APPRAISAL OF URBANIZATION AND ITS IMPACTS ON THE ALBEDO AND CLIMATE CHANGE OF THE PUNJAB-PAKISTAN: A SPATIO-TEMPORAL ANALYSIS

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ABSTRACT. The research is aimed at evaluating the process of urbanization and it's spatio-temporal impacts on albedo and the changing climate of the Punjab. Climate change in urban areas has become a public focal point, as urban development in our present-day environment is one of the most critical aspects of human activities. The shift in the reflective properties of the surface is one of the particular climatic consequences of urbanization which most researchers have overlooked (Albedo). Changes in urbanized land surface properties resulted in a global, regional, and local changes in biochemical cycles and environment. This analysis aims to identify the urban land use of the 1990-2018 study area (decadal) and evaluate Albedo and Climatic Variables' trends over the selected region. This study will provide a complete code of classification in Google Earth Engine for researchers. In Google Earth Engine, the classification technique was utilized to detect urban areas and barren land cover types by applying coding over four images of 1990, 2000, 2010, and 2018 of Punjab Province. The Albedo maps were created in the same way for the years 2000 and 2018. Climatic maps were created from 1990 to 2018 by applying the Inverse Distance Weighted method in a GIS system. There has been an apparent increase in the urban area of Punjab Province from 1990 to 2018. The urban area has increased from 1183.5342 km2 to 8396.4618 km2 during the study period. Results from climatic maps showed hotspots in the areas that have undergone urbanization. Overall, the accuracy of the classification images was 81-88 percent, which was foremost to achieve the objectives of the research.

Key words: Google Earth Engine, Urbanization, Punjab, Climate Change, Surface Albedo.

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INTRODUCTION

Climate change in urban areas is a national focus since urbanization is currently one of the profound features of our biome. (Chandra, Sharma, & Dubey, 2018; Grimmond, 2007; Sarvari, 2019; Seto & Shepherd, 2009; Tang *et al*., 2018a) Urbanization is one factor that changes the climate (Chapman, Watson, Salazar, Thatcher, & McAlpine, 2017; Li, Wu, Liang, & Li, 2020; Wen *et al*., 2019; Zhou, Leng, Su, & Ren, 2019). After all, it changes our planet's reflective properties and directly connects with surface albedo (Trlica, Hutyra, Schaaf, Erb, & Wang, 2017) and other solar variables (Spångmyr, 2010). The world has seen a stunning increase in urban development in Asia over the last decade 2000-2010 (Ebanks & Cheng, 1990; Ichimura, 2003; Kanbur & Zhuang, 2013; Sim & Balamurugan, 1991), with expanding multiple megacities in different regions of the world (Aguilar, Ward, & Smith Sr, 2003; Gadanho *et al*., 2014; Jacobson, Nghiem, Sorichetta, & Whitney, 2015; Liu, Zhan, & Deng, 2005; Zhang *et al*., 2018). Deforestation (Aslam, Amjad, Kausar, & Sarwar, 2019; Khanna, Medvigy, Fueglistaler, & Walko, 2017; Longobardi, Montenegro, Beltrami, & Eby, 2016), modern structural surface materials (Saini & Tiwari, 2020), streets and a different setting along with improvements in surface morphology (Shukla & Jain, 2019), change water and wind currents' vitality and circulation. As urban areas develop, the cover material for constructions, squares and roads is wide. This study led to the questions of surface emissivity alteration and albedo (Ban-Weiss, Woods, Millstein, & Levinson, 2015; Falasca *et al*., 2019; Pomerantz, 2000; Stone, Vargo, & Habeeb, 2012; Sugawara & Takamura, 2014), caused energy and surface radiation shifts, and increased extreme weather intensities in urban areas (Grimmond, 2007; Kuang, Liu, Dou, Li, & Lu, 2019).

The alteration of the reflective properties of the surface is one of the special climatic effects of urbanization, overlooked by most researchers (Albedo of the surface) (Ban-Weiss *et al*., 2015; Falasca *et al*., 2019; Pomerantz, 2000; Sailor & Fan, 2002; Santamouris & Fiorito, 2021; Stone *et al*., 2012). The urban areas span the city's outskirts (Spångmyr, 2010) due to the increase in population throughout the world. As a result of primary urbanization conversions, surface atmospheric radiation changes occur and not only because of the warm surroundings and Urban Heat Island. (Kim, 1992;

Oke, 1982; Roth, Oke, & Emery, 1989; Voogt & Oke, 2003), but it is also an enormous commitment to global and territorial warming (Grimmond, 2007). In biochemical cycles and atmospheres at the world, provincial and national levels, changes in land surface properties have been caused by urbanization. (Hu *et al*., 2016). Albedo demonstrated the Earth's reflective limits by sun-driven radiation methods and showed the allocation of radiative strength and vitality between the condition and surface of the Earth. (Dickinson, 1983; Lofgren, 1995). Climate change has become a major priority both internationally and locally over the past few years due to changes in surface albedo. (Blok *et al*., 2011; Tedesco *et al*., 2011) Compared with the impacts of fossil-fueled combustion on climate change resulting from the surface albedo change (Caiazzo *et al*., 2014; Stull, Sun, & Zaelke, 2010). If the surface albedo and reflection are increased in city areas, climate change can be combated (Ban-Weiss *et al*., 2015; Falasca *et al*., 2019; Pomerantz, 2000; Sailor & Fan, 2002; Santamouris & Fiorito, 2021; Stone *et al*., 2012) since the radiative flux of carbon dioxide and other forcing gases to climate, along with aerosols was compensated for (Stull *et al*., 2010). In the context of further research into climate change, estimating variations in surface albedo is also important. (Tang *et al*., 2018a). Thus, as the world progresses towards urbanisation, an awareness of developments caused by urbanisation is imperative. (Che *et al*., 2005; Dickinson, 1983; Grimmond, 2007; Hu *et al*., 2016; Ichimura, 2003; Jacobson *et al*., 2015).

(Tang *et al*., 2018b) aimed at assessing the effects of urbanization on albedo and climate. The study used DMSP/OLS data to extract urban areas and characterizes them as core areas, fringe areas, and rural areas. Urban expansion is studied by considering the core areas and fringe areas, and the Expanded Area is defined as the area where the fringe area in 2000 turned into the core area in 2010. A shift linear analysis method is used to identify the breakpoint in the albedo time series.

In another study (Kuang, Liu, Dou, Li, Lu, *et al*., 2019) the surface net radiation, which is important in the study of atmospheric radiative transfer, is calculated by adding the net shortwave and net longwave radiation components using the surface radiation balance equation. The shortwave and longwave radiation are calculated using various parameters such as the solar constant, solar zenith angle, atmospheric transmittance, and emissivity.

This study is significant because climate change is one of the most important challenges for human beings now a day. With the rapid increase in the number and extent of urban areas and changing land cover types, it is very necessary to highlight the related factors responsible for deteriorating the human environment and its atmosphere. This study attempts to explain the impacts of increasing urbanization on Surface Albedo and how it plays a role in climate. Creating a linkage between these factors has always been neglected in Pakistan. This research will provide a basis for urban planning and controlling environmental deterioration. Furthermore, this study can be used to promote awareness about the effect of different types of surfaces on Albedo and consequently on climate. This research work will provide a new benchmark for the researchers to do mapping on Google Earth Engine.

MATERIALS AND METHODS

To fill the gap of previous researches in Pakistan on urbanization and its consequent effects on surface albedo and climate have been observed and analysed in this qualitative research. Punjab is the eastern province of Pakistan and includes 36 districts covering approximately 205, 345 km2. There are 73,621 million people here, making it one of the most populated regions of the world. (Tahir, Jamil, Zaidi, Arif, & Ahmed, 2005). Therefore, an effort has been made to develop the latest research design through the use of generalized Google Earth Engine supervised classification techniques (Amani *et al*., 2019; Brovelli, Sun, & Yordanov, 2020; Goldblatt, You, Hanson, & Khandelwal, 2016; Yu *et al*., 2018; Zurqani, Post, Mikhailova, Schlautman, & Sharp, 2018) to detect the urban extension. The main variations in urbanization and albedo across the whole region are achieved using this method by comparing 4 images with 10 years. In Google Earth Engine, satellite images were processed using an algorithm based on javascript. This is a new approach for classifying urban extension and making albedo maps using remotely sensed images and applying codes and algorithms.

Weather data were obtained from the Pakistan Weather Department (PMD) for the Punjab Province from 1990 to 2018. Various weather reports provide weather observations. In Microsoft Excel, weather data is tabulated. One way of urban quantification is the remote sensing of optical or multi-spectral satellite, which was done by developing Google Earth Engine codes. Although urban areas or other humans can be easily visually observed, accurate and reliable quantification with spectral remote sensing can be provided through area awareness and ground monitoring (Hu *et al*., 2016; Jacobson *et al*., 2015). For the years 1990, 2000, 2010 and 2018, four satellite images were taken. In the first stage, urbanization and albedo maps were created using Google Earth Engine (a new platform for mapping the world through coding). The next step evaluated the impacts of urbanization on Albedo and Climate. As a result, expanding the metropolitan area in the province from 1990 to 2018 is very evident.

Data Sources: Landsat's time and space combination was rapid and efficient with the GEE API (Application Program Interface) (Mitraka, Benas, Gorelick, &

Chrysoulakis, 2016). Google Earth Engine (GEE) includes publicly available satellite images with data sets from the U.S. Geological Survey (USGS) and NASA. Satellite images in Landsat 5 and 8, available in Google Earth Engine (a new tool for mapping the planet by coding), were taken to spot the land and urban area expansion of Lahore. The pictures were taken from Landsat / LT05/C01/T1 TOA reflectance for 1990, 2000, and 2010 by entering a code for each image. The image was named TOA Reflectance Landsat 8 OLI/TIRS TM C1 Level 2 for 2018. Thus, the uniformity of the data was guaranteed. The following are the satellite images with full detail.

Table 1. Datasets by Landsat Sensors.

Sensors	Entity ID	Acquisition Period
Landsat 8 OLI/TIRS TM C1 Level 2	LANDSAT/LC8_L1T_TOA/LC81500412016090LGN00	2018-01-01 to 2018-12-31
Landsat 5 TM C1 Level-2	'LANDSAT/LT05/C01/T1'	2010-01-01 to 2010-12-31
Landsat 5 TM C1 Level-2	'LANDSAT/LT05/C01/T1'	2000-01-01 to 2000-12-31
Landsat 5 TM C1 Level-2	'LANDSAT/LT05/C01/T1'	1990-01-01 to 1990-12-31

Data Processing

Processing of Satellites datasets in Google Earth Engine: Google Earth Engine (GEE) processed data for classification technique. Google Earth Engine is a new tool that can provide insight into datasets on a petabyte-scale. Google Earth Engine has made it possible for the first time in history to process large quantities of satellite imaging quickly and accurately. The web-based code editor is used for the rapid, interactive creation of algorithms with immediate access to petabytes. Firstly, the shapefile of Punjab Province was uploaded in the assets of Google Earth Engine software. To clip and highlight the study area, the image was then imported into the code editor. From the Landsat collection, already available in the datasets of GEE, raw image for Punjab Province was imported. Images from Landsat 8 and Landsat 5 were utilized and mentioned in table 1. The methodology comprises these steps. First, for a single year, load a raw Landsat 5 Image Set. Create a standard cloud-free composite. Then build a cloud-free composite with individual cloud score threshold and percentile parameters. Display the composites and use the band combination in the prediction. Finally, make training data by 'overlaying' the points on the image. After this, make any random classifier to train it. Classify all the classes and train them from 0-4 as per requirement. After displaying the classification, export the classified data. The next step was to check the correctness of the classification (fig IV). In the last step, the code was added to download the classification. Maps for mosaic processing in Arc GIS have been further processed. The following formula calculated the area of each class.

Area Calculation Formula = (count)*(pixel size) ^2/1000000: The final step in Arc GIS was the application of symbology and the complete design. Weighted techniques were used to build climate maps of the Province of Punjab in Pakistan. Advances in GIS now enabled the analysis of data with different types of interpolations. Interpolation is widely used in sciences concerning spatial data and phenomena. Furthermore, interpolation data quality or reliability would directly affect the performance, as the precision of interpolations based on isolated data will be disrupted. It is useful for assigning unknown sample point position values near the unknown point.

RESULTS AND DISCUSSION

A crucial test in studying land cover variations is the segregation of different variation components (Aspinall & Hill, 2007).

Extent of Urbanization in Punjab 1990-2018: Previous researches utilized object-based supervised classification technique through a different software (Al-Kofahi, Hammouri, Sawalhah, Al-Hammouri, & Aukour, 2018; Di Palma, Amato, Nolè, Martellozzo, & Murgante, 2016), but in this study, classification was done through coding in Google Earth Engine (Amani *et al*., 2019; Brovelli *et al*., 2020; Goldblatt *et al*., 2016; Yu *et al*., 2018; Zurqani *et al*., 2018). Throughout the world, research on expanding urban regions at global (Wang, He, Liu, Zhuang, & Hong, 2012), especially in the Asian region (Costa, 1989; Gade, 1990; Jones, 1988) focused on the issues and planning of urban regions, but few types of research correlated it with climate change (Chandra *et al*., 2018; Grimmond, 2007; Sarvari, 2019; Seto & Shepherd, 2009; Tang *et al*., 2018a). This research provides a strong relationship between Urban extension and albedo that other research has not addressed in Punjab Province of Pakistan. The four groups in Figure 1, namely water, urban, vegetation and forest, have been categorized. In 1990, all the regions under Dera Ghazi Khan, Rahim Yar Khan, South-East Bahawalpur were classified as barren land, according to Figure I. The region north of Rahim Yar Khan, Muzaffarabad and Multan have many vegetation and farming fields because the supply is fertile. In central Punjab, Layyah, Bhakkar, has a small amount of vegetation on the eastern side. Khanewal and Khusab and Multan have bare soils under East Jhang and East. Western Punjab is more fertile due to the rivers that pass through the Kasur, Okara, Pakpatan, Faisalabad, Sahiwal, Hafizabad. Most Western Punjab is fertile. Trees and agriculture cover these areas. The rivers run to the north and west and east (namely the Indus, Jehlum, Ravi, Chenab and the Sutlej). The study focused on the build-up and metropolitan areas. Since the study area is very wide, the picture can be viewed in red. The urban area has spread slightly across the entire Punjab region. The largest concentrations of urban areas are in eastern and central Punjab. Classification accuracy was 81 percent (fig IV). According to the 2000 classification, the region's underwater, farming and vegetation have declined. Much of the bodies of water shrank from eastern Punjab, mostly from Sialkot, Gujranwala towns. Gujrat, Hafizabad and Sargodha, Mandi Bahauddin. In addition to Lahore and Kasur, Okara and Sheikhupura, the built-up and urban areas have increased in the vicinity of Toba Tek Singh. In 10 years, overall, urban and construction has increased, which is primarily for the report. Classification accuracy was 88 percent (fig IV). According to the 2010 classification, all land cover forms have changed in terms of area. Comparing classes from 1990 to 2010, there has been a declining trend in water bodies between 5616 km2 and 3652 km2. A decreasing trend also occurred in the region under agriculture and vegetation. The population is also growing over time, and the need for food and water has risen. The region covered by dense forest and vegetation was 8251 km2, and it has grown to 8798 km2. Our research centered on urban development, which demonstrated a huge increase of 1,183 square kilometers in 1990 to 5,647 square kilometers in 2010. Overall, the classification improved the urban and built-up land cover to achieve the research objectives. Classification accuracy was 85 percent (fig IV). The findings of the analysis are very visible on the land cover map of 2018. After observing the map, a rise in urban areas can easily be observed. Water bodies have been reduced and the explanation for this may be the decline of river basins. As the population grew, the land under agriculture was also supplied with food. The urban and built-up region with the red colour distributed throughout eastern Punjab is indicated. Classification accuracy was 83 percent (fig IV).

In 1990, underwater region according to Figure II, is 2% (5616,9495 sq km), vegetation and farming area is 33% (78994,1952 km2), vegetable area and forest area are at 3% (8251,8993 sq km), building areas are at 1% (1183,5342 km2) and urban areas are at 61% (145,586,0913 sq km). As of the year 2000 underwater is 1% (3062,592 km2) and vegetable and cultivation areas are around 25% (60509,9817 km2), forested area 3% (6649,0209 km2), urban area 1% but increased to 2,527,749 km2, Barren classes comprise 70% and 16,7183,3259 km2. For the year 2010, the marine area is 2 percent (3652,3593 km 2), the underwater area is 31 percent (75608,0775 km2), the underwater area and the woodland area is four percent (8798,3793 km2), the built-up area and the metropolitan area is 2 percent (5647,131 km2) whereas barren classes include 61 percent (1462,324 km2). The underwater area in 2018 was 1% (2692.0332 sq. km), and vegetation and agriculture was 31% (74716.9902 sq. km) and 4% (9432,1224 sq. km), while urban and urban areas were 4% (8396,4618 sq. km), barren 60% (74716,9902 sq. km.).

Urbanization in Punjab Province 1990-2018: The pattern of urban land cover from 1990-2018 is shown in Fig III. Urbanization in the province of Punjab increased enormously during the study from 1183,5342 to 8396,4618 km2. Like our results (Mukhtar *et al*., 2018) in Punjab Pakistan, the rate of urbanization is quite high, especially in Punjab Pakistan.

Albedo and Climate: Reducing the albedo causes more daytime radiation to be retained on the urban surface than reflected in the environment. The strong material may also be low in albedo than the standard broadband albedo surface. The dry urban surface often triggers a large area of albedo (wet surface area is low albedo; wet sands tend to be more dangerous than dry sands. However, the urban surface albedo is highly heterogeneous and may not be less consistent than other regions (Jin, Kessomkiat, & Pereira, 2011).

Albedo of Punjab 2000-2018: Comparing the 2000 and 2018 Albedo, Albedo of Surfaces can be seen to have reduced a lot. The albedo showed a strong decline in Bahawalpur, Rajanpur, Rahim Yar Khan, and Dera Ghazi Khan in southern Punjab (figure V). The albedo surface and emissivity of roads, houses, parking areas and waterproof concrete are significantly reduced by removing a natural vegetative surface. Overall, it is clear from the maps that the urbanized areas were also affected by declining albedos since the non-urban albedo areas were 0.05-0.40 (minimum soil range) and 0.40-0.95 (maximum snow range), while the urban areas were Albedo 0.05-0.20 (minimum asphalt range), and 0,10-0.35 (maximum snow range) (range of Tile). In the two maps of 2000 and 2018 of the province of Punjab, this disparity between albedos of different surfaces can be observed. Our findings were accompanied by (Spångmyr, 2010) Who also showed global urbanization albedo impacts. Thus, when the world is heading towards urbanizations, the changes occurring due to urbanization must be understood.

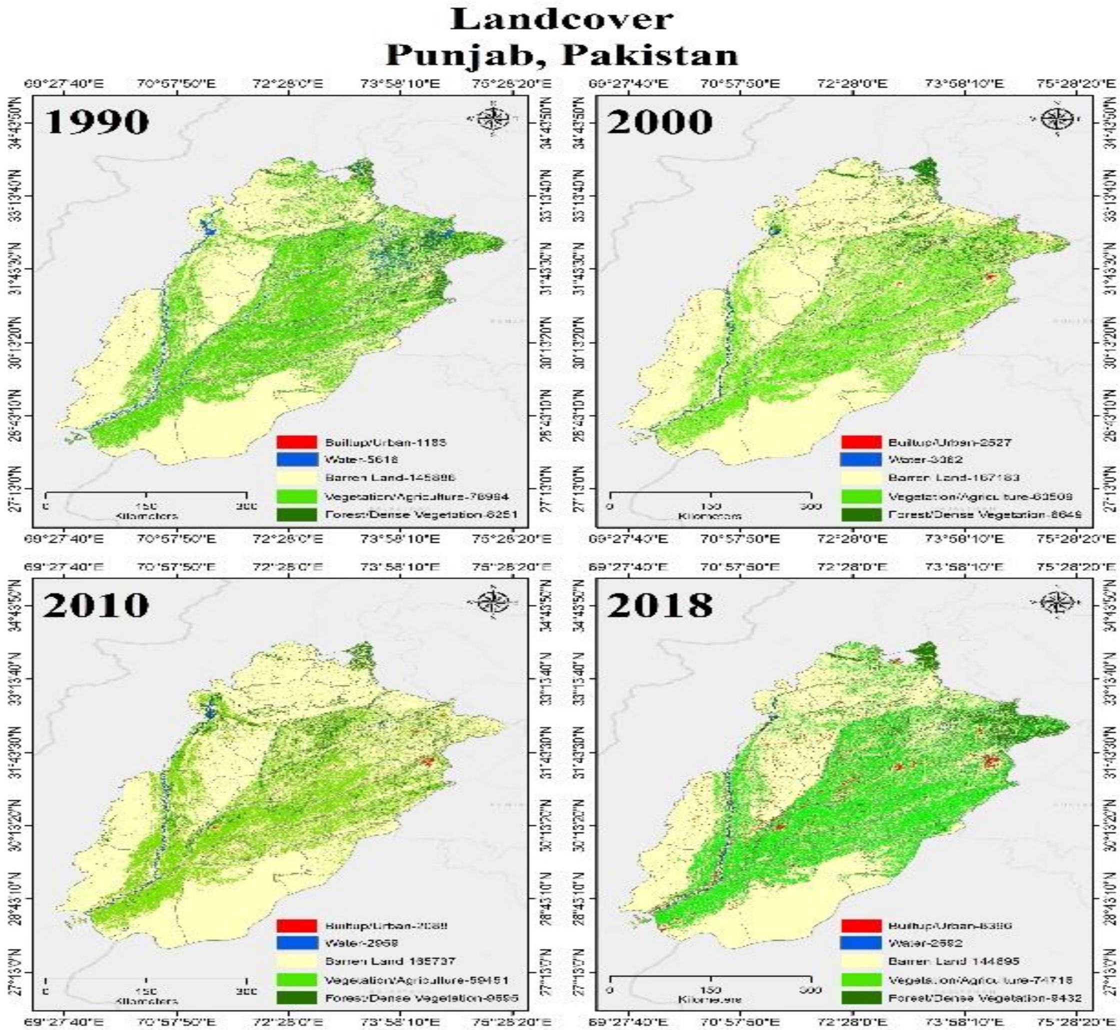

Fig. 1. Urban and Barren Land-cover in Punjab 1990-2018

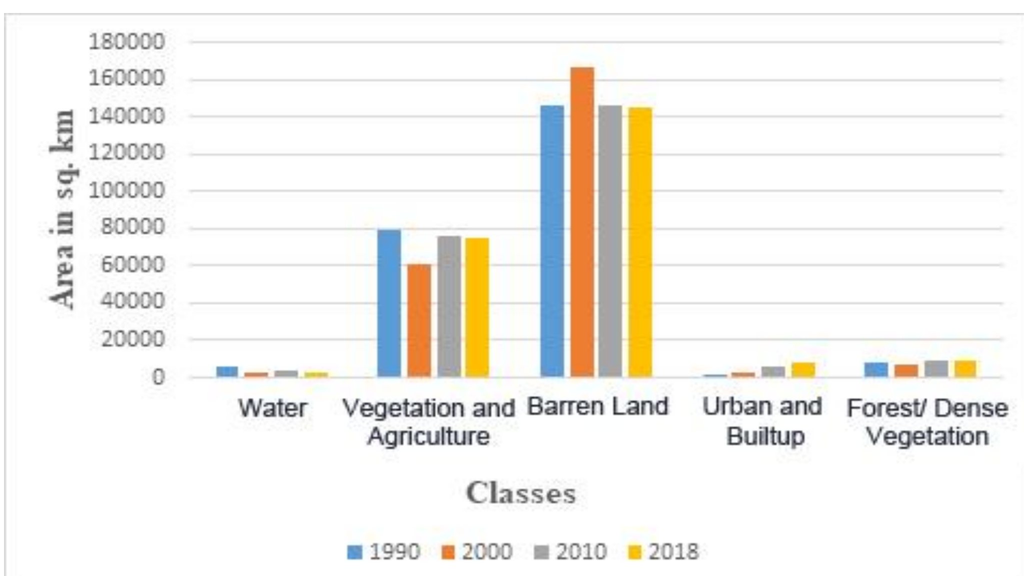

Fig. 2. Land Cover Area in Sq. Km

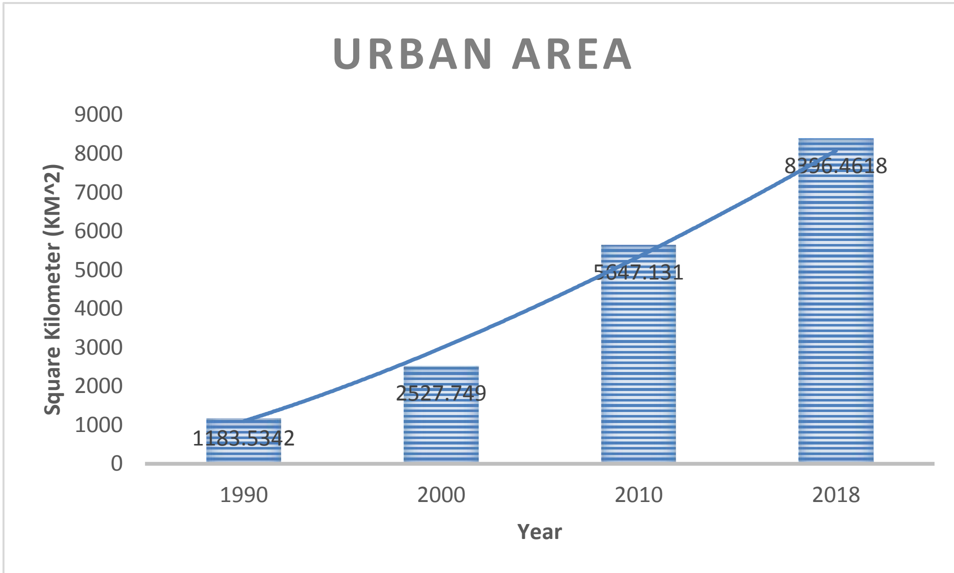

Fig. 3. Urbanization in Punjab Province 1990-2018

Accuracy Report of Classification 1990-2018

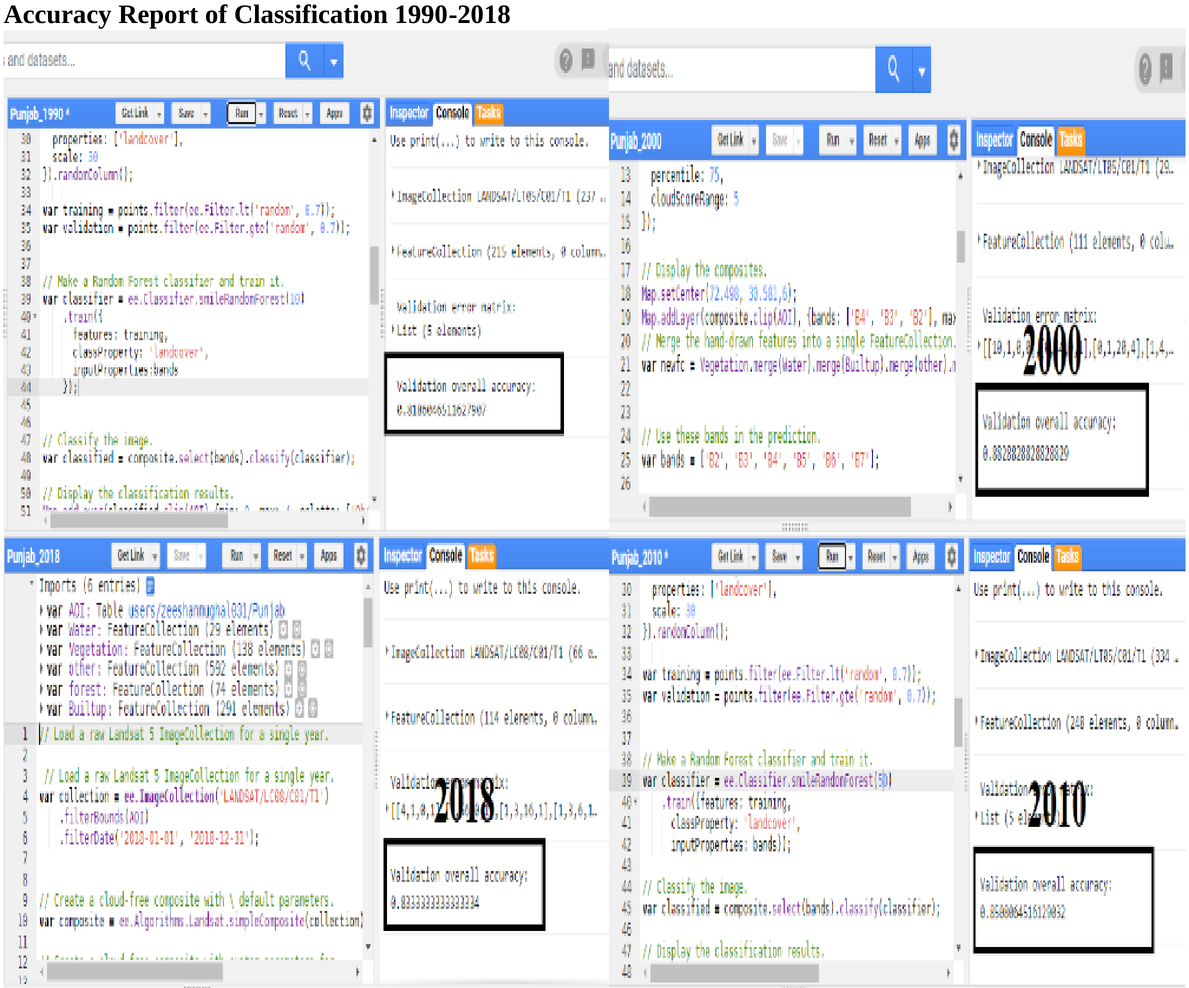

Fig. 4. Accuracy Report of images 1990-2000

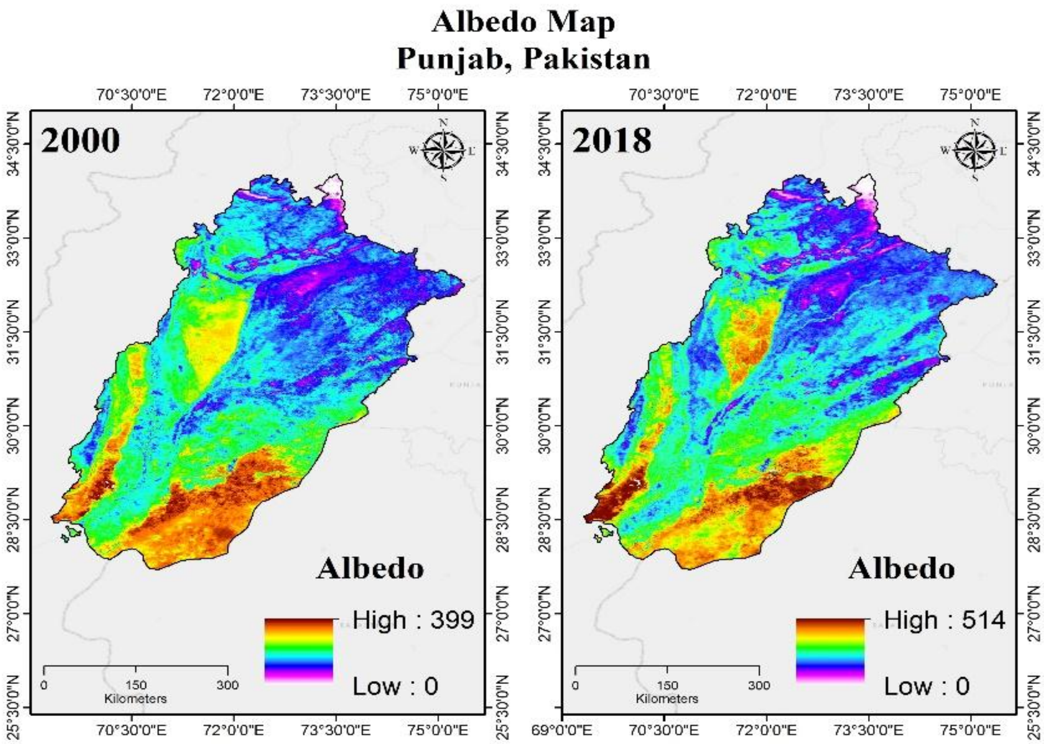

Fig. 5. Spatial Albedo 2000 and 2018

Climatic Trend in Punjab Province: In this study, IDW type of interpolation is used to estimate uncertain analytical point values. In the report, a total of 11 control points were taken from PMD to the minimum average temperature, maximum average temperature and annual average rainfall in Punjab, Pakistan (Fig VI).

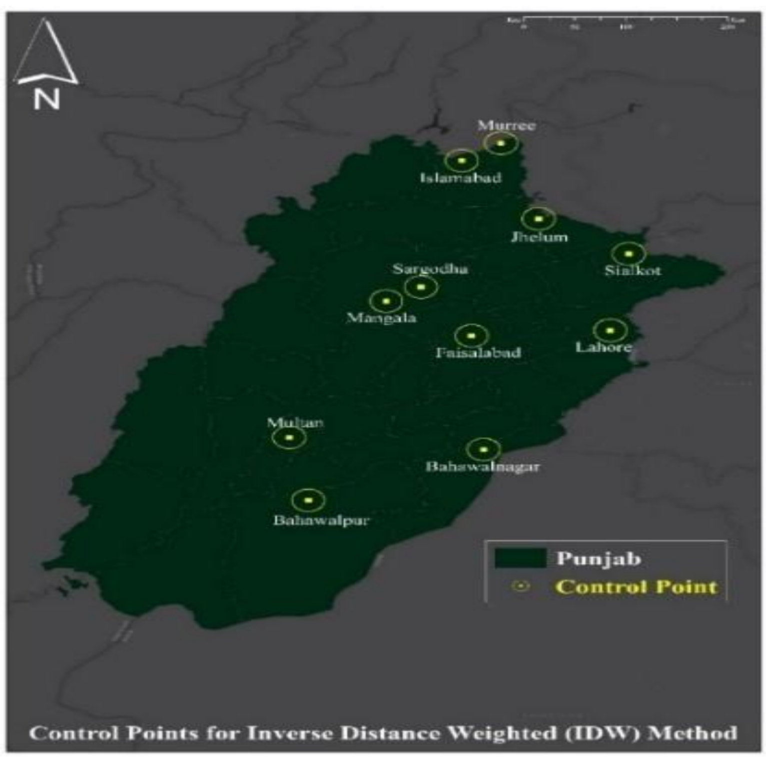

Fig. 6. Map of Control Points for IDW (Interpolation)

Aggregated Annual Minimum Temperature: The analyzed data suggest that areas around Multan district, Bahawalnagar, Lahore and Sargodha have higher minimum temperature values because they are hot spots. According to urbanization results, these areas undergo rapid urbanization. At the same time, Murree and Islamabad were analytically cold. Therefore, the districts adjacent to Islamabad were also judged to be a Punjab area with a low temperature when taken annually. Similar to our findings (Chen & Frauenfeld, 2016) The same relationship between urbanization and its effects on climate change has been shown.

Aggregated Annual Maximum Temperature: The areas in Southeast Punjab have been determined to have an annual average maximum temperature of approximately 33 0C. Furthermore, the maximum temperature and the distant points from control points were not correct following the design identified and the realities of those areas. This inaccuracy also occurred due to the distribution of control points. Therefore, the small rise in maximum temperature concentrations of different areas from 1990 to 2018 was interpreted as the maximum temperature interpolation study.

Aggregated Annual Rainfall: According to the data from 1990, 2000, 2010 and 2018, the rainfall interpolation production shows a strong image of the Punjab rainfall decrease. The low precipitation of Multan, Bahawalnagar, Lahore and Sargodha is a direct picture of climate change. In the northeast part of Punjab, this rainfall pattern can determine precipitation as most control points lie.

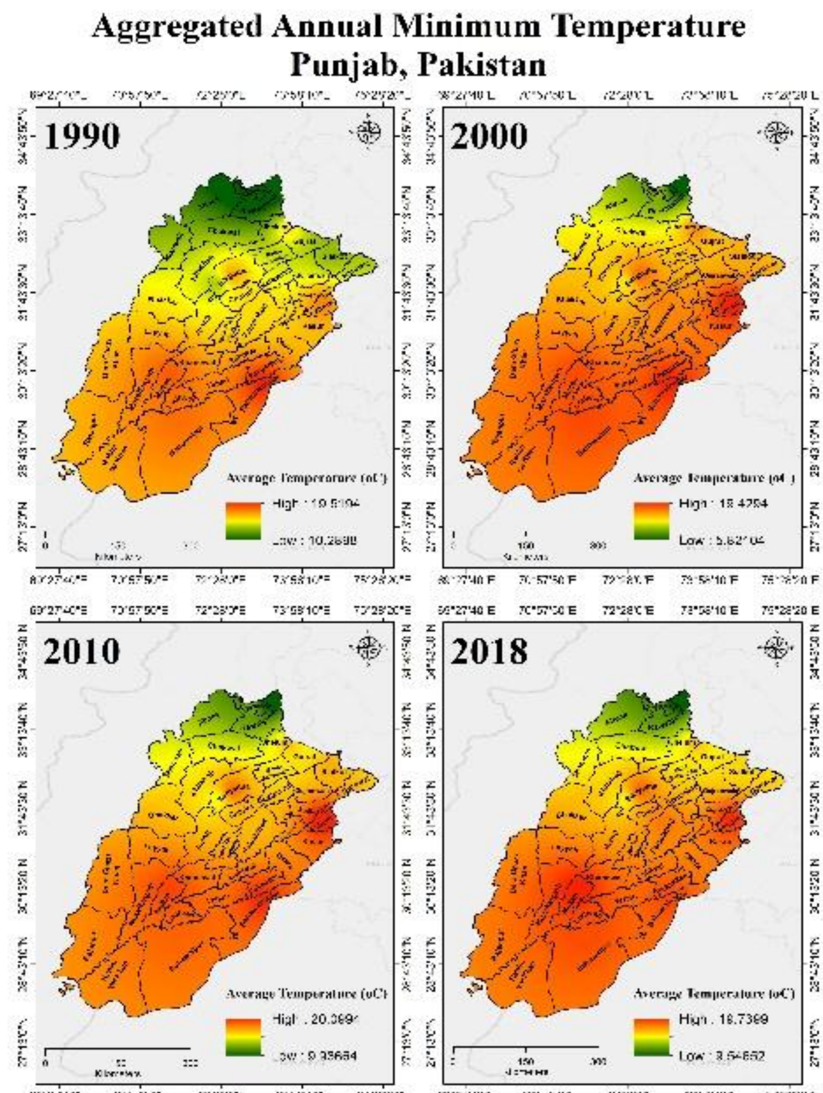

Fig. 7. Map of Estimated Annual Minimum Temperature across Punjab, Pakistan using Interpolation (IDW) Method

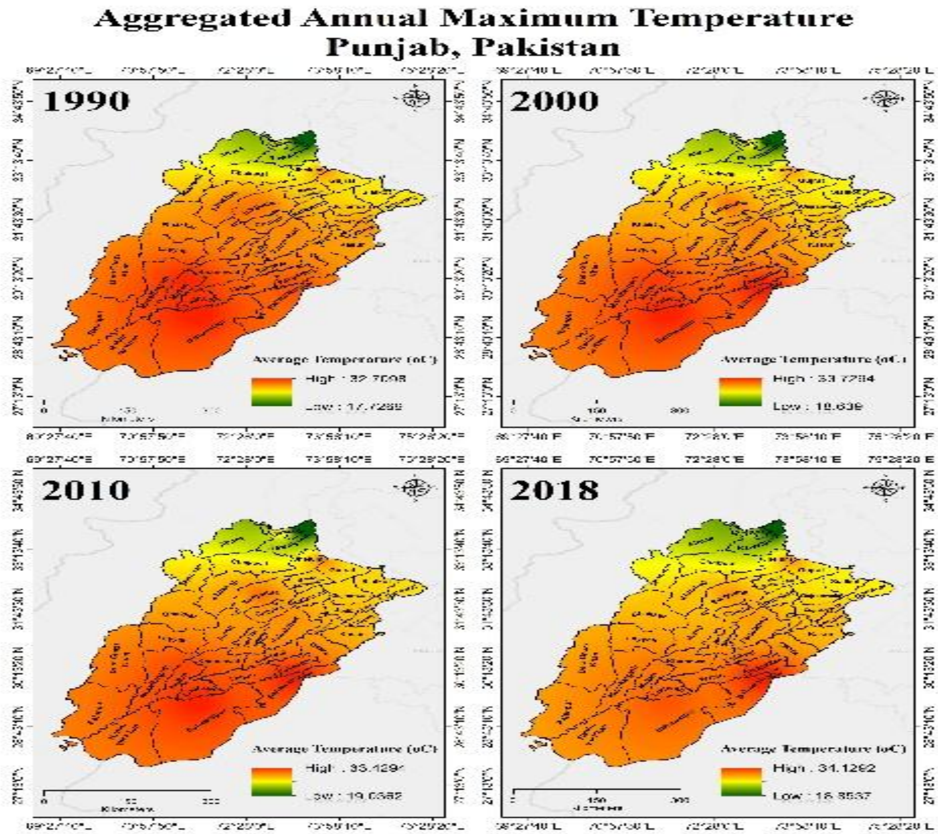

Fig. 8. Map of Estimated Annual Maximum Temperature across Punjab, Pakistan using Interpolation (IDW) Method

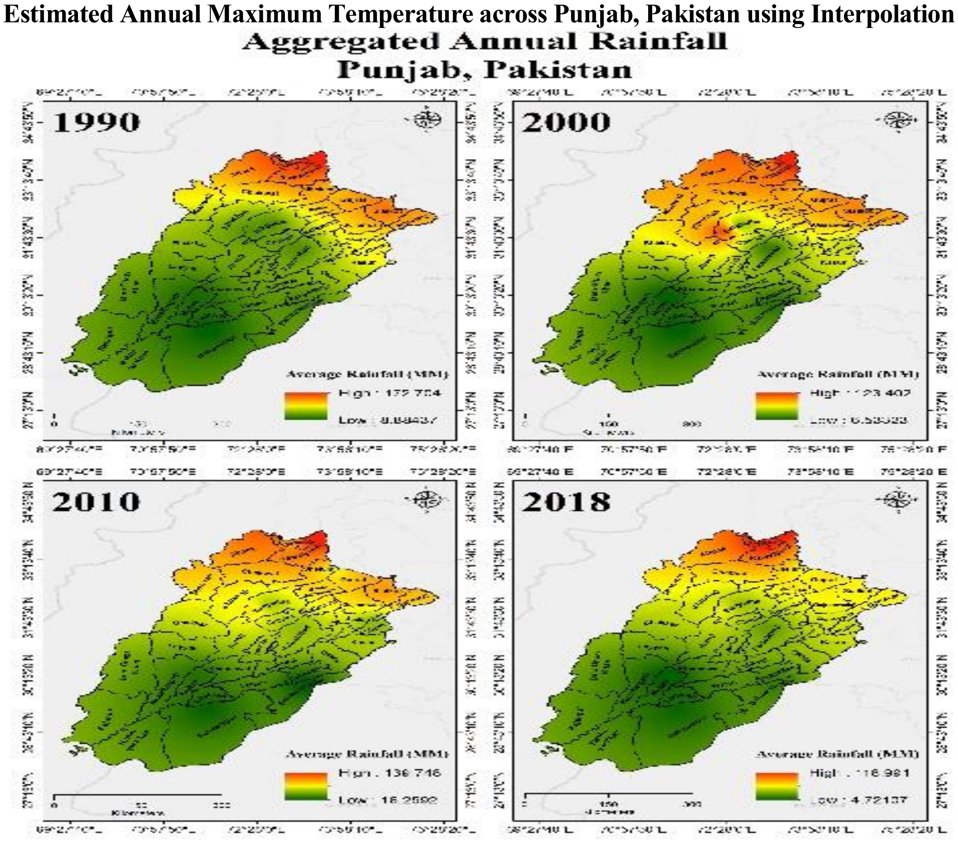

Fig. 9. Map of Estimated Annual Rainfall across Punjab, Pakistan using Interpolation (IDW) Method

Conclusions: A portion of the resulting scale, extent and nature of land cover variations is anticipated, given the rapid change in land use within Pakistan's Punjab province. This is also confirmed by the residence' reactions to the major driving forces of land use. For example, as earnings or livelihoods (for example, a source of the job) and the quality of life have proved to be a major incentive for change in land use in Punjab, the growing population of agricultural land leads to increased urbanization and land coverage. In addition, the results of meetings with farmers show that the development of suburbs and new towns in various cities of Punjab rapidly creates land changes. The fundamental problem of aggregating CO2 emissions and other atmospheric heating gases and pressurized canned goods is not solved by expanding surface albedo, which essentially dispels radiation from the air framework. If the world moves towards urbanizations, shifts that take place due to urbanization need to be understood. Cooler buildings and asphalt will also decrease temperatures at late spring, increase air quality and reduce the various problems linked to the effects of the urban heat island. Considering the importance of cool towns and proper urban infrastructure for the global climate and the complexity of types of land cover in the province of Punjab, it is possible to explore and experiment with alternative classification approaches to achieve better results. Proper urban infrastructure and several green areas in urban planning should be enforced. The study field could be further explored and future studies on the consequences of this study and its results could be ready with a focus on urban planning.

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