural land must be approved by the town or state council.

The study recommends and encourages such studies in other urban areas as well, as such studies provide valuable data for land-use planners and urban developers.

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