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SHORT COMMUNICATION

Impact of Climate Change on Land use/Land cover of Chakwal District

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Introduction

Alterations in land use and land cover, either natural or anthropogenic can disturb the balance of fragile ecosystems. Climate change plays a unique role in governing the structure and state of land features and alters the structure of ecosystem as well as its services required by earth. Human health and environment are matter of concern due to changes induced by human in its natural environment (Jat et al., 2008). Human has an urge to remain near nature, for that they shift from dense urban areas to less dense areas (Western, 2001). So is the case of new housing societies where the land mafias intimate the people about new settlements (Zaman and Baloch, 2011), which are made by cutting the forests, removing trees and disturbing the ecosystem. For proper planning and management of natural resources, it is necessary to study the land cover and its associated changes (Asselman and Middelkoop, 1995). Modelling of changes within land cover to identify environmental trends on the local, national or regional level, have been realized in the scientific community (Nath et al., 2020). GIS/RS provides continuous change dynamics (Berlanga-Robles and Ruiz-Luna, 2011) of land cover/land use, i.e. by satellite monitoring (Ruiz-Ruano et al., 2016). The understanding of land cover changes is necessary for decision making (Lu et al., 2004) in the natural resource management (Seif et al., 2012). This study was carried out to identify the impact of changes in climate upon land use and land cover of Chakwal district from 1995 to 2020. Geospatial techniques were applied to estimate the differences in land features, using different time interval satellite datasets (Table 1). Six major classes of land features including, agriculture, bare land, built-up, forest, shrubs/grass and water were selected for this study, with respect to time.

Materials and Methods

Study Area: Chakwal district is located in Potohar region at north 32°56′ and east 72°54 (Fig. 1) and covers an area of 6,604 sq. km (Mahmood et al., 2014). The data was acquired from various sources. Geographic boundary of the study area was acquired from Survey of Pakistan (2019).

Climate: Climate data was obtained from Pakistan Meteorological Department (PMD), Islamabad (2020). The data were in word files including temperature in Celsius degree and precipitation data in Millimeters (mm) from 1995 to 2020 (Fig. 2). Besides, climate data relevant information was gathered from different sources such as websites, newspaper and past research papers to get insight of past climatic events in Pakistan especially in Chakwal district between years of 1995 – 2020 (Table 2).

Satellite Imagery: Five different years, Landsat images for the month of May, were downloaded from United States Geological Survey (2020) website (http://earthexplorer.usgs.gov/). The month of May was selected, which will be better for analysis and cloud free images. Object Based Image Classification (OBIA) was used to classify the satellite images as it is regarded as the most accurate image classification technique (Ma et al., 2017). Ecognition software was used for OBIA classification. Different indices were applied to extract the required classes (Table 3).

Results and Discussion

Climate records of 1995 to 2020 reveal the climatic trend for a long time. The precipitation trend starts declining after 1996 and dry period occurred between 2000 to 2002. In 2006 the average annual precipitation was again on peak with more than 100 mm average annual rainfall. After this the rainfall pattern kept fluctuating without any record-breaking event. While temperature kept rising since 1995. Consistent ups and downs were noticed till 2015. In 2016 the hottest year was recorded which came back to normal in the coming years. In year 1995 climate followed a normal trend and no major climatic event was recorded till 1995 (Fig. 2).

Other than agriculture and built-up area all other classes decreased, as agricultural and built-up areas are directly interlinked (Fig. 3, 4, 5, 6, 7). Cultivated area in 1995 increased to 50% in 2020, only a minor decrease was observed in 2002. Bare land/soil class includes barren areas or areas where soil is exposed. Such rugged areas are common in the study area. Expanse of bare land also decreased with time from 1995 to 2020, i.e., 39.21% to 31.96% respectively.

Very sharp increase in the built-up class was observed due to industrialization and rapid urbanization. Several housing schemes and factories have come up in Chakwal district.

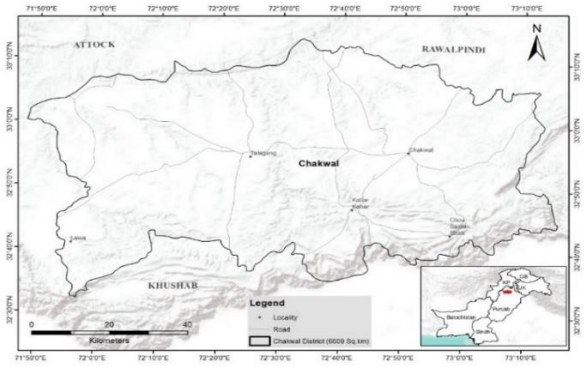

Fig. 1 Location map of the study area.

Table 1 Data sets.

Data	Source	Date
District Boundary and Base map	Survey of Pakistan (SOP)	2019
Climate Data (Temperature & Precipitation)	Pakistan Meteorological Department Islamabad (PMD)	2020
30m Landsat 8 2020	Earth Explorer USGS	2020/05/20
30m Landsat 5 2015	Earth Explorer USGS	2016/05/24
30m Landsat 5 2009	Earth Explorer USGS	2010/05/19
30m Landsat 7 2002	Earth Explorer USGS	2002/05/26
30m Landsat 5 1995	Earth Explorer USGS	1995/05/31

Table 2 Major climatic events in Pakistan.

Year	Event	Source
1998 - 2002	Punjab Pakistan Worst Droughts	Amin et al., 2019
July,2001	Cloudburst Rainfall in Islamabad Division 12-hour Heaviest Rainfall Breaking 100 Years Record	Shahid et al., 2013
June, 2005	Monsoons in Chakwal	Jameel et al., 2005
May, 2010	10 Cities with above 50° C Temperature	Abbas et al., 2013
2010	Floods in Pakistan	Shabir, 2013
2016	Hottest Year of Pakistan	
2017	Another Warmest Year for Pakistan	Merlone et al., 2019

Table 3 Indices for classification

Indices	Description	Formula	Reference
NDVI	Normalized Difference Vegetation Index	$\frac{NIR-RED}{NIR+RED}$	Ozyavuz et al., 2015
NDWI	Normalized Difference Water Index	$\frac{GREEN-NIR}{GREEN+NIR}$	McFeeters, 2013
NDSI	Normalized Difference Soil Index	$\frac{RED-SWIR1}{RED+SWIR1}$	Rasuly et al., 2010
NDBI	Normalized Difference Built-up Index	$\frac{SWIR1-NIR}{SWIR1+NIR}$	Guha et al., 2018
BSI	Barren Land Index	$\frac{Green^2 + RED^2 + NIR^2}{60}$	Ahmed and Ahmad,2013

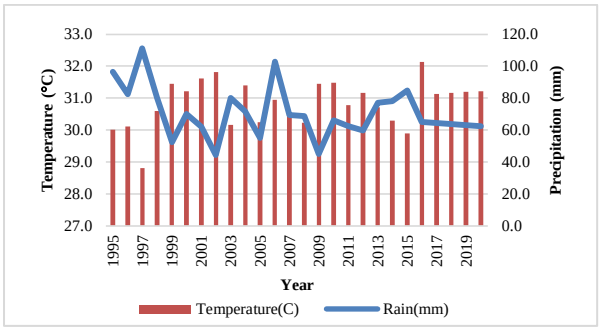

Fig. 2 Climatic data of Chakwal from 1995 to 2020.

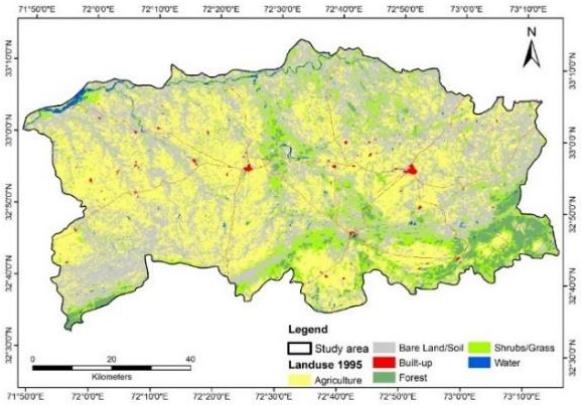

Fig. 3 Land use/land cover of Chakwal in 1995.

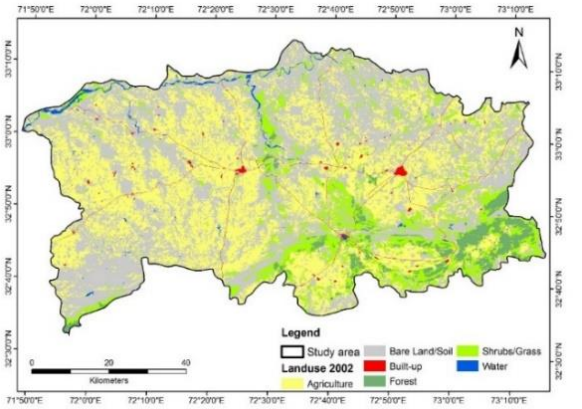

Fig. 4 Land use/land cover of Chakwal in 2002.

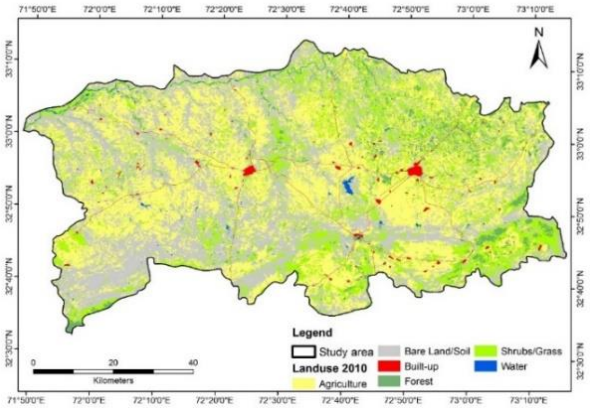

Fig. 5 Land use/land cover of Chakwal in 2010.

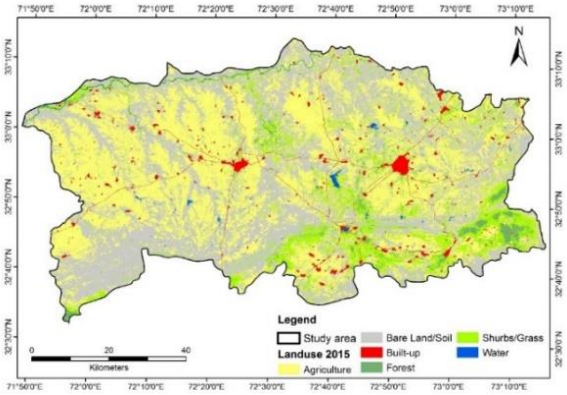

Fig. 6 Land use/land cover of Chakwal in 2015.

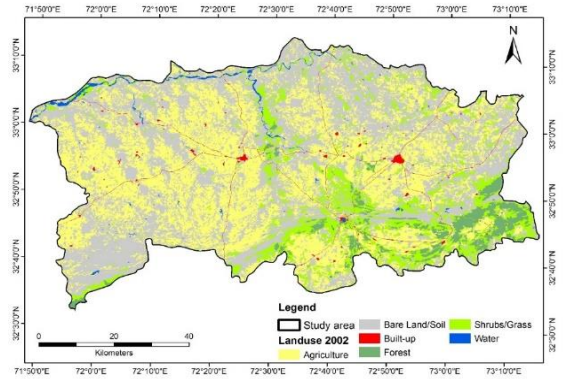

Fig. 7 Land use/land cover of Chakwal in 2020.

Built-up area increased from 0.8 to 2.29% in 2020. In 1995 forest cover was 5% of the total area which declined in 2002 to 3.5% nearly half of its size. Finally, in 2020 forest class covers an expanse of 4.3%. Shrubs/grasslands are commonly found in study area, which also serve as house to wildlife. Gradual decrease in the shrubs/grasses was observed with time. The 12.3% cover decreased to 11.3% in 2020, which is not a significant decline. Demand of water rises with the development, agriculture and population increase. The water bodies have been declining in the study area since 1995. Water was estimated to gradually decrease from 1% to 0.4% in 2020. Increase up to 4.2% was observed in 2009 due to favorable climate but this expanse eventually declined again to 3.1%. As a result, during 1998 to 2012 Pakistan suffered drought, due to erratic rain pattern. After the year 2002, precipitation followed normal trend since 2005. Chakwal is arid region where agriculture depends on water. With the increase in population the demand for food, water and consumption of land also increase. Ahmed et al., 2009, highlighted that changes in forested area of Chakwal were directly linked with climatic pattern. The maximum temperature in Chakwal was recorded in 2005-2006, i.e., 33.8 degree Celsius, while the current study identifies year 2016 as the hottest year with temperature 38.2 degree Celsius in the month of June. The forest cover in current study is also linked with the climate especially the shrubs and grass vegetation.

Conclusion

Changes in climate directly impact the land use/land cover of study area. The barren lands shrink and expand with respect to wet periods, while changes in agriculture and built-up area is a result of rapidly increasing population and infrastructure. Along adverse impacts of anthropogenic activities, government efforts for forest restoration in Chakwal brought positive impact. The shrubs/grass increased due to favorable climate, while no change was observed in the forest cover. Water bodies have seen drastic decrease since years. The study also highlights the strong link between increasing built-up infrastructure including houses, roads and industries because of population growth. The conversion of bare land into agriculture and depleting water resources in response to development. With the adoption of rainwater harvesting practices such challenges could be met. If the rainfall pattern remains same, a dire need of water and conservation practices will be required. Results of this study proves to be a detailed picture of study area's topographic changes as a result of development, which emphasizes the need for preparedness in case of flood and proper management in case of dry climate.

References

Abbas, F. (2013). Analysis of a historical (1981–2010). Temperature record of the Punjab province of Pakistan. *Earth Interactions*, **17** (15), 1-23.

Ahmed, M.A., Ahmad W. A. (2013). Barren land index to assessment land use-land cover changes in Himreen Lake and surrounding area east of Iraq. *Journal of Environment and Earth Science*, **3** (4), 15-26.

Ahmed, S.S., Fazal, S., Waleem, E.E., Zafar, I. (2009). Evaluation of ecological aspects of roadside vegetation around Havalian city using multivariate techniques. *Pakistan Journal of Botany*, **41** (1), 53-60.

Amin, M., Khan, A.A., Perveen, A., Rauf, Z., Hassan, S.S., Goheer, M.A., Ijaz, M. (2019). Drought risk assessment: A case study in Punjab, Pakistan. *Sarhad Journal of Agriculture*, **35** (1), 234-243.

Asselman, N. E. M., Middelkoop, H. (1995). Floodplain sedimentation: Quantities, patterns and processes. *Earth Surface Processes and Landforms*, **20** (6), 481-499.

Berlanga-Robles, C.A., Ruiz-Luna, A. (2011). Integrating remote sensing techniques, geographical information systems (GIS), and stochastic models for monitoring land use and land cover (LULC) changes in the northern coastal

region of Nayarit, Mexico. *GIScience and Remote Sensing*, **48** (2), 245-263.

Guha, S., Govil, H., Dey, A., Gill, N. (2018). Analytical study of land surface temperature with NDVI and NDBI using Landsat 8 OLI and TIRS data in Florence and Naples City, Italy. *European Journal of Remote Sensing*, **51**(1), 667-678.

Jameel, A., Mahmood, A., Jafri, S.A.A. (2005). Weather in Pakistan northeast monsoon season (Jan–March 2005). *Pakistan Journal of Meteorology*, **2**(4), 121-237.

Jat, M. K., Garg, P. K., Khare, D. (2008). Monitoring and modeling of urban sprawl using remote sensing and GIS techniques. *International Journal of Applied Earth Observation and Geoinformation*, **10** (1), 26-43.

Lu, D., Mausel, P., Brondizio, E., Moran, E. (2004). Change detection techniques. *International Journal of Remote Sensing*, **25** (12), 2365-2401.

Ma, L., Li, M., Ma, X., Cheng, L., Du, P., Liu, Y. (2017). A review of supervised object-based land-cover image classification. ISPRS *Journal of Photogrammetry and Remote Sensing*, **130**, 277-293.

Mahmood, T., Irshad, N., Hussain, R. (2014). Habitat preference and population estimates of indian pangolin (Manis crassicaudata) in district Chakwal of Potohar Plateau, Pakistan. *Russian Journal of Ecology*, **45** (1), 70-75.

McFeeters, S.K. (2013). Using the normalized difference water index (NDWI) within a geographic information system to detect swimming pools for mosquito abatement: A practical approach. *Remote Sensing*, **5** (7), 3544-3561.

Merlone, A., Al-Dashti, H., Faisal, N., Cerveny, R. S., AlSarmi, S., Bessemoulin, P., Rahimzadeh, F. (2019). Temperature extreme records: World meteorological organization metrological and meteorological evaluation of the 54.0 °C observations in Mitribah, Kuwait and Turbat, Pakistan in 2016/2017. *International Journal of Climatology*, **39** (13), 5154-5169.

Nath, B., Wang, Z., Ge, Y., Islam, K., Singh, R.P., Niu, Z. (2020). Land use and land cover change modeling and future potential landscape risk assessment using Markov-Ca model and analytical hierarchy process. *ISPRS International Journal of Geo-Information*, **9**, 1-25.

Ozyavuz, M., Bilgili, B.C., Salici, A. (2015). Determination of vegetation changes with NDVI method. *Journal of Environmental Protection and Ecology*, **16** (1), 264-273.

Pakistan Meteorological Department (2020). Government of Pakistan. Sector H-8/2, Islamabad.

Rasuly, A., Naghdifar, R., Rasoli, M. (2010). Monitoring of Caspian Sea coastline changes using object-oriented techniques. *Procedia Environmental Sciences*, **2**, 416-426.

Ruiz-Ruano, F. J., López-León, M. D., Cabrero, J., Camacho, J.P.M. (2016). High-throughput analysis of the satellitome illuminates satellite DNA evolution. Scientific reports, 6, 28333.

Seif, A., Mokarram, M. (2012). Change detection of Gil Playa in the northeast of Fars province, Iran. *American Journal of Scientific Research*, **86**, 122-130.

Shabir, O. (2013). A summary case report on the health impacts and response to the Pakistan floods of 2010. PLoS Currents: 5.

Shahid, J. (2013). Climate experts: Change strategy now. Dawn Newspaper.

Survey of Pakistan (2019). Ministry of Defense. Faizabad, Murree Road Rawalpindi Pakistan.

United States Geological Survey (2020). Website: http://earthexplorer.usgs.gov

Western, D. (2001). Human-modified ecosystems and future evolution. *Proceedings of the National Academy of Sciences*, **98** (10), 5458-5465.

Zaman, K.U., Baloch, A.A. (2011). Urbanization of arable land in Lahore city in Pakistan: A case-study. *Canadian Social Science*, **74** (7), 58-66.