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Use of GIS and RS Tools for Analysis of Land Use Land Cover and Land Surface Temperature: A Case Study of District Khairpur, Pakistan

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Abstract:

Land use and land cover (LULC) monitoring plays an important role in sustainable planning and management of resources. This research focuses on analysing historical LULC changes over the Khairpur district of Sindh province of Pakistan. Remote Sensing and Geographic Information System (RS & GIS) tools have been employed using the maximum likelihood algorithm of the supervised classification method. Temporal data of the latest high-resolution satellite imagery provided by NASA GLCF (Global Land Cover Facility), Landsat 8 Operational Land Imager (OLI), and Landsat 4, 5 Thematic Mapper (TM) for 2001, 2010, 2015, and 2020 were acquired from Earth Explorer of United States Geological Survey (USGS). The study area is classified into four major classes namely Barren Land, Vegetation, Built-up areas, and Water Bodies. Analysis revealed that for 2001 and 2005 there was no change in barren land area, whereas in 2010 slight decrease in barren land was found which further decreased for the analysis period of 2020, overall barren land class decreased at a rate of 07% (i.e., 74% to 67%) during the analysis period. Also, vegetation and water bodies classes experienced variations throughout the analysis period, however built-up areas showed constant increase throughout the analysis period where built-up area classes increased from 9% to 15%. Whereas land surface temperature (LST) throughout the analysis period showed increasing trends, for both high ranges and low ranges. It was analysed that the areas having dominancy of the barren land class experienced the highest temperature ranges whereas low temperature ranges were discernible in the areas having vegetation covers. It can be concluded from the study that barren land covers the major area of the study area and there is an increase in built-up areas which can further enhance the LST in the study area.
Keywords: USGS; ArcGIS, NASA GLCF; Built-up; Barren Land; Vegetation, Water Bodies

1. Introduction

Land cover land use change (LCLUC) has been identified as a factor influencing environmental change in the landscape on a worldwide scale in recent years (Kharazmi et al., 2018). Land use and Land cover are used to manage natural resources and track ecological changes. (Xie et al. 2008; Ibharim et al. 2015; Kantakumar and Neelamsetti 2015; Lin et al. 2015). One of the primary causes of the Earth system's land degradation processes is changes in land use and cover. LULC (Verburg et al. 2011).

Nevertheless, multitemporal satellite photos images have not been as widely utilized for LULC change planning assessment and monitoring in semi-arid and dry arid regions (Aredehey et al., 2018). These days, a lot of researchers investigate the relationship between LST, NDVI, and land use/cover using GIS and remote sensingRS techniques (Dong, et al. 2018)

Furthermore, because LULC modifications typically impose have an imminenta negative influence on the state and integrity of ecosystem functioning, they need greater consideration in land management (Quintas-Soriano et al. 2016). The availability of Landsat data facilitates better land cover monitoring and assessment of huge areas in fast-developing regions. (Kharazmi et al. 2018). The physical characteristics of the land's surface, such as forests, rivers, agriculture, and urban infrastructure, are referred to as land cover (LC). On the other hand, Landuse (LU) is the alteration of LC according to human needs and behaviour. LC is a reliable predictor of LU .(Udin & Zahuri, 2017).

2. Study Area

The study area will be bounded by the Khairpur district of middle and northern Sindh Pakistan. It was situated on the left side of the River Indus. The co-ordinate of Khairpur district is 27°31'46.13" N 68°45'42.12"E. The district of Khairpur is situated on a smooth plain and consists of eight tehsils: Khairpur

(District headquarters), Kangri, Gambat, Sobhadero, Kot Diji, Nara, Thari Mirwah, and Faiz Gunj. The district of Khairpur is bounded on the east by India, on the north, Shikarpur and Sukkur, South Sanghar and Shaheed Benazeerabad, and the West Larkana and Noshoro Feroz. The climate of Khairpur was typically that of the upper Sindh region. There are two well-defined seasons, hot and cold. The former begins at the end of March and extends till October. May, June, and July are the hottest months. During this period, the mean maximum and minimum temperatures are about 42°C and 27°C, respectively. December, January, and February were the coldest months. During this period, the mean maximum and minimum temperatures were about 25°C and 7°C, respectively.

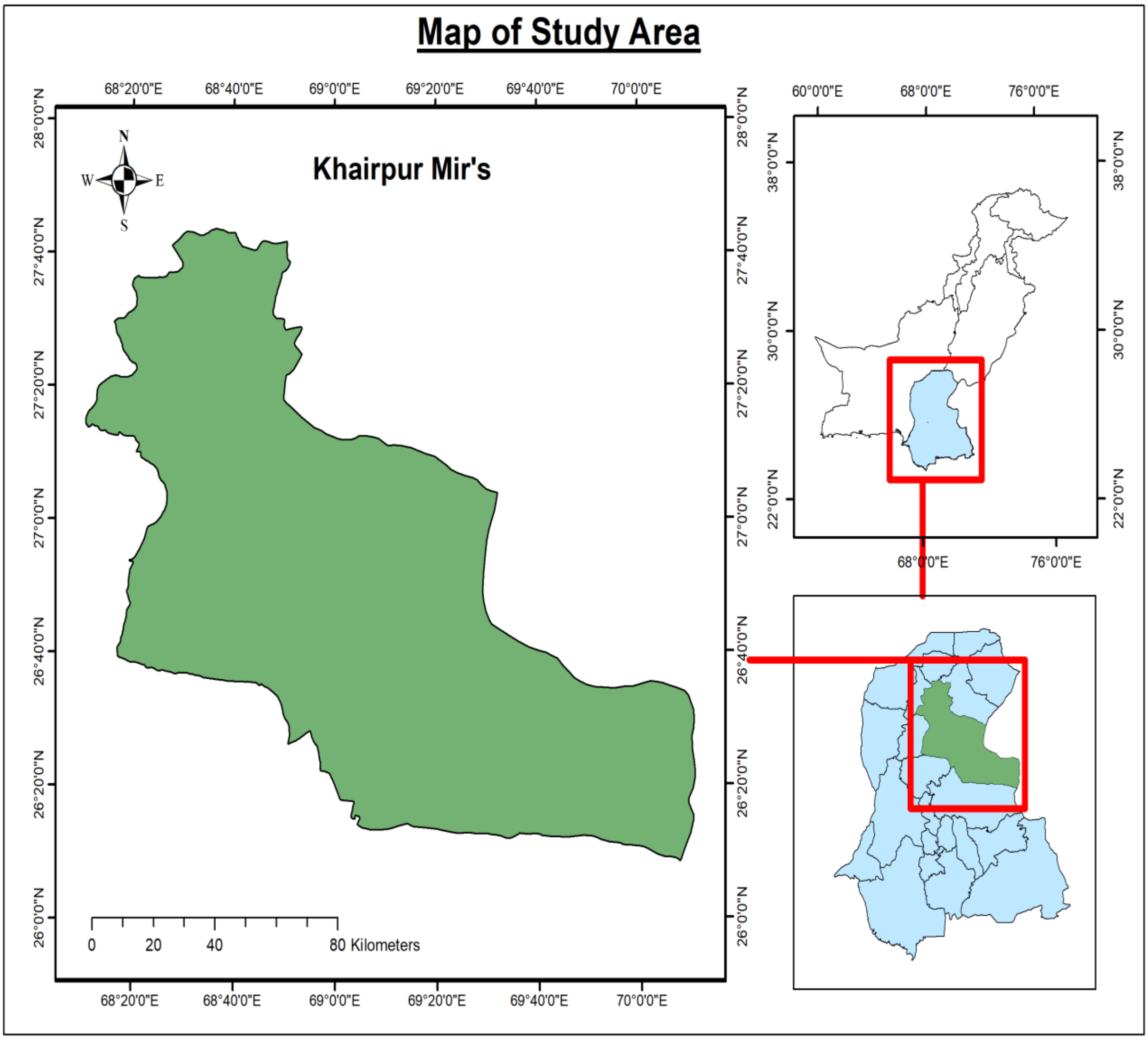

Fig. 1: The Study Area (District Khairpur)

3. Estimation of NDVI and NDBI

The vegetation characteristic like NDVI will be estimated for mentioned vegetation area duration for every study year. To calculate the vegetation indices, NDVI is estimated as follows.

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

Where NIR near-infrared band (TM and ETM band 4, OLI band 5) and R is the red band (TM and ETM band 3, OLI band 4).

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NDBI will be calculated by using Arc GIS 10.3 software following

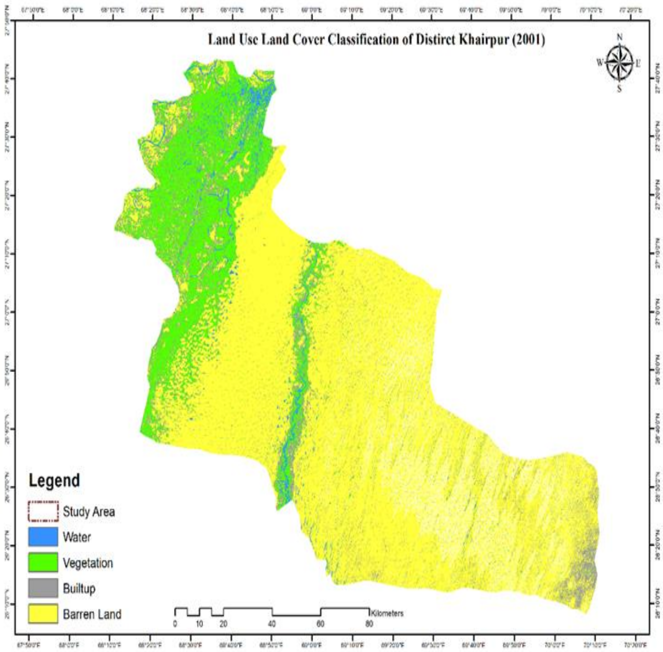
$$NDBI = \frac{(\mathrm{MIR} - \mathrm{NIR})}{(\mathrm{MIR} + \mathrm{NIR})}$$

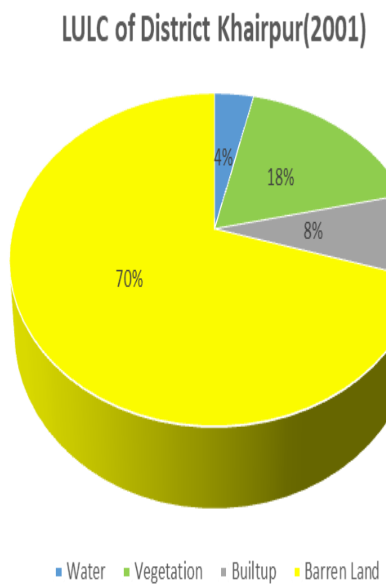
Where MIR is the middle infrared band (TM and ETM band 5, OLI band 6) and NIR is the near-infrared band (TM and ETM band 4, OLI band 5).

4. Results & Discussion

Results of LULC for the Year 2001:

Barren Land: It covers the largest portion, accounting for 70% of the study area.
Vegetation: It occupies 18% of the total area.
Built-up Areas: It represents 8% of the study area.
Water bodies: It comprise of 04% of the total study area





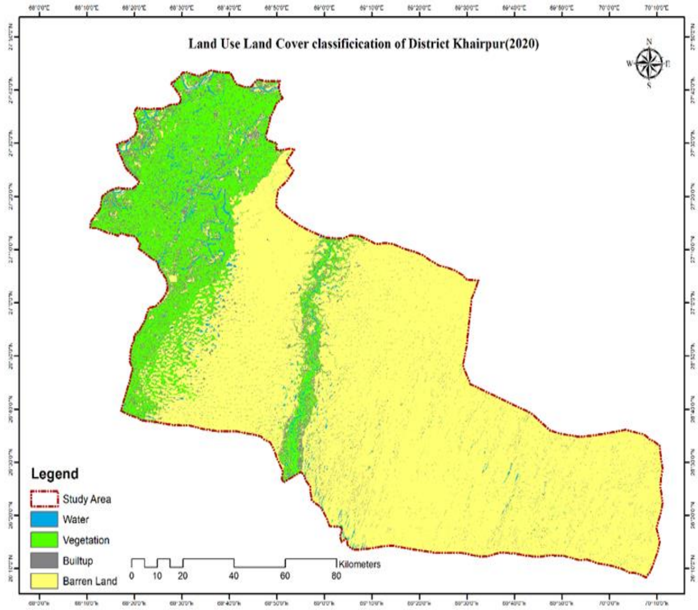
Results of LULC for the Year 2020:

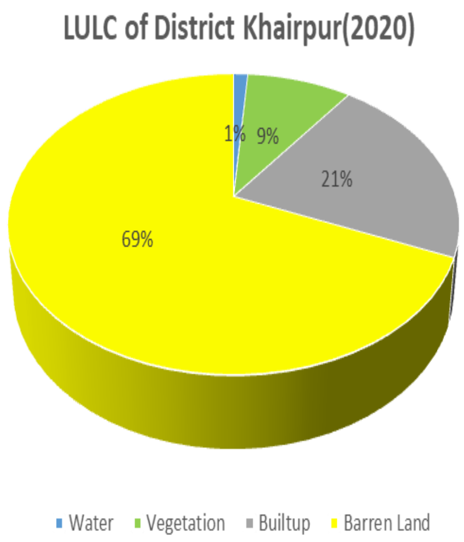
Barren Land: It covers the largest portion, accounting for 69% of the study area.

Vegetation: It occupies 9% of the total area.

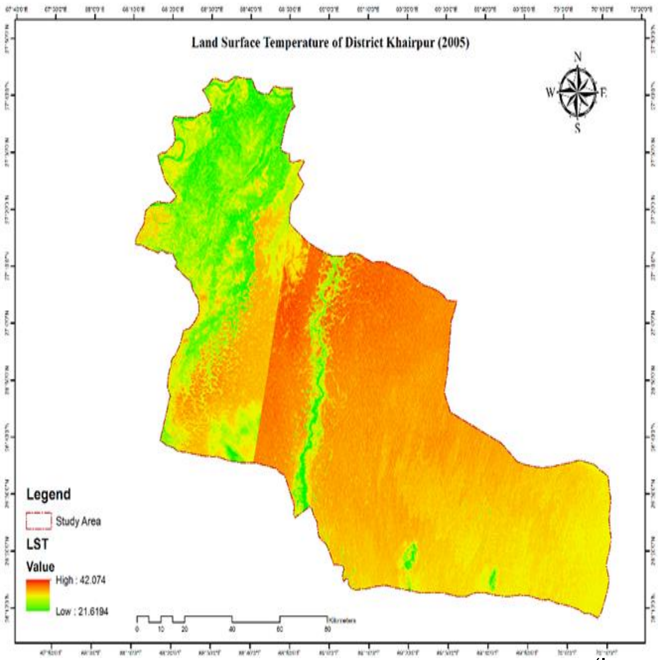
Built-up Areas: It represents 21% of the study area.

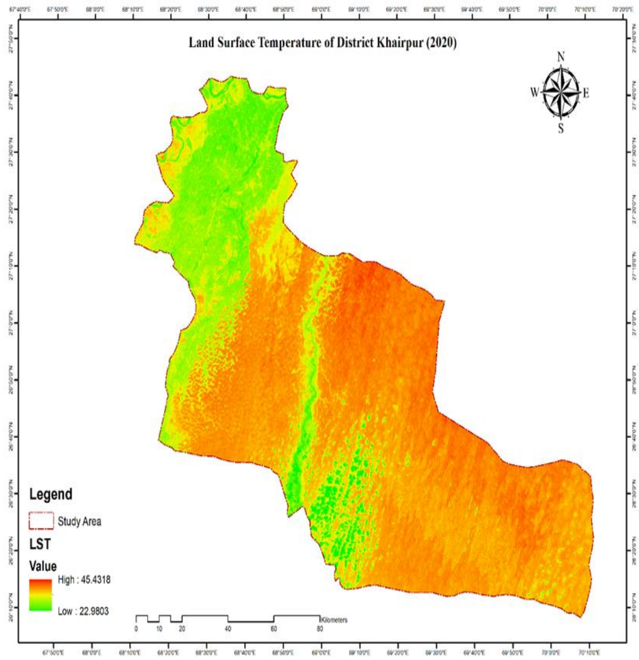
Water bodies: It comprise of 01% of the total study area





- Landsat Temperature map of 2001 and 2005 have been shown where red areas shows the highest temperature and green color represents the low ranges of temperature.
- It can be found from both LST maps that highest range in 2001 was 35^{0}C and 42^{0}C in 2005, whereas, lowest temperature ranged 18^{0}C and 21^{0}C in 2001 and 2005, respectively.
- The LST map for the year 2020 is shown, where red colored areas show the highest temperature and green color represents the low ranges of temperature.
- However, we found 450C as highest LST and 230C as lowest LST map in 2020.





5. Conclusion

- ✓ As this study focused on analyzing LULC and LST of Khairpur district, in LULC four major classes were identified i.e., Barren land, vegetation, built-up and water bodies.
- ✓ It was found that for the period of 2001 and 2010 there was no change in barren land class, whereas in 2015 and 2020 slight decrease in barren land found, overall barren land class decreased from 70% to 69% during the analysis period.
- ✓ Vegetation and water bodies classes experienced variations throughout the analysis period, however built-up areas showed constant increase throughout the analysis period where built-up area class increase from 8% to 21%.
- ✓ As this study focused on analyzing LULC and LST of Khairpur district, in LULC four major classes were identified i.e., Barren land, vegetation, built-up and water bodies.
- ✓ It was found that for the period of 2001 and 2010 there was no change in barren land class, whereas in 2015 and 2020 slight decrease in barren land found, overall barren land class decreased from 70% to 69% during the analysis period.
- ✓ Vegetation and water bodies classes experienced variations through out the analysis period, however built-up areas showed constant increase throughout the analysis period where built-up area class increase from 8% to 21%.

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