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Assessment of Temporal Changes in Gilgit City using Multisource Datasets: Way forward up to 2030

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Urbanization has become a hot issue in context of environmental and socio-political scenarios which has become a point of discussion at every forum globally. The aims of this research was to detect the changes in land use and land cover in Gilgit city by using remotely sensed data. Comparative and temporal analysis was done to detect the changes in built-up area, vegetation cover, water bodies and barren land from year 2003 to 2020 by taking satellite images of the year 2003, 2013 and 2020 the result of overall changes in area for the three classes: build up land, vegetation cover and barren land. From the year 2003 built up land was 3.37 sq.km, water body was 4.01 sq.km, vegetation cover 19.83 sq.km and barren land was 25.37 sq.km. A significant change was observed in area of these classes in 2013, where an increase in builtup was observed up to9 sq.km and water body covered 4.01 sq.km which was almost constant as compared to 2003 while vegetation cover declined to 19.43 sq.km and the barren land was also declined to 20.33 sq.km. The time span from 2013 to 2020 shows a change in buildup land which was observed increased by17 sq.km.

Keywords:
LULC, temporal analysis of Gilgit city, Landuse classes in Gilgit, Landcover

Introduction

On the global scale, the impact of changes made on land can be better understood by examining the factors effecting Land Use and Land Cover (LULC). Urbanization has become a hot issue in context of environmental and socio-political scenarios which has become a point of discussion at every forum globally [1] The population growth with passage of time exert pressure on the landscape as it requires multiple factors e.g., resources like water, food, shelter, and power source need to be fulfilled. The social and economic factors mostly determine how land is utilized regionally.[2]

It is necessary to know the contrast between LULC which refers to determine how land is being utilized by humans. Typical example of land use includes emergence of new buildings, parks, air ports, golf courses and athletic fields. On the other hand, Land cover represent the natural features on the earth's surface e.g., vegetation, waterbody and snow etc [3]. The current status of LULC of an area actually represents the socio – economic factors over time and space. Hence, data on LULC is required for the arranging, selection and enforcement of land use policies to fulfill the emerging needs for basic human requirements. In the ancient times, surveys were conducted to monitor the changes in landuse which was a time taking and cost-effective process which has now become obsolete with emergence of new technologies. In the current time, spatiotemporal patterns of land use are drawn by remotely sensed data which provide the comprehensive detail. In this study remotely sensed data was used because of its effectiveness in evaluating the changes in land cover and land use. Visual interpretation of Ariel photographs provides valuable information in depth.[4]

Before evolution of computer-based technologies, LULC changes were noticed with the help of simple surveys by drawing them on paper and using topographic sheets. Extraction of detailed information at large scale is tricky and difficult to perform. Standard methods used in ancient period for land use mapping were laborious and time consuming however, with invention of geographical information system and satellite remote sensing techniques we are able to generate exact LULC maps [5]

There are basic two types of classifications, supervised and unsupervised. In this research supervised classification was used which take specified number of classes/pre-defined trainy samples and detailed analysis is performed. [6] [7].

The fact that homo-sapiens are the major correspondent to these changes and are the also experiencing the result of these changes, it is necessary to know the phenomena of interaction between man and its environment. This need becomes more imperious as changes in land use is more touching the maintenances of societies [8]

Land cover can be affected by both the degradation/overflow of water in case of a dry season or surplus of rainfall respectively, while the permeability of land cover can disturb the rates of evaporation. Land cover determines the regulation of water which drifts both above and below the ground e.g., vegetation can reduce the rate of soil erosion because the root network increases its grip on the ground and don't let the soil to displace with water [8][9].

Land cover change and other industrial emissions are contributing in making significant changes to climate change and industries produce maximum toxic gases in sunshine hours[10] The Kyoto Protocol in United Nations Framework Convention on Climate Change (UNFCCC) explained various anthropogenic activities and their role in altering the climate.

The discharge of various poisonous gasses is becoming a main reason of degradation in vegetation cover e.g., acidic rainfall cause to burns the leaves, which leads to alter the overall face of a region. The increasing number of vehicles have added greenhouse gasses and Chloro Fluro Carbons (CFCs) in the atmosphere which absorb the outgoing long wave radiations that

contribute to increase the city temp [11]. Economic development and speedily growing urbanization have boosted up the energy demands by 30% in last two decades [12]. The burning of fossil fuels indicates the release of greenhouse gases into the atmosphere [13]. The removal of vegetal cover from urban areas cause the solar radiations to approach earth's surface directly which result to an abrupt increase in urban temperatures in comparison to its surroundings [14]. Most of the terrestrial biosphere is being changed by a rapid change in human's populations which resulted in such changes that cause a number of new ecological shapes which has been prominent for more than eight thousand years[15].

The availability of archive remotely sensed datasets provides an opportunity to evaluate significant temporal changes in trend mapping. A research was conducted in Delhi for analyzing the changes in LULC using datasets of previous 15 years. This research was conducted to assess the district-wise changes using LISS -III imageries of 2008 and 2012 year. Supervised classification was performed in ERDAS imagine which resulted in remarkable changes to landusedue to massive migrations of masses from outskirts toward urban centers. This study reveals that there is an increase in built up land by 1.8% on the other hand agriculture land was declined by 4.5% but water body is showing a constant state during this time span[16].

LULC maps were produced of Shijiazhuang for the years 1993, 2003 and 2009 to monitor the possible changes in agriculture. For this purpose, three multi-temporal satellite images of the above-mentioned years were used. The rapid urbanization and the population growth, have increased the demands of fresh water to manage various tasks from domestic to industrial scales[18]. Major landuse classes e.g., vegetation, soil and water were examined by using various well renowned indices including Normalized Difference Vegetation Index (NDVI), Normalized Difference Builtup Index (NBVI) and Normalized Difference Water Index (NDWI) respectively. Cellular automata Markov was used to detect over all change in the classified image. The results show more than 85% accuracy in classification with considerable and alarming rate of change in urban population pointing toward various alarming issues to be faced in future e.g., famine, water scarcity, law and order and polluted environment[19]

The main objective of this research was to analyze the changes in LULC of Gilgit city using remote sensing and GIS. It also aim at investigating the spatiotemporal trends of urban sprawl by providing a way forward upto 2030.

Material and Methods.

Investigation site.

This research was conducted in "Gilgit city". The city is located in a broad valley near the junction of the Gilgit and Hunza River. Itis located at a spatial location 35° 55' 0" N, 74° 17' 49" E". The total area covered by Gilgit city is 4208 km^2 and it is elevated at 1600 to 3000 meter above sea level. The city is mostly consist of hilly terrain which receive surplus of rainfall. The spatial extent of study site is shown in Figure 1

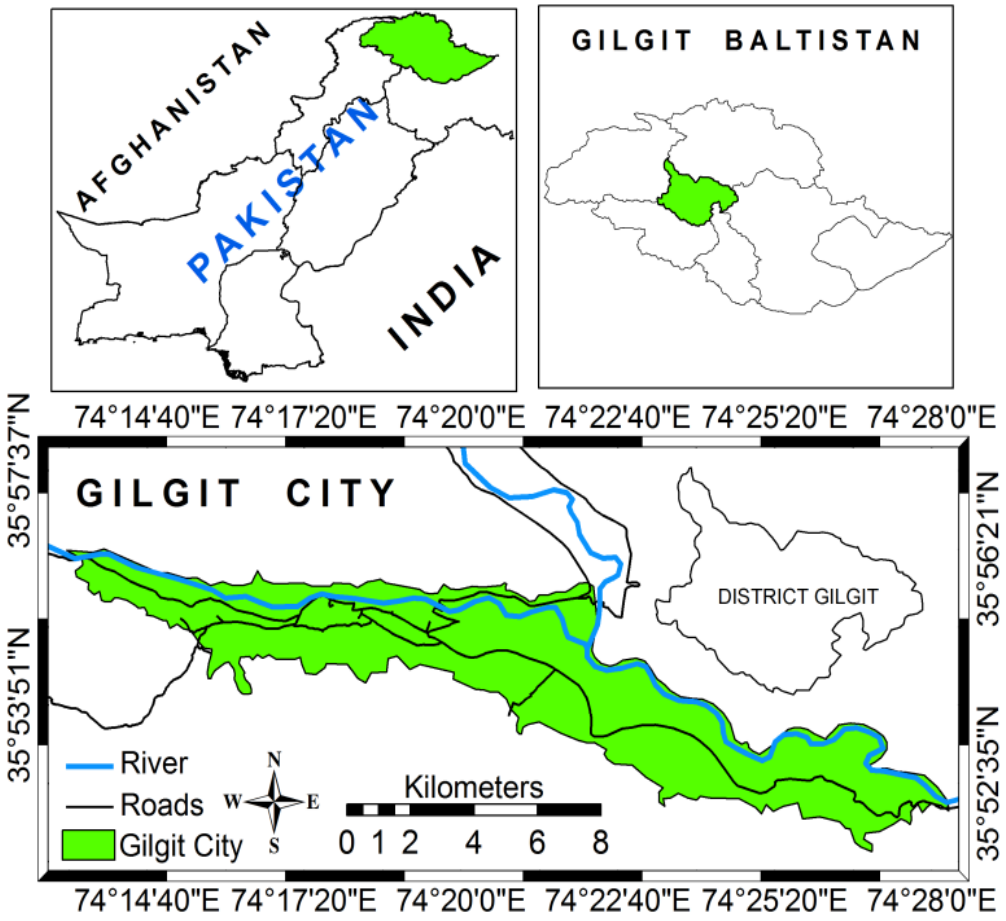

Figure 1. Spatial extent of study site.

Material and methods.

The flow of study followed in this research is shown in figure 2, This research was conducted on the basis of primary dataset in form of ground surveys, real time photographs of various key sites and personal interviews with the locals using questionnaire-based survey. The secondary data used in this research was comprised of the rate of population growth collected from Election commission office of Gilgit-Baltistan. Flora and fauna related data was collected from Karakorum International University (KIU).

In this research three, satellite-based datasets of Landsat and Sentinel-2 have been downloaded from United States Geological Survey (USGS) website. The years selected to download these datasets were 2003, 2013 and 2020 of Landsat7, Landsat8 and Sentinel-2. The area was mainly classified into four major classes including built-up land, vegetation comer, barren land and water body.

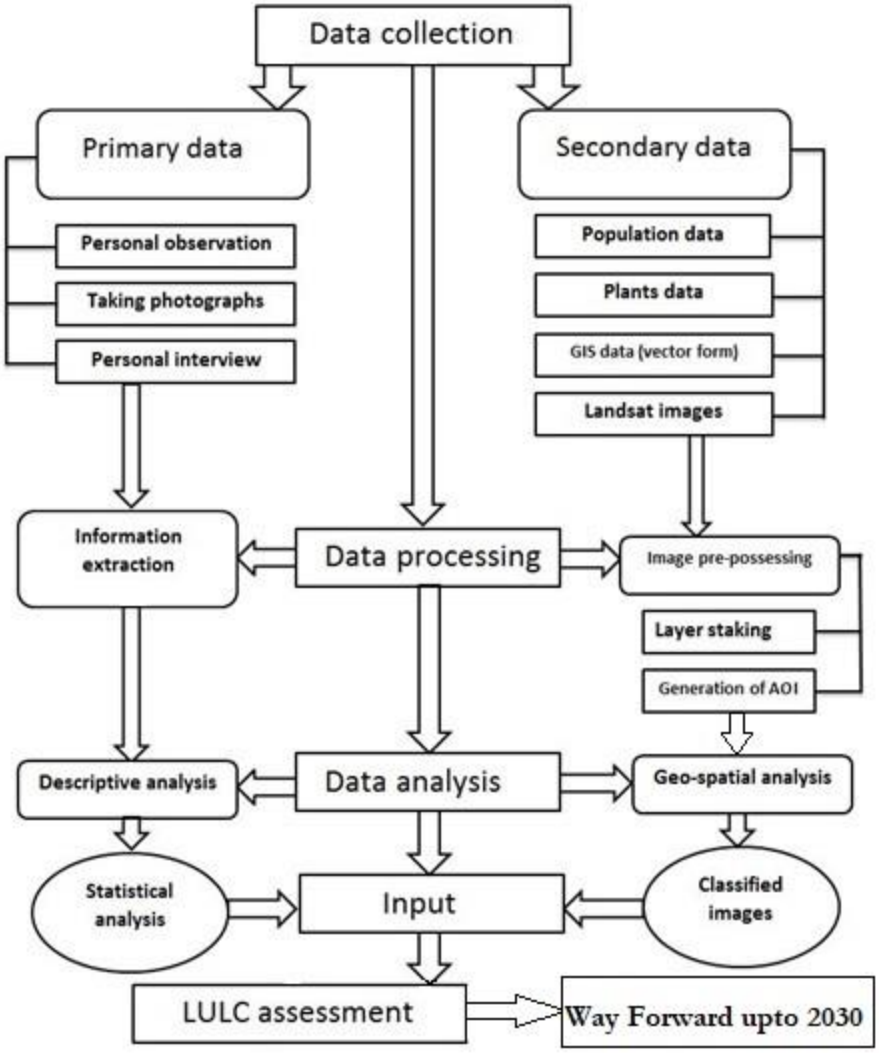

Figure 2. Flow of study

Results and discussion.

Classified Images of 2003, 2013 and 2020

The classification results of satellite image of year 2003 are mapped in Figure 3(a). The results determine that about 52.63 km^2 area was under observation which was comprised of 25.35 km^2 barren land, 4.01km^2 water body, 19.88 km^2 vegetation and 3.37km^2 built up land.

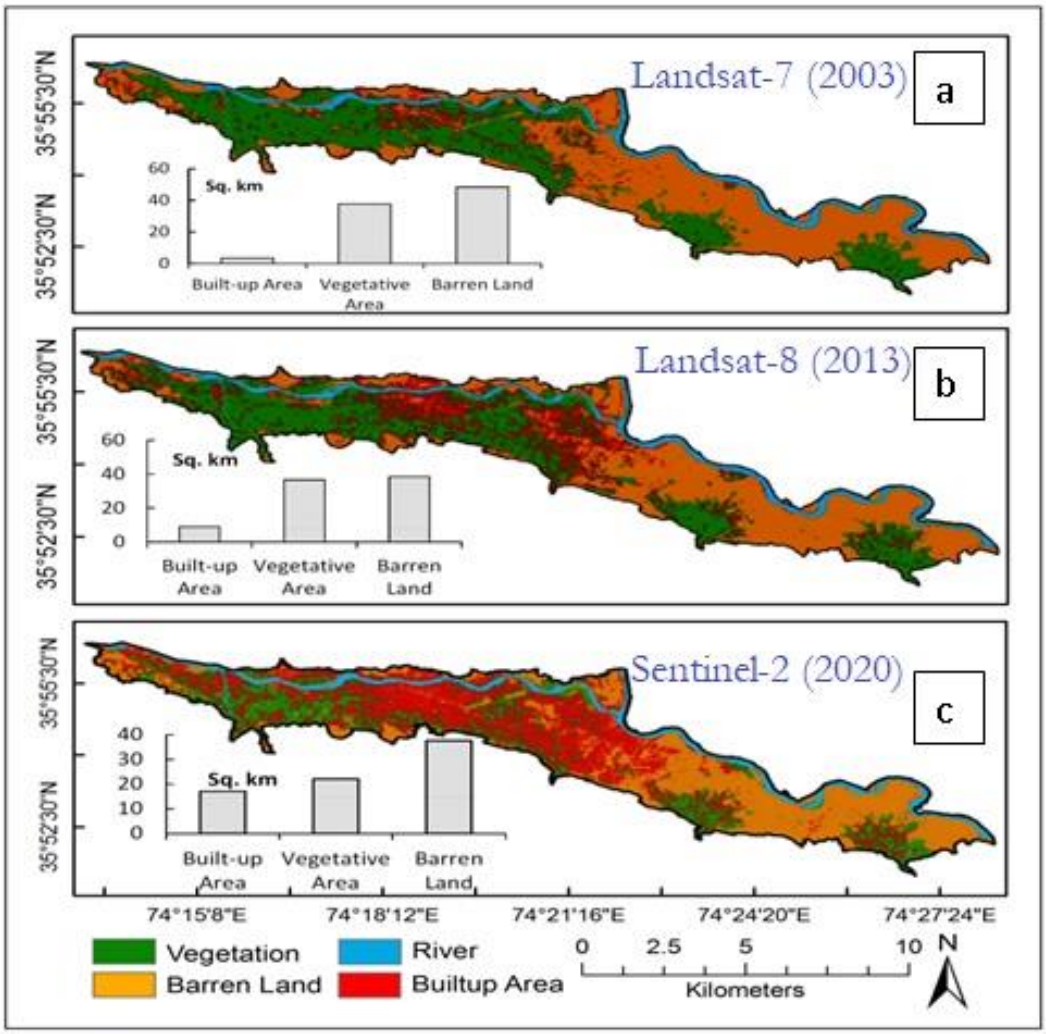

Figure 3. Classification results of Landsat-7(2003), Landsat-8 (2013) and Sentinel-2 (2020) satellite images.

The supervised classification results of image 2013 was mapped in Figure 3(b) which show that barren land was declined to 20.33 km^2 in comparison to 25.37 km^2that was in 2003. Vegetation was observed almost intact as compared to the year 2003 which was about 19.43 km^2 whereas the area under water body and the buildup land were estimated as 4 and 9 km^2respectively.

The results of supervised classification of satellite image 2019 are mapped in Figure 3(c) which show that the area under barren land was observed as 19.74 km^2,vegetation cover was 11.60 sq.km, water body was 4.25 sq.km and built-up land was 17 sq.km.

Comparison of change in land use during years2003, 2013&2020

Layout of classified satellite images of various years are shown in Figure 3 which help to understand pattern and concentration of change visually. The results show a significant change in built up area in 2020 as compared to 2003 which has increased. Most of the new

infrastructure is being built with increase in the density in the middle and eastern side of urban center showing that the process of stratification is negligible as most of the people have settled or migrated to the middle and eastern side due to better employment opportunities The areas with potential change include Jutial and Kashort where there were a large number of educational institutes, markets, hotels and restaurants. On the other hand, the western side of city was observer comparatively less urbanized.

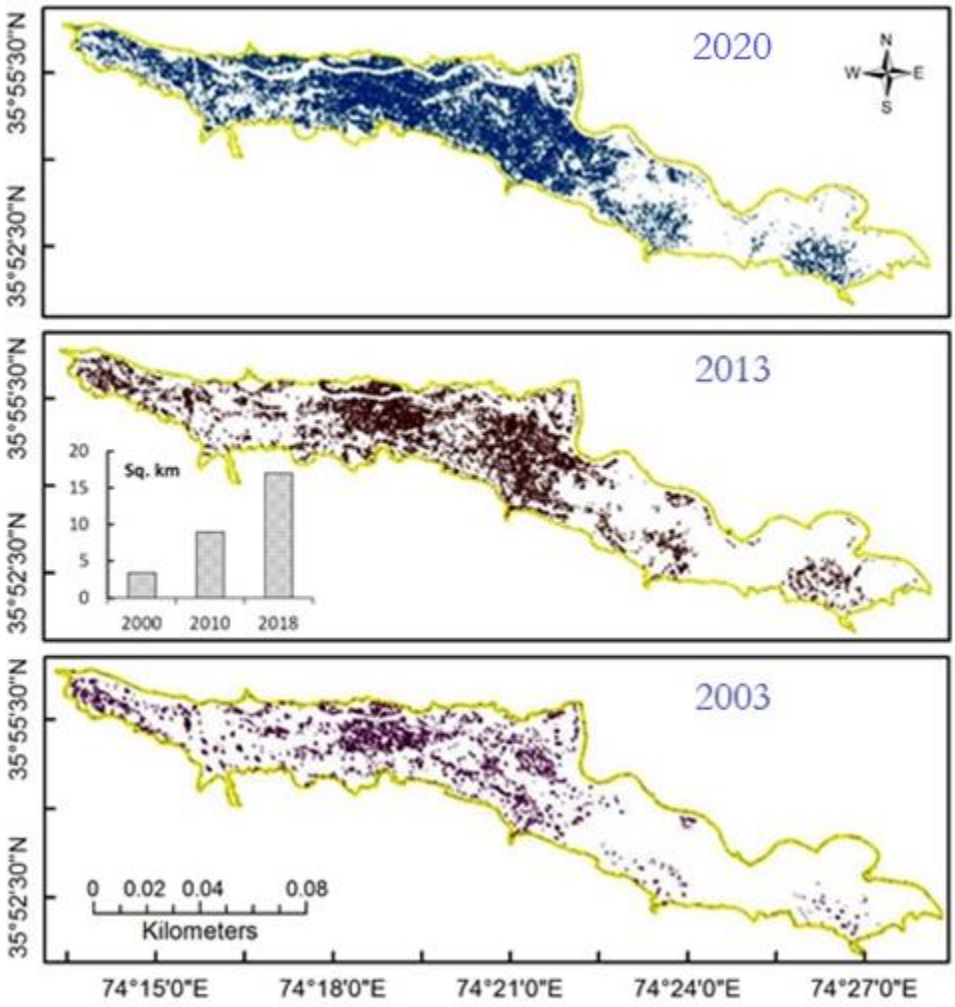

Figure 4: classified images of built-up land for the year 2003, 2013&2020

A drastic change in urban areas was observed specially during 2013-2020. During this period, most of the people have migrated from different areas specially from Chilas, Diamer, Jaglot and Nager district to Gilgit city and settled mostly in the middle or eastern side of Gilgit city (Figure 4).

The area under vegetation was observed declined during (2003 to 2020) (Figure 5). Most of trees were cut for establishing new settlements in the eastern side. The climate of Gilgit-Baltistan remains cold during winter season which approaches to zero and remain in

the same state up to 6 to 7 months. Economic development and speedily growing urbanization have boosted up the energy demands by 30% in last two decades [17]. Natural gas is unavailable in this region therefore, people are helpless but to use wood for cooking and heating purpose. It may be one of the main reasons for decline in vegetation cover. The rapidly increasing population of this region need more biomass and fuel to maintain the temperature of their houses suitable for living and the wood of forest is considered easily accessible which is also cost effective.

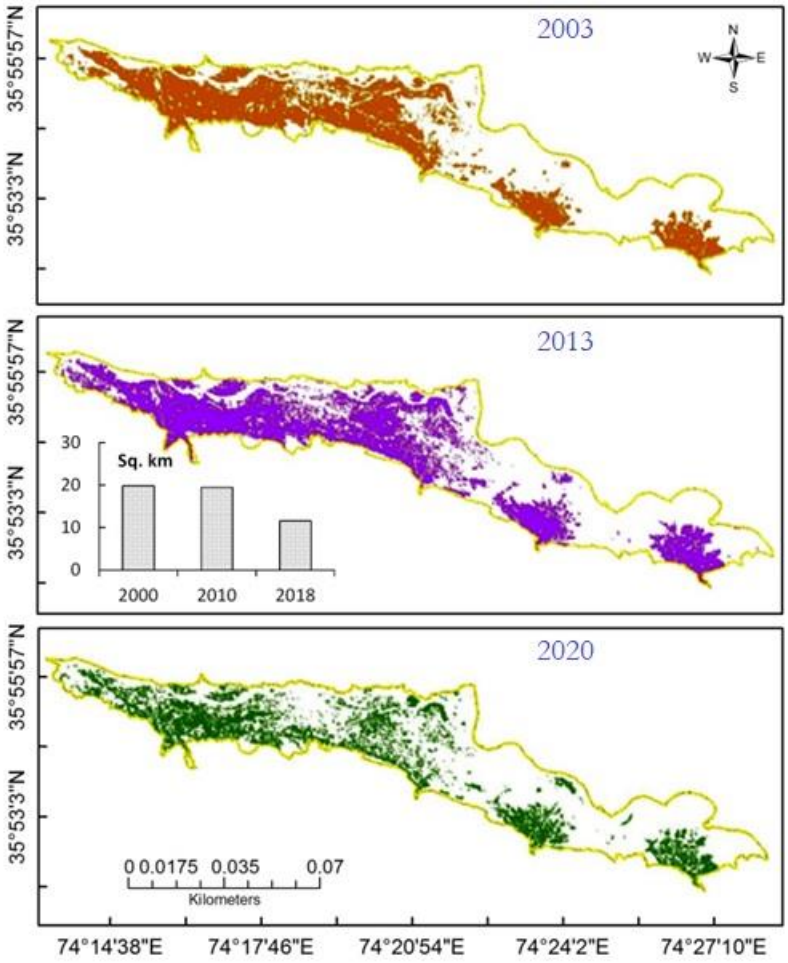

Figure 5: Classified images of vegetation cover for the year 2003, 2013&2020

The hotspots were created for built up areas highlighting the most populated regions. These hotspots determine the regions under drastic change with population growth by many folds. Figure 6 determine that Sakwar/Jutial, at the northern bank of Gilgit river is Nager colony and at the southern bank is Kashrut area. By a comparative analytical method, hot spots were detected in the built-up land and vegetation cover. By overlapping the polygons generated for the three images of the year 2003, 2013and 2020 two hotspots were identified in built up land and few in vegetation cover.

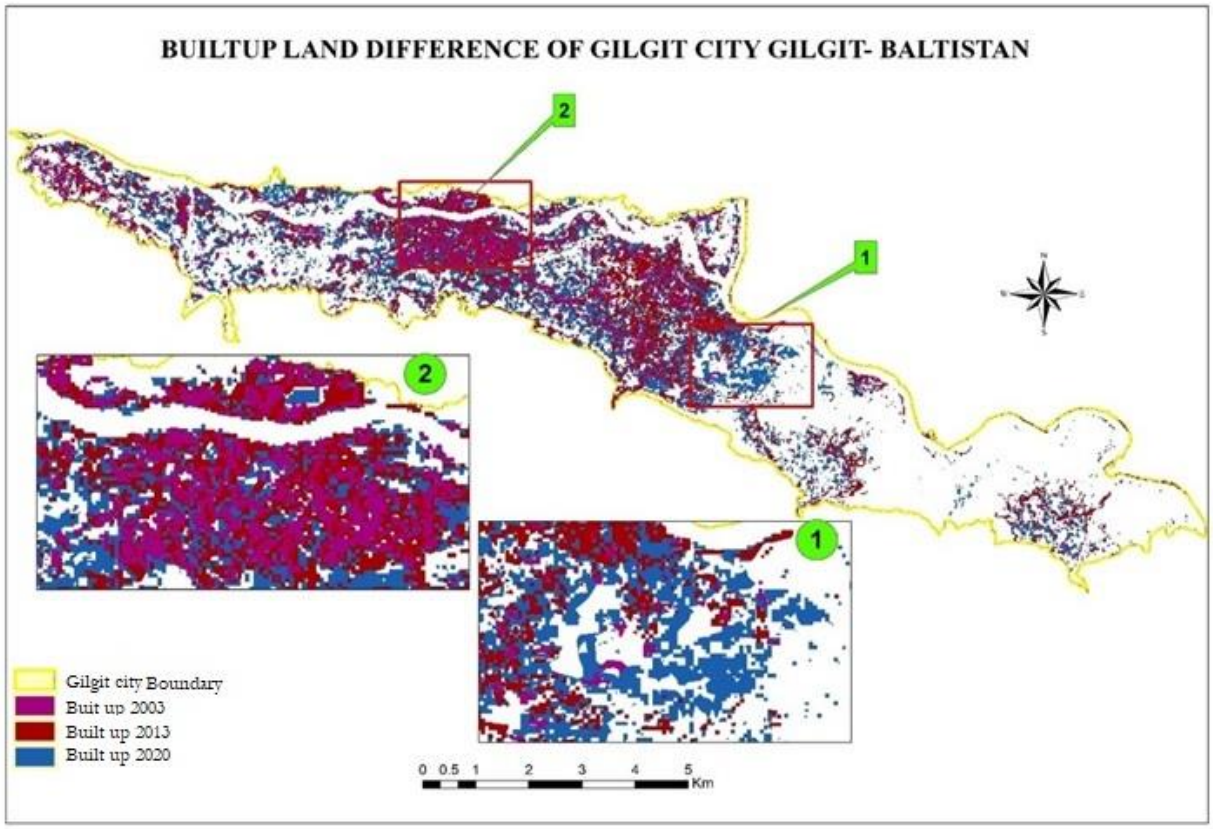

Figure 6: Difference in built-up land for the year 2003, 2013&2020

Explanation of Increase in Built-up Land of Area 1

Sakwar/Jutial lies in the middle of Gilgit city which show that most of eastern side has changed. The change was not prominent form 2003 to 2013 but a major change was observed in 2013-2020 due to considerable development during this time span. The major factors responsible behind this change were observe through field surveys by interviewing the general public.

Factors responsible for this increase in built-up land were observed as follow, 1). Construction of Dam was one of the prominent reasons which offered many jobs and attracted people to migrate toward this dam site therefore, most of the people migrated towards Gilgit city and settled in Sakwar/Jutial region.

- Compensation fund provided by the government to these people have attracted them to purchase land in this area.
- These migrants during interview told that they selected here because of better health and educational facilities.
- Most of the people belong to a specific sect and they don't feel themselves secure in other regions as compared to other area of the Gilgit city.

Sakwar/Jutial is a barren and rocky area but with the advent of time this barren land was converted into built-up land. Water and Sanitation Extension Program (WASEP) is a program which has benefitted more than 350000 people. Due to WASEP, this areas was considered water rice and the people started buyin land despite of high prices. Figure 7 is showing newly builtd houses in Sakwar region.

Figure 7: Newly build houses in Sakwar/Jutial area of Gilgit city

Area 2 in Figure 7 show some prominent change in the built-up area during the time span of 17 years but most considerable duration was of 2013to 2020. Area 2 was comprised of two regions, on the north side called Konodas and Nager colony while on the south of the river is called Kashrot region. The areas 2 have undergone a vast change in built-up land due to the following reasons revealed during survey.

Kashrut:

- People of kashrut were migrants from Kashmir province of Pakistan.
- They were brought to Gilgit from Kashmir for the cultivation of rice by the local people by giving them subsidized lands.
- With the passage of time these people have changed their occupation towards jobs and business and the cultivable land was converted to built-up land.
- It is considered as commercial hub of Gilgit city but most of the traders and the shopkeepers are not local (pathans).
- Due to the proximity to airport and city park, most of the visitors preferred to stay in this area therefore, it is also dominated various well renowned hotels, including park hotel and Shaheen hotel.

Konodas:

Konodas has an administrative core having multiple governmental buildings. Mujahid colony was observed highly saturated with built up land. About 80% buildings were owned by government as shown in Figure 8.

Figure 8: Governmental buildings in Konodas area of Gilgit city

Nager colony:

Nager colony was comprised of only 30 houses in 2003 while this number was increased upto 350 in 2020. The trend of population was observed toward this area due to availability of water and other joys of life. Significant educational facilities were found available in Nager colony due to availability of Agha Khan higher secondary school and university which attracted people to migrate for acquiring education for their young ones. The drainage system of this area was not found up to the mark even then people prefer to live in this area due to better health and education facilities.

Hotspot Detected in Vegetation Cover During Comparative Analysis

Significant changes were observed in vegetal cover during the span of 20 years where vegetation has shown decline in area from 19.83 sqkm to 11.60 sqkm. This decline has its own consequences on environment as well as on the land cover. Figure 9 shows a comparative analysis of vegetation cover for 3 different years.

In figure 9, two hotspot were detected which show a prominent change on the eastern side of the city where area 1 is showing an increase in vegetation while on the western side the vegetation cover was observed enhanced.

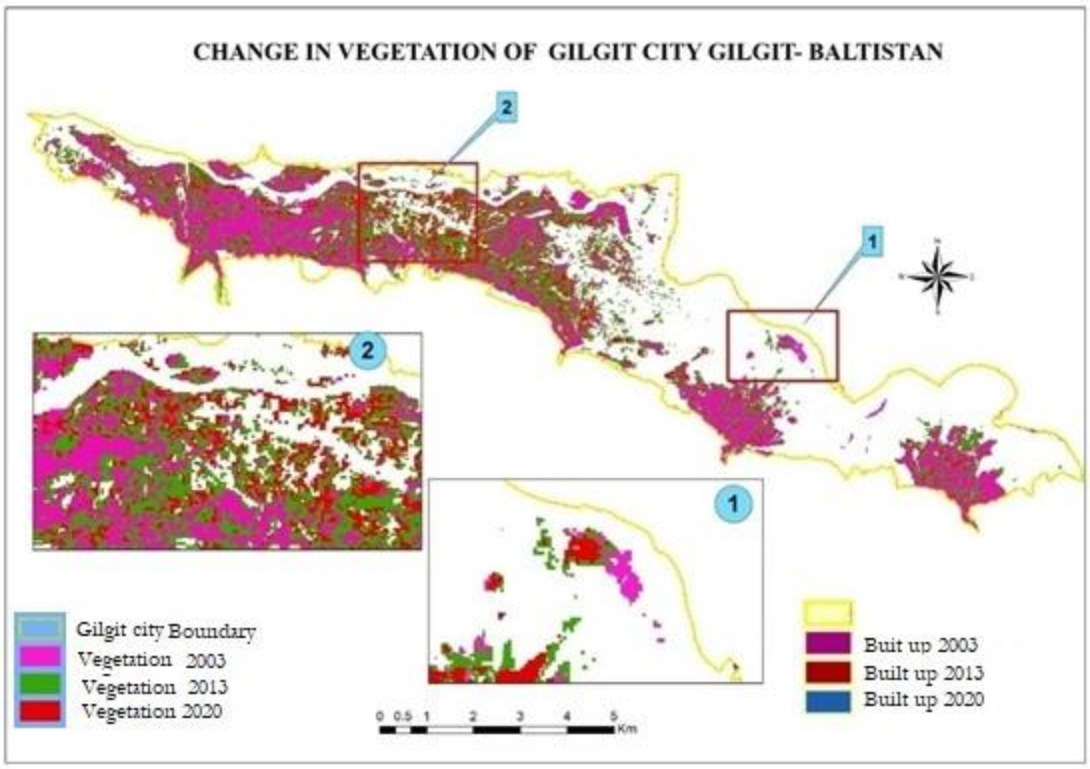

Figure 9: Change in vegetation cover (year: 2003, 2013&2020)

Reasons for enhanced vegetation cover (kashrut area)

- The decline to vegetal cover was due to dense human settlements, heavy population and commercial activities due to which the presence of hotels and shops were abundant.
- The migrants from Kashmir preferred to execute various kinds of businesses and jobs as compared to agricultural activities.

Area 1 lies in Sakwar/Jutial region but it is a specific part of Jutial region which has recently shown an increase in vegetation cover. The main reason for increased vegetation was that most of migrants were from village so their major occupation was related to agriculture. These individuals had converted the barren land into cultivable area.Most of the farmers planted trees on uneven surfaces where crops could not be cultivated. Most of the farmers involved in fruit selling business so they planted fruit trees. With the passage of time these farmers were found more intend to convert barren land into cultivable land. Irrigation of these lands were dependent upon river water therefore mostly electric motors were used for this purpose. Equal distribution of water for irrigation to agricultural crops was one of factors for such an increase in vegetation because there was no conflict.

The residents of this area have shown a very great effort for converting barren land into cultivable area as shown in Figure 10.

Figure 10: Photographs showing planation in Sakwar/Jutial area of Gilgit city

Table 1 shows the result of overall changes in area for the three classes: build up land, vegetation cover and barren land. From the year 2003 built up land was 3.37 sq.km, water body was 4.01 sq.km, vegetation cover 19.83 sq.km and barren land was 25.37 sq.km. A significant change was observed in area of these classes in 2013, where an increase in builtup was observed up to9 sq.km and water body covered 4.01 sq.km which was almost constant as compared to 2003 while vegetation cover declined to 19.43 sq.km and the barren land was also declined to 20.33 sq.km. The time span from 2013 to 2020 shows a change in buildup land which was observed increased by17 sq.km.

Table 1: Overall result of classification for the year 2003, 2013&2020 in sq.km

Year	Built-up Area		Vegetative Area		Barren Land		Water Bodies	
	Sq. km	%age	Sq. km	%age	Sq. km	%age	Sq. km	%age
2003	3.37	6.4	19.83	37.67	25.37	48.33	4.02	7.61
2013	9	17.4	19.32	36.76	20.17	38.26	4	7.69
2020	17	32.33	11.6	22.05	19.75	37.54	4.25	8.08

A way forward upto 2030:

The results of the temporal analysis of previous seventeen years show a changing pattern in vegetation, built up land and barren land, in such a way that the vegetation cover has decreased from 36% to 22%. Further, there are maximum chances of reducation in the vegetation cover through deforestation and increasing population in upcoming year mostly in the middle and eastern side of the Gilgit city. Data extracted from election commission of Gilgit shows an increase in population of adults from 30397 in 2015 to 77100 in 2020 which shows increase in population in exponential rate. The decreasing trend in vegetation as observed in previous 10 years was 2%. So if the percentage continues there will be only 2% of vegetation cover will be left in Gilgit city incase of afforestation in Jaglot region. Decline in

vegetation cover will be more prominent in Jutial and kashrut area. These two areas where built-up land is increasing show a decreasing pattern in vegetation cover in Kashrot area which is mostly due to deforestation for construction new settlements. Reduction in barren land was observed mostly at Sakwar\Jutial area because the eastern side of Gilgit city is mostly dry and barren. Barren land is decreasing with 1.5% per year according to the above finding of research so if this pattern continues there will be a deduction to 27% of barren land from 37% in the next 10 years. In Kashrot, the area will be fully converted into commercial area with no vegetation cover because of increasing construction activities. Whereas in Sakwar\Jutial, lots of newly constructed infrastructure is observed on barren land and this area will undergo a massive change with increase in buildup land. Built up land is increasing in Gilgit city in an exponential order so if the increasing percentage of builtup in maintained in the next 10 years, the percentage will increase from 32% to almost 47%. On the other hand, there are some specific areas, where afforestation were observed and is likely to increase in the upcoming year due to the availably of fertile land and water.

Conclusion.

A temporal analysis of land use and land cover of Gilgit city for a duration of 17 years was executed by taking the satellite images of the year 2003, 2013 and 2020. Through supervised classification, four classes were generated: built-up land, waterbody, vegetation cover and barren land. The area for these classes was calculated and was comparatively analyzed by overlapping polygons generated in Arc GIS. The result of area calculated for three different years reveal that built up area has increase from 3.37 sq.km to 17 sq.km for a duration of 17 years due to this increase in built-up land, Gilgit city has shown a dramatic urban expansion in terms of buildup area. There is no regular pattern of expansion rather it is arbitrary in direction. Important fact which is to be noted is that the buildup area has shown an increase is not consistent but is surprisingly irregular. the migration of people from rural to urban land was in search of better health and educational opportunities, however the prominent factor of migration from other district was construction of Diamer/Basha dam. The urbanization pattern observed during this research was neither concentric, nor linear but had shown an arbitrary pattern.

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Conflict of interest. Authors declare no conflict of interest for publishing this manuscript in IJASD.

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