IJASD
P ISSN : 2618-1193
E ISSN : 2709-6122

ASSESSMENT OF IRRIGATED LAND TRANSFORMATIONS IN LAHORE

Muhammad Tanveer[1], Sajid Rashid Ahmed[1], Rana Waqar Aslam[2*], Muhammad Burhan Khalid [4], Hameed Ullah[1], Aqsa Aziz[3], Waqas Abbas[4], Ali Imam Mirza[5]
[1]College of Earth and Science Department, University of the Punjab, Lahore, Pakistan.
[2] State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing (LIESMARS), Wuhan University, Wuhan 430079, China.
[3] Department of Geography, University of the Punjab, Lahore.
[4]Punjab University College of Information & Technology, University of the Punjab, Lahore.
[5] Department of Geography, Government College University, Lahore.
*Corresponding Author's Rana Waqar Aslam Email: ranawaqaraslam@whu.edu.cn.

Citation | Tanveer.M, Ahmed.S.R, Aslam.R.W, Khalid.B.M, Ullah.H, Aziz.A, Waqas.A, Mirza.A.I, "Assessment of irrigated land transformations". International Journal of Agriculture & Sustainable Development, Vol 02 Issue 04: pp 114-126, 2020.
Received | Nov 18, 2020; Revised | Dec 10, 2020 Accepted | Dec 14, 2020; Published | Dec 14, 2020.

Abstract.

Urbanization is the biggest issue of emerging economies now a days, which is badly effecting cities, and considered a communal phenomenon worldwide. In this study GIS and remote sensing techniques are used to estimate transformation of irrigated areas into built-up areas. Irrigated lands are considered most beneficial lands because these provide grain and contribute healthy in national economy. The loss of agriculture land directly effects the regional economy. We used satellite images to determine land loss in km^2 in 85 villages of district Lahore. The results show that the irrigated area has been transformed into integrated areas. The overall discharge of Khariam BRBD decreased by 46.13; Niaz Beg Disty decreased by 42.45; Badoki Minor is decreased by 0.8 and Raiwind Disty by 2.2; The null discharge of KohaliDisty and Ladhiki is measured. A deemed management system is significant for maintaining or serving irrigated land and development, resulting in substantial environmental and socio-economic implications for these imperious lands.

Keywords: Irrigated Lands; Landcover, Remote Sensing, GIS.

INTRODUCTION

The masses migrate towards developed cities for the sake of basic human needs [1]. The development of urban structures around the world is documented as the key frontier for environmental decimation that begins with natural disasters and then ends the species[2]. Despite its value, urbanization is linked to major repercussions on neighboring environments [3]. The big cities are the main hub of social and economic development [4].

Agricultural land degradation is appraised through anthropological exercises in urbanization [5][6]. The functioning of biological communities is affected by remarkable

transition in traditional urban environments [7]. Rapid urbanization and the population growth, have increased many problems at domestic level as well as at commercial level[8]. It is a notable force driving changes such as LULCC, biodiversity misfortune, biogeochemical cycles, hydrological systems and the atmosphere [9]. The population growth is another remarkable operator associated with the tremendous development seen in urban extension [10]. According to Sidddiqi (2004)et.al, the population of Lahore increased up to 6.32 million by the migration of 1.03 million people which is almost 16.4 percent of the whole country's population [11][12].

Land cover can be altered by many forces other than anthropogenic activities. The land can also be modified by natural clematises such as weathering, climate changes, floods, burning, volcanic activity, and biome dynamics. Numerous human activities, including agriculture, deforestation, livestock farming, urban and suburban growth are changing the land cover globally [13].

Typical and traditional land-use mapping methods are time taking and expensive which result in multiple errors. These approaches and procedures have become obsolete with the advent of latest technologies e.g., utility of satellite imagery. The GIS and Remote Sensing techniques are time saving in both spatial and temporal aspects [14].

Xiaomei stated in 1999 that land maps and natural resources management must be maintained and collected in order to update the land use. This data can be directly gathered by field visits of different sites or remote sensing equipment [15]. Change detection [16] is an art of mapping temporal changes about any feature at different times. The process of identifying change is an important tool of natural resource management and surveillance as it offers quantitative analysis data to detect the spatial variation [17].

Arvind C Pandy and MS Nathawat examined that land cover patterns are controlled by agro-climate conditions and influenced by water existing drainage patterns. The satellite images are available freely with large temporal resolution in comparison to aerial photographs. The aerial photographs are costly and available with smaller extents [18].

Population growth, different socio-economic activities and other natural phenomena cause rapid changes in the land use and land cover (LULC). This research emphasizes that land cover changes pose a danger to natural resources. Urbanization has put huge pressure on available reservoirs of fresh water, sanitation and food requirements [19]. Essential resources that play a key role in the area's social-economic growth will be lost soon, if we failed to manage these reserves [20].

The main objective of this research is to show a quantitative understanding of the shift in land cover in Lahore between 1999 and 2019. These shifts can be indicated by maps drawn using ARC GIS 10. This study also showed both the rise and decrease in various LULC groups from the year 2000 to 2016 [21].

Significance of Irrigated Agricultural Land

Human survival is largely dependent high quality agricultural productivity. Uncontrolled irrigated farming may endanger the sustainability of ecosystem. The coastal areas having fertile soil and subsequent supply of water are favorable for agriculture. In irrigated agricultural lands, water usage productivity can be increased by increasing yield, reducing water depletion, eliminating unusable water sinks, and allocating water for sophisticated precedence uses.

Loss of Irrigated Land

Urbanization has become a hot issue in context of environmental and socio-political scenarios which is addressed at every forum internationally [22]. Globally, urbanization takes place as a result of rapid economic development and population growth. Many countries face extreme agricultural land loss as a result of rapid urbanization. In developed countries, where urbanization has fallen behind developing countries, agricultural land loss is particularly prominent. In these countries, industrialization and urbanization had left a permanent mark on rural land use and had significantly altered the sustainability of irrigated land. Therefore, it is important to understand the characteristics and mechanisms of agricultural land conversion [23].

There are three common characteristics in developing countries that transform agricultural land into urban land [24]. First of all, agricultural land is intensively reduced due to residential and industrial growth. Secondly, peri-urban agriculture is intensified, under pressure of population growth and agricultural land reduction, and has become commercially focused [25]. Third, the agricultural landscape's spatial dynamics change as a result of urbanization. Agricultural parks have become smaller and less associated in the peri-urban region leading to habitat decay. Habitat fragmentation is also a process where the habitat is converted into many smaller areas with a smaller total area and separated by the habitat matrix from the beginning [26].

Objectives of the Study

The objectives of the study is to appraise as following:

- Conversion of irrigated cropland of Lahore by remote sensing and GIS from 1999 to 2019.
- The amount of the water saved from the conversion of irrigated croplands.

Material and Methods.

Investigation site. Lahore is Pakistan's second-largest city and the capital of the province Punjab covering an area of 1762km^2 between 31°15'-31°45'N and 74°01' and 74°39'E. It lies in north-west side of the district of Sheikhupura, to the east by the Wahgah frontier, and to the south by district of Kasur [27] mapped in Figure 1. A comparative picture of Lahore is shown in Figure 2, as it was in 1999 and in 2019. Zone wise map of Lahore is shown in Figure 3.

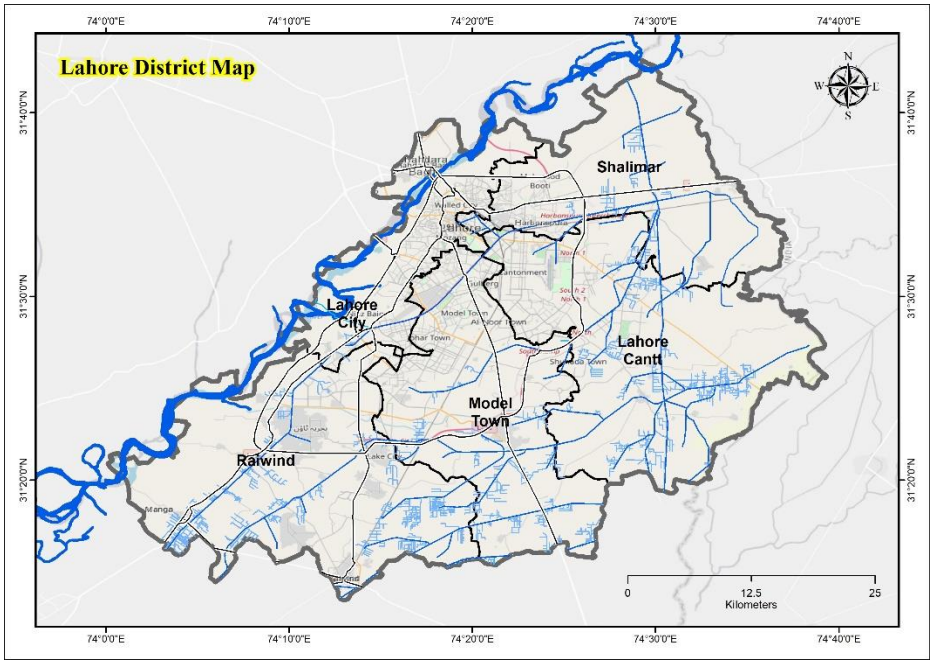


Figure 1. Location map of the study area

Data Sets and Sources

We used three kinds of datasets including satellite images downloaded from Glovis, irrigated data from Urban Unit Lahore and Built-up form digitization of satellite image.

Table 1. Sources and data layers.

Data Layers	Sources
Satellite images	https://glovis.usgs.gov/
Irrigation network data	The Urban Unit
Builtup (2019)	Digitization and satellite image

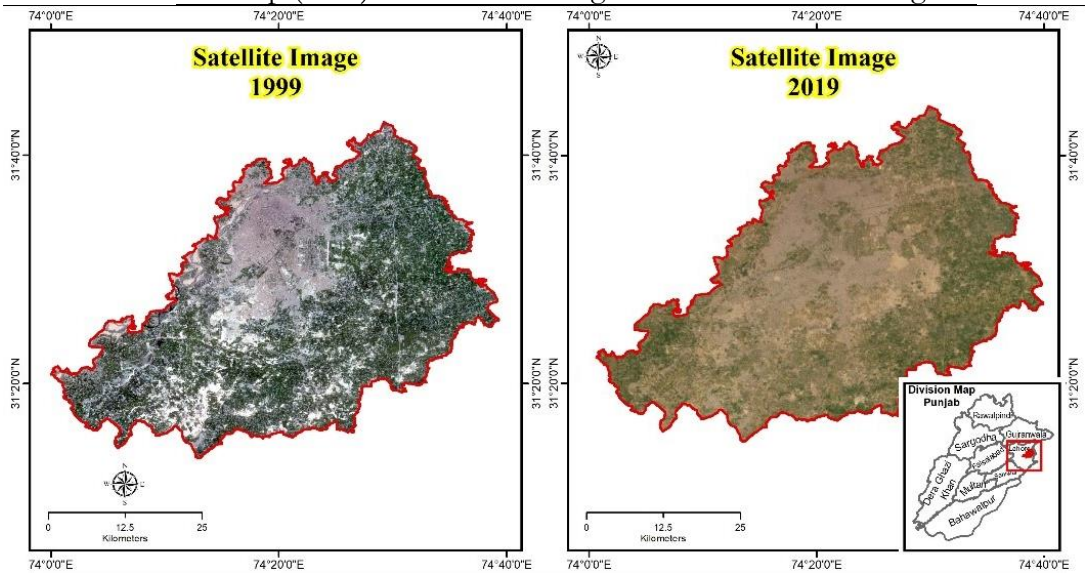
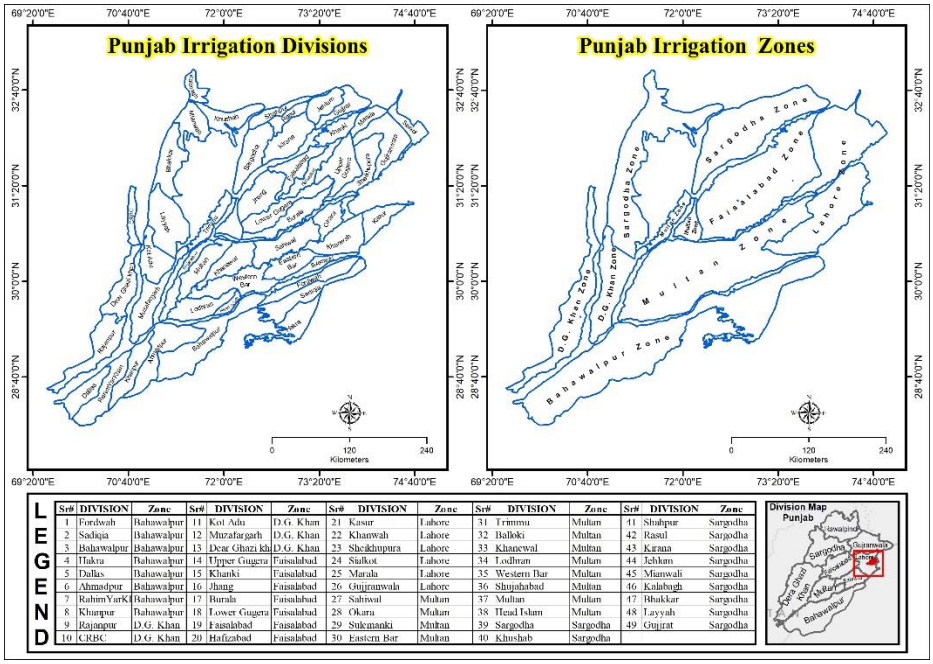


Figure 2. Satellite imagery of 1999 and 2019



Sr#	DIVISION	Zone	Sr#	DIVISION	Zone	Sr#	DIVISION	Zone	Sr#	DIVISION	Zone	Sr#	DIVISION	Zone
1	Fordwah	Bahawalpur	11	Kot Adu	D.G. Khan	21	Kasur	Lahore	31	Trimmu	Multan	41	Shahpur	Sargodha
2	Sadiqia	Bahawalpur	12	Muzafargarh	D.G. Khan	22	Khanwah	Lahore	32	Balloki	Multan	42	Rasul	Sargodha
3	Bahawalpur	Bahawalpur	13	Dear Ghazi kh	D.G. Khan	23	Sheikhupura	Lahore	33	Khanewal	Multan	43	Kirana	Sargodha
4	Hakra	Bahawalpur	14	Upper Gugera	Faisalabad	24	Sialkot	Lahore	34	Lodhran	Multan	44	Jehlum	Sargodha
5	Dallas	Bahawalpur	15	Khanki	Faisalabad	25	Marala	Lahore	35	Western Bar	Multan	45	Mianwali	Sargodha
6	Ahmadpur	Bahawalpur	16	Jhang	Faisalabad	26	Gujranwala	Lahore	36	Shujahabad	Multan	46	Kalabagh	Sargodha
7	RahimYarKh	Bahawalpur	17	Burala	Faisalabad	27	Sahiwal	Multan	37	Multan	Multan	47	Bhakkar	Sargodha
8	Khanpur	Bahawalpur	18	Lower Gugera	Faisalabad	28	Okara	Multan	38	Head Islam	Multan	48	Layyah	Sargodha
9	Rajanpur	D.G. Khan	19	Faisalabad	Faisalabad	29	Sitkanaki	Multan	39	Sargodha	Sargodha	49	Gujrat	Sargodha
10	CRBC	D.G. Khan	20	Hafizabad	Faisalabad	30	Eastern Bar	Multan	40	Khushab	Sargodha			

Figure 3. Punjab Irrigation Divisions and Zones Map

NDVI

The Normalized Vegetation Difference Index (NDVI) was applied to both 1999 and 2019 images to compute the extent of vegetation. The coverage of vegetation is an important indicator for the measurement of vegetation extent via Landsat images. The NDVI functions on the basis of the representation of complex green vegetation patterns. The NDVI helps to determine targets or entities using remote sensing requirements from a remote platform. As specified in equation 1, NIR and Red channels are used for computation of NDVI.

Equation (1)

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Image preprocessing

First, the ETMþ Landsat image was geometrically corrected with by applying GCPs and 99% features were correlated with their position on the surface of earth.

Mapping built-up area

Following the NDVIc image, a continuous NDBI, NDBIc and the BUc image were directly extracted from the Landsat ETMβ image. To determine the optimum threshold value NDVIc, NDBIc and BUc have been standardized from 0 to 255. A random stratified sampling approach was used to assess the NDBI method efficiency in 80 samples in each build-up and non-built field.

Result and discussion.

The results determined that almost 80.35 km^2 area of Raiwind Tehsil, 56.16 km^2 area of Cantt, 39.69 km^2 area of Model Town, 19.34 km^2 area of Shalimar town and 16.06 km^2 area of Lahore city has been transformed in to non-irrigated land which was extensively utilized for agriculture before the development of colonies to provide settlement for migrants.

Table 2: Tehsilwise vegetation area in km^2 from 1999 to 2019

Tehsil Name	Area/Sq km 1999	Area/Sq km 2019

Cantt Tehsil	277.60	221.44
Lahore City Tehsil	49.33	33.27
Model Town Tehsil	139.26	99.57
Raiwind Tehsil	247.35	167.45
Shalimar Tehsil	156.66	137.32

Figure 4 is showing a comparison of built-up area between 1999 and 2019. In 1999, total built-up area was 284 sq km, which increased to 716 sq km in 2019. Figure 5 showed the comparison of vegetation between 1999 and 2019. In 1999, total vegetation area was 870 sq km, which decreased to 659 sq km in 2019 and converted into a built-up area. Figure 6 showed the comparison of barren land between 1999 and 2019. In 1999, total barren land was 578 sq km, which decreased to 319 sq km in 2019 and converted to a built-up area. Figure 7 is a detailed landcover/land-use map of Lahore showing a comparative transformation from 1999 to 2019. Figure 8 is showing the existing irrigation network in the Lahore district for 1999 and 2019.

A total of 350 cusecs water was reserved, while over 250 cusecs water was distributed into three channels (BatapurDisty, KohaliDisty and Bucher Kana Disty Reserve) which enough for 85 villages as shown in Figure 9.

The results show that the suggested NDBI solution was 86.30 percent accurate. The original NDBI method was also applied to produce binary built-up imagery and tested the accuracy of both results. The results showed that the initial NDBI approach was 74.38 percent accurate. After an inadvertent urbanisation in Lahore district, irrigated farming in Lahore is getting declined every day. Some of the distributors for recharge are listed below,

Badoki minor

Badoki Minor of Bucharkhana disty has an affiliated Bambanwali Ravi BedianDipalpur (BRBD) channel Bucharkhana distributary connection. Badoki irrigates tehsil Model city & tehsil Raiwind. It has 15.95 cusec water for automatic Flow System Discharge (AFS Discharge), and its net recharge remains at 15.15 cusec, after a reduction of 0.8 cusecs, it comes from the Pandoki subdivision.

Kharian distributary

The BRBD connecting channel Kharian distributary is the parent BRBD connection channel which is the main resource channel of Lahore district. Kharian disty is divided into the Lahore irrigation system subdivision with a (AFS) of 132,89 cusec and 46,13 cusec, the final net flush of which is 86,76 cusec. The distributary of Kharian is irrigating the land of Lahore Cantt, Model Town and Tehsil Raiwind.

Niaz Baig distributary

The distribution of Niaz Baig falls in Raiwind Tehsil with a flow of 261 cusecs (AFS discharge).

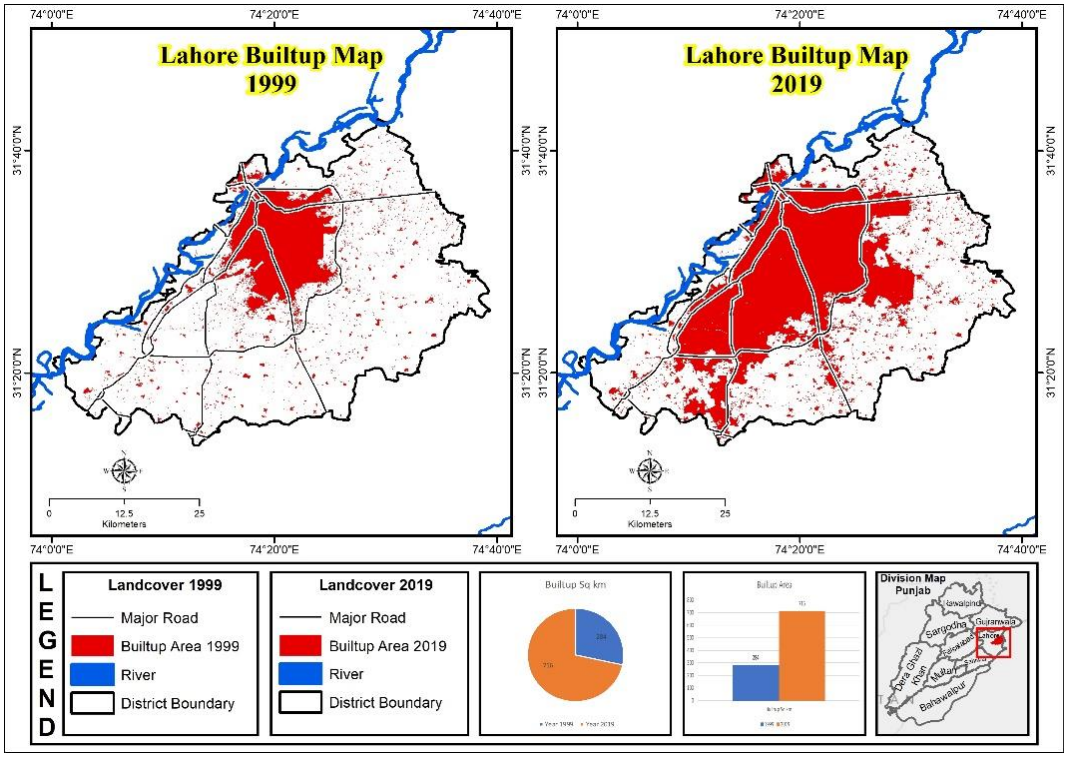


Figure 4. Builtup area of Lahore district 1999 & 2019

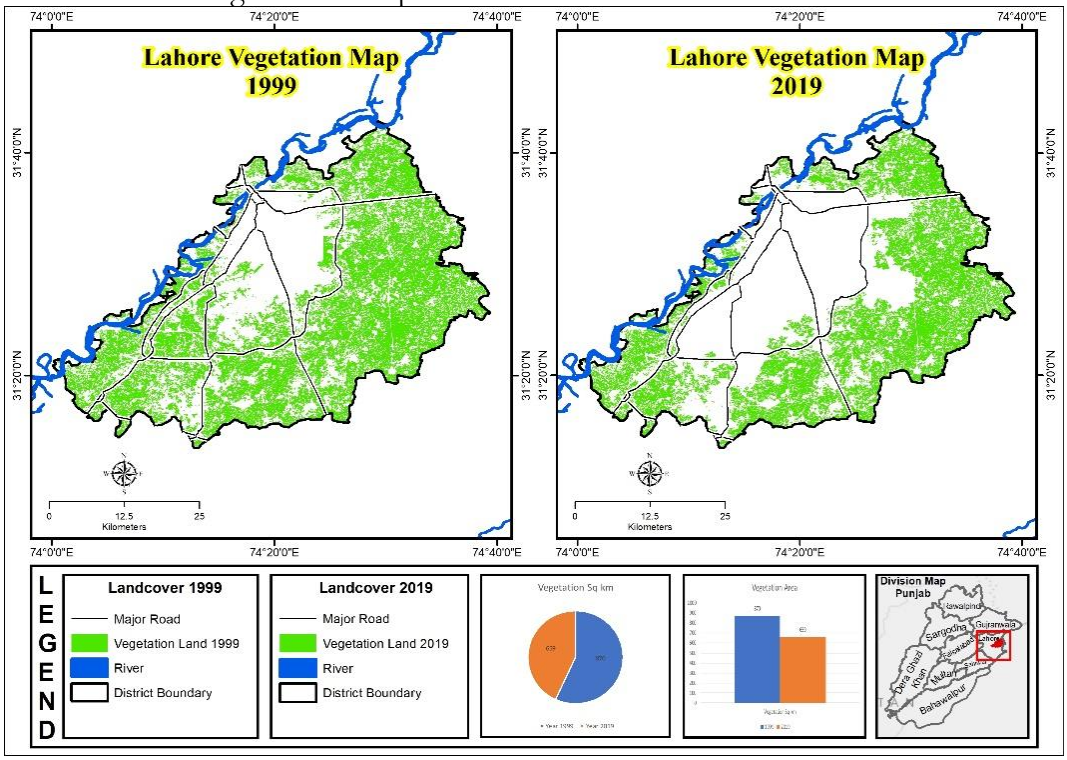


Figure 5. Vegetation area of Lahore district 1999 & 2019

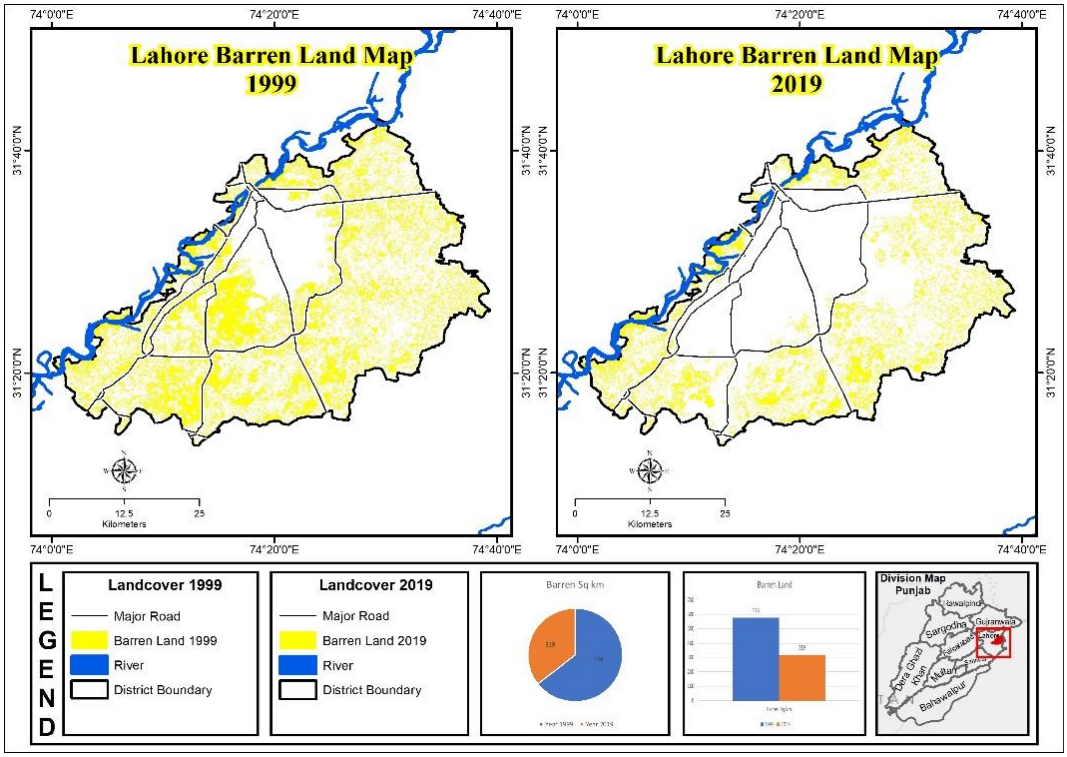


Figure 6. Barren land area of Lahore district 1999 & 2019

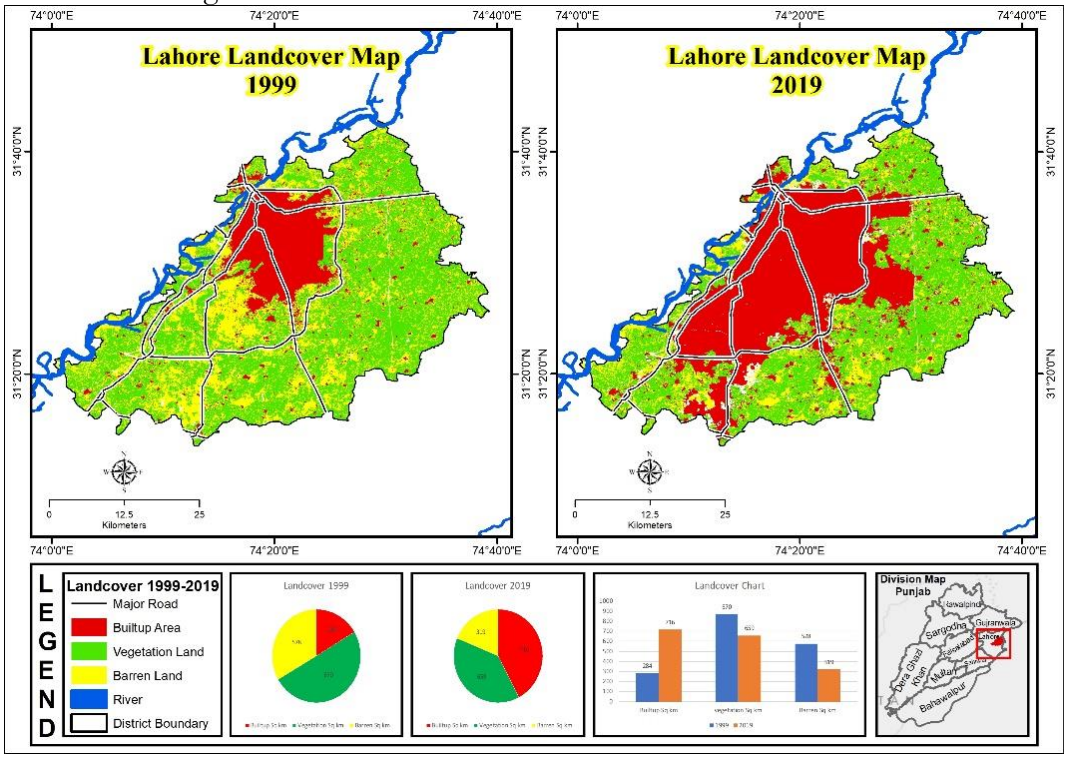


Figure 7. Landcover Map of Lahore district 1999 & 2019

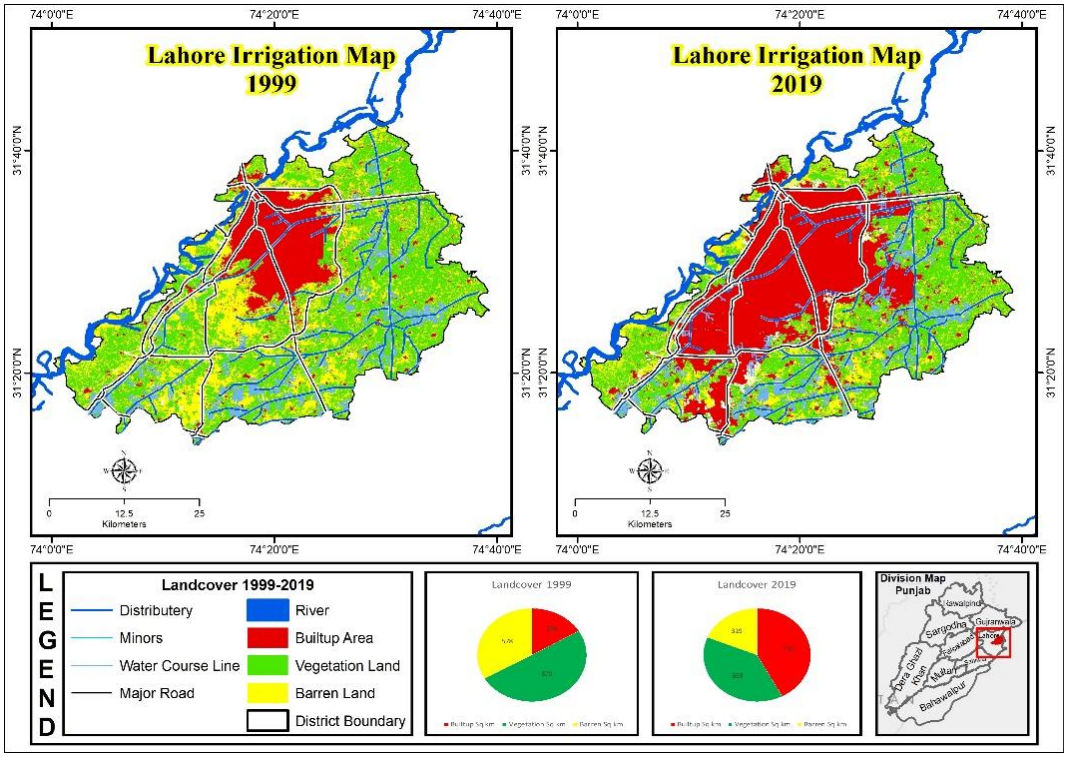


Figure 8. Irrigation Map of Lahore district 1999 & 2019

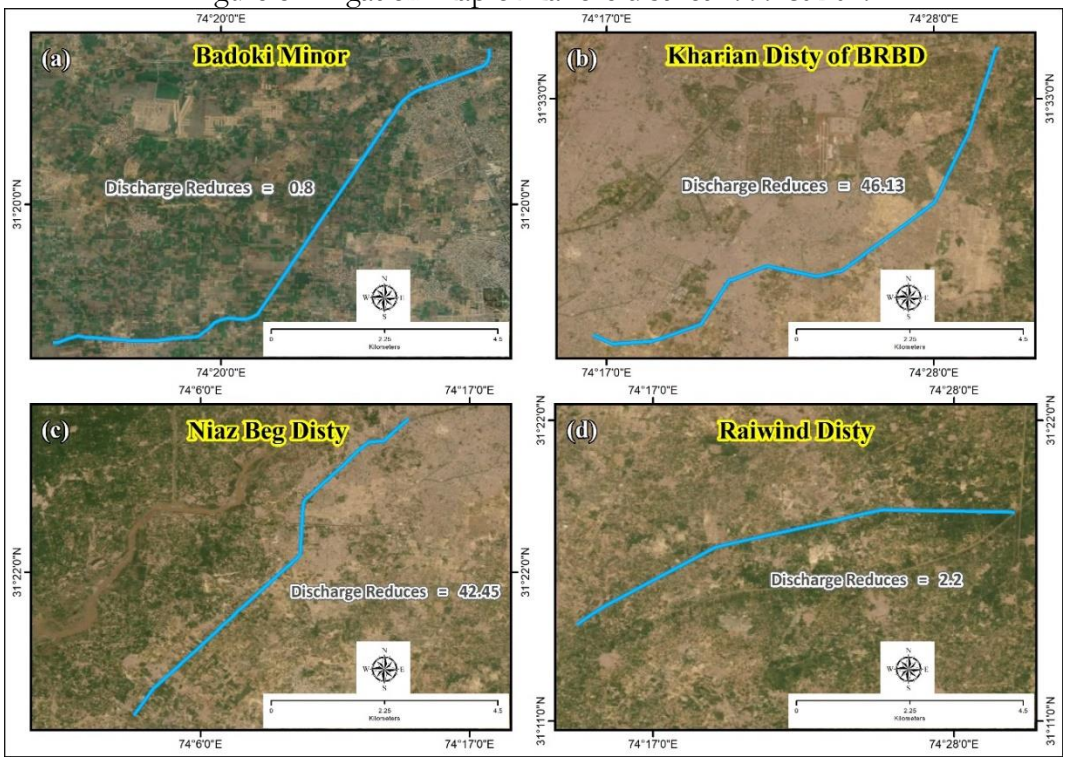


Figure 9. Discharge reduced analysis, (a) Badoki minor, (b) Kharian distributary of BRBD, (c) Niaz Beg Distributary, (d) Raiwind distributary.

Raiwind distributary

Raiwind is part of the Pandoki subdivision and its parent channel is the BRBD Link Main Branch Lower (M.B.L). Raiwind distributes Tehsil Model Town and Tehsil Raiwind irrigated land and joins the Kasur district. The distributary Raiwind (AFS Discharge) provides 85 cusecs and is down to 2.2 cusecs, the final net discharge stands at 82.8 cusecs. Figure 11 indicates the reduced discharge of the Raiwind distributor.

Certain distributors in Lahore have a net zero discharge reduction. Their flow remains unmodifiable for all release free cycles, some of their distributaries have been shut down and their water usage for irrigation or irrigation lifts, number of distribution units for the Lahore Subdivision, Batapur Subdivision and Padoki Sub are shut down to supply the water and the irrigation lifts to other distributaries as shown in Figure 10.

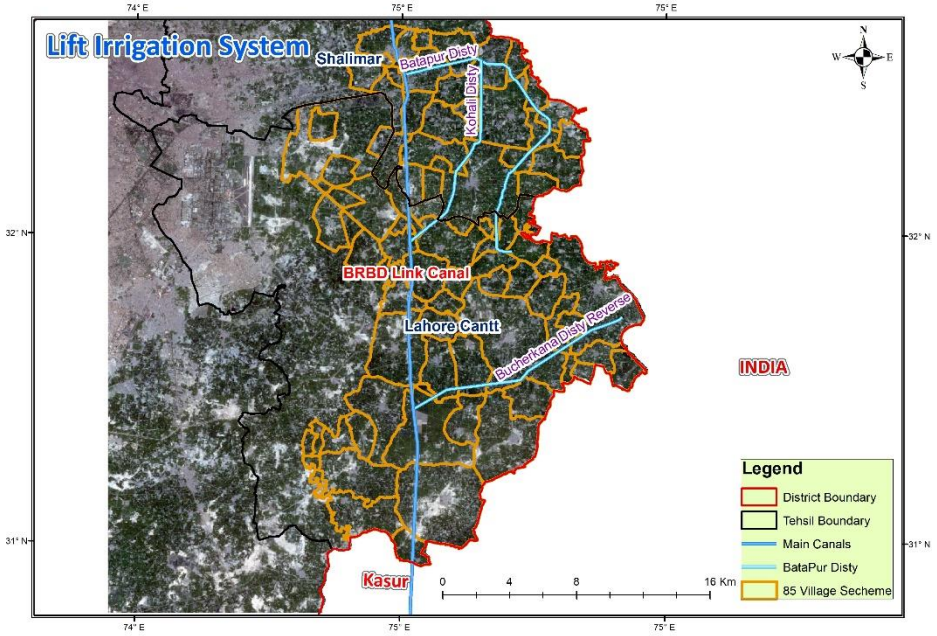


Figure 10. Lift irrigation (85 villages scheme)

Lift Irrigation System

The irrigation department, the Govt. of Punjab, introduced the lift irrigation system to irrigate the land where the irrigation channel that came from India had been closed. With the lift irrigation system, the land of tehsil Shalimar & tehsil Lahore Cantt near the Border area was irrigated through the new channels like Batapur, Kohali and Bucherkana distributaries. These channels are recharged from the water saved by the reducing recharge from different channels because of the unplanned urban expansion.

Conclusion.

This study incorporates land-based classification techniques into irrigated areas to establish an overview of transformation of area to improve our understanding about spatial changes in land use in the District of Lahore. The research shows that Raiwind and Lahore Cantt Tehsil are transformed at high rates, from 80.35 km^2 to 56.16 km^2. The reserve water has already been used in 85 villages and the remaining 100 cusec reserve water in Lahore division can be used elsewhere when needed for agriculture only.

Suggestions.

The urban extension cannot be avoided. It can be regulated and managed in a required and sustainable manner with proper planning and management, safeguarding productive plant land and groundwater. This is why, a ban on the development of new housing companies in Lahore is proposed. These housing societies use groundwater rather than irrigation water, so groundwater is being decreased every day.

Acknowledgement. Acknowledgments are considered necessary.

Author's Contribution. All authors have contributed equally.

Conflict of interest. The authors declare no conflict of interest in publishing this manuscript in IJASD.

REFRENCES

1. Anderson, e. a. (1976). A Land Use and Land Cover Classification System for Use with Remote Sensor Data. Geological Survey Professional Paper No. 964,. Washington, D.C.: U.S. Government Printing Office, Washington, D.C.
2. Aslam, Rana & Saeed, Urooj & Mehmood, Hammad & Ullah, Hameed & Younas, Imtiyaz. (2017). Impure Water, a Future Disaster: A Case Study of Lahore Ground Water Quality with GIS Techniques.
3. Aslam, Rana & Amjad, Dania &Kausar, Sumaira& Sarwar, Faiza. (2019). Land cover change analysis and impacts of deforestation on the climate of District Mansehra, Pakistan. Journal of Biodiversity and Environmental Sciences. 14 (6). 103-113. 10.6084/m9.Figureshare.13352873.v1.
4. Butt, A., Shabbir, R., Ahmad, S. S., & Aziz, N. (2015). Land use change mapping and analysis using Remote Sensing and GIS: A case study of Simly watershed, Islamabad, Pakistan. The Egyptian Journal of Remote Sensing and Space, 18, 251–259.
5. Cheruto, M. C., Kauti, M. K., Kisangau, P. D., & Kariuki, P. (2016). Assessment of Land Use and Land Cover Change Using GIS and Remote Sensing Techniques: A Case Study of Makueni County, Kenya. Journal of Remote Sensing & GIS, 5(4).
6. DiBari, J. N. (2007). Evaluation of five landscape-level metrics for measuring the effects of urbanization on landscape structure: The case of Tucson, Arizona, USA. Landscape and Urban Planning, 79, 308–313.
7. Grimm, N.B.; Faeth, S.H.; Golubiewski, N.E.; Redman, C.L.; Wu, J.G. Global change and the ecology of cities.Science 2008, 319, 756–760. [CrossRef] [PubMed]
8. Hahs, A.K.; McDonnell, M.J.; McCarthy, M.A.; Vesk, P.A.; Corlett, R.T. A global synthesis of plant extinction rates in urban areas. Ecol. Lett. 2009, 12, 1165–1173.
9. Holdgate, M.W. The sustainable use of tourism: A key conservation issue. Ambio 1993, 22, 481–482.World Health Organization. Urbanization: Urban Population Growth.
   Availableonline:http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/ (acessed on 12 October 2015).
10. J.F, O. (1983). Monitoring Urban Land – Use in Developed Countries – An aerial photographic approach. Environmental Int, 9, 27 – 32.

11. Lopez, E.; Bocco, G.; Mendoza, M.; Duhau, E. Predicting land cover and land use change in the urban fringe a case in Morelia City, Mexico. Landsc. Urban. Plan. 2001, 55, 271–285.
12. Meyer, W. (1995). Past and Present Land-use and Land-cover in the U.S.A. Consequences. 24-33.
13. Meyfroidt, P., & Lambin, E. F. (2008). Forest transition in Vietnam and its environmental impacts. Global Change Biology, 14,1–18
14. Nathawat, A., Pandy, C., & S., M. (2006). Land Use Land Cover Mapping Through Digital Image Processing of Satellite Data – A case study from Panchkula, Ambala and Yamunanagar Districts, Haryana State, India.
15. Pham, V. C. et al. (2015) 'The conversion of agricultural land in the peri- urban areas of Hanoi (Vietnam): patterns in space and time', Journal of Land Use Science. Taylor & Francis, 0(0), pp. 1–19. doi: 10.1080/1747423X.2014.884643.
16. Riebsame, W.E., M. W., & Turner, B. I. (1994). Modeling Land-use and Cover as Part of Global Environmental Change. Climate Change. 28, 45.
17. Seto, K.C.; Kaufmann, R.K.;Woodcock, C.E. Landsat reveals China's farmland reserves, but they're vanishing fast. Nature 2000, 406, 121–121.
18. Tahir, Muhammad & Ahmad, Sajid & Aslam, Rana & Ahmad, Israr & Ullah, Hameed & Aziz, Aqsa & Zubair, Muhammad Hamza & Mirza, Ali & Hassan Raza, Dr-Syed. (2020). CRITICAL STUDY OF GROUNDWATER QUALITY OF METROPOLITAN LAHORE USING GEO-SPATIAL TECHNIQUES. 2. 89-105. 10.6084/m9.Figureshare.13352717.v1.
19. Turner, B.L.I. Local faces, global flows: The role of land use and land cover in global environmental change.Land Degrad. Dev. 1994, 5, 71–78.
20. Y, X., & Ronqing L.Q. Y. (1999). Change Detection Based on Remote Sensing Information Model and its Application to Coastal Line of Yellow River Delta. Earth Observation Center, NASDA, China.
21. Yuan, F.; Sawaya, K.E.; Loeffelholz, B.C.; Bauer, M.E. Land cover classification and change analysis of the
22. Singh, A. (1989). Digital Change Detection Techniques Using Remotely Sensed Data. International Journal of Remote Sensing, 10(6), 989-1003.
23. Gillani.S.A, Rehman.S, Ahmad.H.H, Rehman.A, Ali.S, Ahmad.A, Junaid.U, and Ateeq.Z.M Appraisal of Urban Heat Island over Gujranwala and its Environmental Impact Assessment using Satellite Imagery (1995-2016). International Journal of Innovations in Science and Technology, Vol 01 Issue 01: pp 1-14, 2019.
24. Saifullah.M, Zafar.M, Sohail.A, Mehmood.F, Musharaf.M, Khan.J, Ashfaq.A and Mahmood.S.A. "Appraisal of Urban Sprawl in Mega Cities of Punjab Pakistan in context of Socio-Political Issues using RS/GIS". International Journal of Innovations in Science & Technology, Vol 01 Issue 03: pp 108-119, 2019.
25. Imran.R.M, Rehman.A, Khan.M.M, Jamil.M.R, Abbas.U, Mahmood. R.S, and Mahmood.S.A, Ehsan. U.H. Delineation of drainage network and estimation of total

discharge using Digital elevation Model (DEM). International Journal of Innovations in Science and Technology, Vol 01 Issue 02: pp 50-61, 2019.

26. Imran.R.M, Rehman.A, Khan.M.M, Jamil.M.R, Abbas.U, Mahmood. R.S, and Mahmood.S.A, Ehsan. U.H. Delineation of drainage network and estimation of total discharge using Digital elevation Model (DEM). International Journal of Innovations in Science and Technology, Vol 01 Issue 02: pp 50-61, 2019.
27. Saifullah.M, Zafar.M, Sohail.A, Mehmood.F, Musharaf.M, Khan.J, Ashfaq.A and Mahmood.S.A. "Appraisal of Urban Sprawl in Mega Cities of Punjab Pakistan in context of Socio-Political Issues using RS/GIS". International Journal of Innovations in Science & Technology, Vol 01 Issue 03: pp 108-119, 2019.