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An Analysis of Land Use and Land Cover Change Detection Using Geospatial Technology-A Case Study of Phalsoond Tehsil in Jaisalmer District, Rajasthan, India

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Abstract: ***Analysis of Land Use and Land Cover (LULC) change is significant indicators of environmental changes, resource utilization and sustainable development, especially in arid regions where land and water resources are very fragile. The present study has investigated the spatio-temporal analysis of LULC changes in Phascoond Tehsil of Jaisalmer District of Rajasthan, India from the year 2017 to 2024 using Remote sensing and Geographic Information System (GIS) techniques. To classify the study area, multi-temporal Sentinel-2 data with 10 m spatial resolution were provided by the Esri Sentinel-2 Land Cover Explorer, which was used to separate the area into five categories i.e. water bodies, agriculture land, built-up areas, bare ground and wasteland. LULC changes were quantified in terms of magnitude and direction using post-classification comparison and GIS-based change detection techniques. The findings show significant change in landscape over the year 2017 to 2024. Wasteland remained the dominant land-cover category but declined from 779.07 km² (78.28%) in 2017 to 726.86 km² (71.41%) in 2024. Agricultural area grew by 86.62 km² (+19.48% to 280.52 km²), adding 94.76 km² of wasteland. Gradual settlement and infrastructure development also resulted in an increase in built-up area from 3.89 km² to 7.73 km². The water bodies were small in spatial extent and slight shifts happened between bare ground and other land-cover classes. The results clearly show that the Sentinel-2 data and GIS-based analysis is useful in monitoring LULC dynamics in data-sparse arid regions. The present extent of agriculture and development has occurred at a time when there is a need to manage the land and groundwater resources sustainably, monitor environment, and plan land use with climate change in Phalsoond tehsil of Jaisalmer District in western Rajasthan.***

Keywords: Land Use/Land cover (LULC), Sentinel-2, Remote Sensing, Geographic Information System (GIS), Change Detection.

I. INTRODUCTION

Land is among the most basic natural resources as it is the foundation of human existence, economic operations, and environmental sustainability (Lambin & Meyfroidt, 2010). It helps sustain agriculture, settlement, infrastructure, and ecological processes, which are the main factors of human civilization and development of the region. Because land use has been a concern of many disciplines, to give it a perfect definition is notoriously difficult (Campell, 1983). A considerable percentage of population of the world relies directly on the land resources to sustain livelihood, thus the sustainable use of the land resources is necessary to achieve food security, economic development, and environmental stability (Foley et al., 2005). Nevertheless, a high rate of population increase, urbanization, agricultural intensification and climatic variability have exerted tremendous pressure on the available land resources which has resulted in a massive change in land use and land cover use patterns (Fajardo et al., 2026). One of the most important elements of international environmental change, especially in the developing world, has become Land Use and Land Cover (LULC) change (Wang et al., 2023). Land use can be defined as human activity and management practice on land, whereas land cover can be described as physical and biological surface features of the earth (Clawson & Stewart, 1965) (Burley, 1961). These alterations in LULC have a direct impact on ecosystem services, hydrology, biodiversity, soil health, as well as the climate conditions in the region. In dry and arid climates, these changes tend to hasten the process of land degradation that would manifest in desertification, soil erosion and loss in vegetation hence posing a threat to sustainable development (Duraisamy et al., 2018).

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There have been significant LULC changes in India over the past few decades because of the high rate of population increase, economic development, agricultural land area increase, development of infrastructures, and land management policies (Roy et al., 2015). These transformations are more particularly evident in the largest state of India in terms of area, Rajasthan that is home to vulnerable ecosystems and severe human demands (Yadav S. C., 2022). The low and unpredictable rainfall, sandy soils, low plant density, and rising human activities make the arid areas of the western Rajasthan, such as the Jaisalmer District, extremely susceptible to land degradation (Yadav & Nath, 2018). Any slight change in the land use practices in such settings, even a change in land use by minor shifts, can have enormous impacts on the environment and socio-economic life. Phalsoond Tehsil which is a part of the Jaisalmer District of Rajasthan can be taken to represent a typical arid environment of sand dunes, sparse natural vegetation, minimal agricultural lands and isolated rural settlements. The land use patterns in the region have been changing in recent years with agricultural growth, irrigation, settlements and Renewable energy infrastructures development i.e. solar plant and wind energy. The combination of these changes with climatic stressors has raised issues of sustainability of land management and environmental stability. Thus, the spatio-temporal analysis of LULC changes in Phalsoond Tehsil needs to be conducted in detail to determine the character, scope, and forces of land change in the arid area.

With the emergence of geospatial technologies, especially Remote Sensing and Geographic Information Systems (GIS), the monitoring and analysis of the dynamics of LULC has become revolutionary (Wang et al., 2023). Satellite remote sensing offers repetitive, synoptic and cost-effective data to be used in mapping the land cover and in detecting the changes that occur over time whereas GIS is effective in conducting spatial analysis, integrating data and visualizing spatial data. Multi-temporal satellite imagery change detection techniques have become effective instruments for measuring of LULC changes, their trends, and evidence-based decision-making. These methods are particularly useful in areas with a scarce amount of data such as arid western Rajasthan (Yadav S. C., 2022), where field-based surveys are time-consuming and resource intensive. The use of geospatial methods to examine LULC change has been proved successful in a number of studies over the past decades on the local, regional and global scales. These studies have presented imperative information regarding the effects of human actions and environmental conditions on land resources, which facilitates land-use planning, management of natural resources, and formulation of policies. Nonetheless, although this literature is on the increase, there is limited micro-level research on tehsil-level investigation in arid areas. Local-scale studies are essential since they help to record local land processes, which are mostly ignored in the larger regional analysis.

It is on this basis that the current study will examine land use and land cover change detection in Phalsoond Tehsil of Jaisalmer District, Rajasthan, with the help of geospatial technology. The study attempts to understand the spatial and temporal trends of LULC changes, the key land transformation trends, and the implications that these trends have on sustainable land resource management by using multi-temporal satellite data and GIS-based analysis. The results of this study will help understand the dynamics of the land in arid areas better and make significant contributions to the work of planners, policymakers and researchers who are aiming at sustainable development and environmental protection.

A. Statement of the Problem

The land use and land cover patterns have been changed seen in Phalsoond tehsil of Jaisalmer District in recent few years because of growth in agriculture, renewable energy infrastructure, land development, and settlement development. In conjunction with these transformations as well as the vulnerable ecosystem of the desert and climatic changes, these effects have changed the distribution of land use and land cover (LULC) in study area. Improved spatial data is required to inform effective land resource management, environmental monitoring and sustainable planning in the region, which is currently compromised with the lack of updated spatial data. This study sets out to look at the land use and land cover (LULC) of Phalsoond Tehsil in Jaisalmer District of Rajasthan using the above remote sensing data, spanning the time period 2017-2024, and Geographic Information System (GIS) methods. In fact the study aims to answer the following research questions:

1) What were the prominent Land Use and Land Cover (LULC) in Phalsoond Tehsil in 2017 and 2024?
2) Calculate the total area (km^2) and percentage of each land use and land cover classes both in 2017 and 2024.
3) How did spatio-temporal change in LULC from 2017 to 2024?

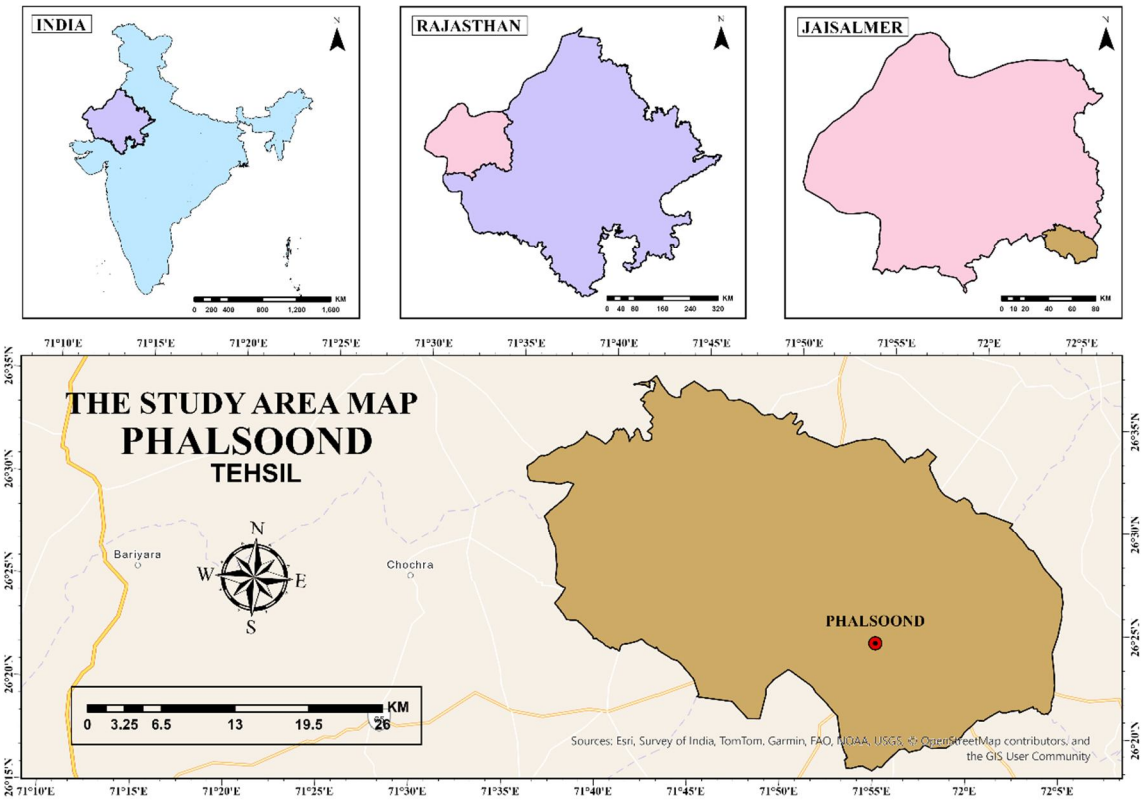
B. Objectives of the Study

The study aimed to analyzed the spatio-temporal changes in the Land Use/Land Cover (LULC) in Phascoond Tehsil in during the period 2017-2024 using the technique of integrating Remote Sensing data and GIS techniques. Specifically, it intends to achieve the following objecives:

1) To detect land use and land cover categories in Phashoond Tehsil of Jaisalmer District in 2017 and 2024.
2) To analyze the spatio-temporal changes in land use and land cover and determine the direction of land use change in the study area.
3) To evaluate the change detection of land use land cover patterns of the study area using geospatial techniques.

C. Study Area

Phalsoond Tehsil is located in the eastern part of Jaisalmer District of Rajasthan, India, and forms part of the arid western Rajasthan region. The tehsil lies between 26°17′54″ N to 26°36′25″ N latitudes and 71°35′26″ E to 72°04′44″ E longitudes. The total geographical area of Phalsoond Tehsil is approximately 1015.26 km². Spatially, the tehsil extends about 52.13 km from east to west and 29.15 km from north to south, as shown in Map 1.



Map 1 : The Study area map of Phalsoond Tehsil

The region is characterized by typical arid landscape features, including sand dunes, sandy plains, sparse natural vegetation, and limited cultivable land. The terrain is predominantly flat to gently undulating, with active and semi-stable sand dunes occurring in several parts of the tehsil. Agriculture is largely dependent on rainfall, with limited irrigation facilities available in selected areas. Climatically, Phalsoond Tehsil experiences an arid to semi-arid climate, marked by extreme temperature variations. Summers are intensely hot, while winters are cold and dry. Rainfall is low, erratic, and largely confined to the southwest monsoon season (Yadav & Nath, 2018). These climatic conditions, combined with fragile soil characteristics and increasing anthropogenic pressure, make the region highly vulnerable to land degradation and land use transformations. Due to its arid environmental setting and emerging land use changes, Phalsoond Tehsil provides an appropriate and significant study area for analyzing land use and land cover dynamics using geospatial techniques. The spatial and temporal assessment of LULC changes in this region is crucial for sustainable land resource planning and environmental management.

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II. METHODOLOGY

The present study employs geospatial techniques integrating Remote Sensing and Geographic Information Systems (GIS) to analyze land use and land cover (LULC) changes in Phalsoond Tehsil, Jaisalmer District, Rajasthan. Multi-temporal Sentinel-2 satellite imagery with a spatial resolution of 10 meters was used to assess LULC dynamics for the period 2017 to 2024. The methodological framework includes data acquisition, georeferencing of topographical maps, image preprocessing, LULC classification, and change detection analysis.

III. DATA ACQUISITION

Land use and land cover (LULC) monitoring can be done in a number of ways; in the context of the present study, land use or land cover classification was performed using the identification Land Cover Explorer database of Esri Sentinel-2. This database comes from data collected by the Copernicus programme of the European Space Agency (ESA) multispectral satellite sensors Sentinel-2 (Land Cover Explorer, n.d.) (Phiri et al., 2020). The high spatial resolution of optical Sentinel-2 sensors, improving their ability to observe and interpret the Earth from space, makes the database available (Zhang et al., 2025).

An important benefit of the Esri Sentinel-2 Land Cover Explorer database is that atmospheric (cloud shading) and radiometric corrections have already been performed eliminating the need for further processing steps. In addition, Sentinel-2 is a non-commercial satellite mission, providing freely available data, and with a spatial resolution of 10 m, further improving the accuracy of land cover mapping (Zhang et al., 2025). There are certain limitations of the database, however. Although there are advantages, there simply are certain limitations of the database. Data only cover the time period since 2017, limiting historical LULC analysis. In addition, the data base offers annual composite land cover data and short-term data (monthly and weekly land cover classifications) is limited. However, due to its high spatial resolution, a database of standardized classification and ease of use, Esri Sentinel-2 Land Cover Explorer was used for analysing recent changes in LULC of Phalsoond Tehsil.

A. Land Use and Land Cover Classification

Esri Sentinel-2 Satellite Land Cover Explorer is a harmonized land cover data set created from Sentinel-2 satellite imagery, with consistent classification algorithms. The dataset classifies the Earth's surface in different classes of land cover like water bodies, agricultural land, built up lands, bare ground and wasteland and hence allows for systematic assessment of the change of land use (Anderson et al., 1976). This consistency of classification for each year increases the accuracy of a temporal change detection and provides a basis for the comparative spatial analysis. Thus, the database can be used as a reliable source to track changes in the landscape, assess land resource variability and to aid evidence-based landscape planning and environmental decision-making at the local and regional level.

B. Change Detection Analysis

Change detection is generally performed using two fundamental approaches: pixel-to-pixel comparison and post-classification comparison (Hussain et al., 2013) (Green et al., 1994)**.** Post-classification comparison was employed to LULC changes detection between 2017 and 2024.

The Change detection method enabled the identification of spatial extent, magnitude, and direction of land use transitions (Singh, 1989). Area statistics and change matrices were generated using GIS tools to quantify conversions among LULC categories (Turner Ii et al., 1995).

IV. RESULTS

A. Land Use and Land Cover Classification of Phalsoond Tehsil (2017)

As per Land Use/Land Cover (LULC) analysis for 2017 in the Phalsoond Tehsil, the land use and land cover which was present in majority was wasteland with 779.07 km² of land cover (78.28% of geographical area). This is a reflection of the dry climatic conditions and desert scenario of the Thar Desert.

Logically, agricultural area accounted for second highest area at 193.86 km² (19.48%) explaining that this area is mostly lies on irrigated and fertile areas. Very little built-up area has occurred, covering just 3.89 km² (0.39%) and there was bare ground covering 18.34 km² (1.84%). There was only 0.10 km² (0.01%) of water bodies, indicating the absence of surface water resources in the area.

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Sr. No.	LULC Classification	Area (km²)	Percentage (%)
1.	Water Body	0.10	0.01
2.	Agricultural Land	193.86	19.48
3.	Built-up Area	3.89	0.39
4.	Bare Ground	18.34	1.84
5.	Wasteland	779.07	78.28
	Total	1015.26	100.00

Table 1 : Land Use/Land Cover Statistics of Phalsoond Tehsil, Jaisalmer District (2017)

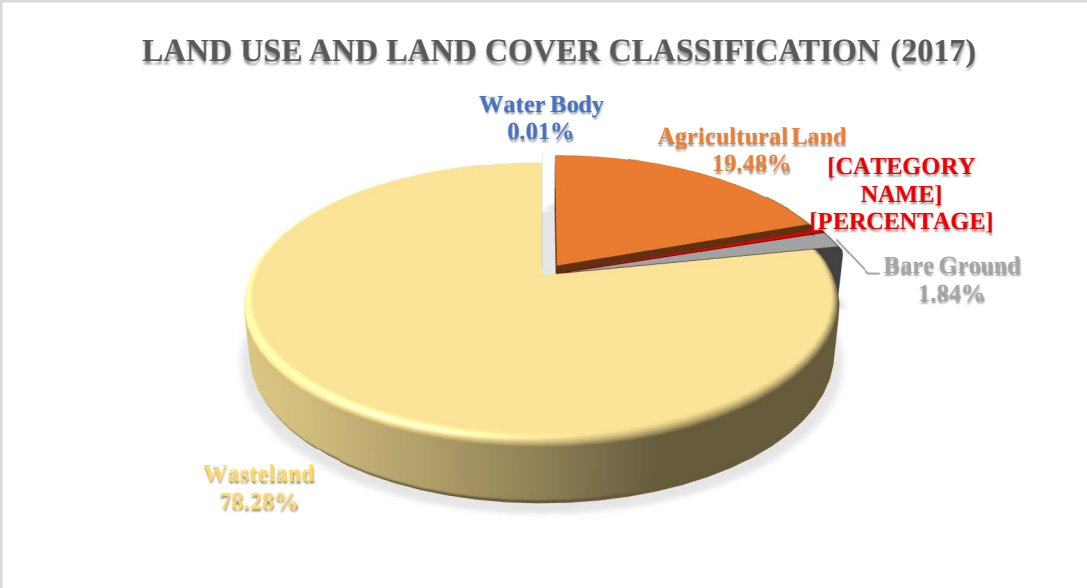
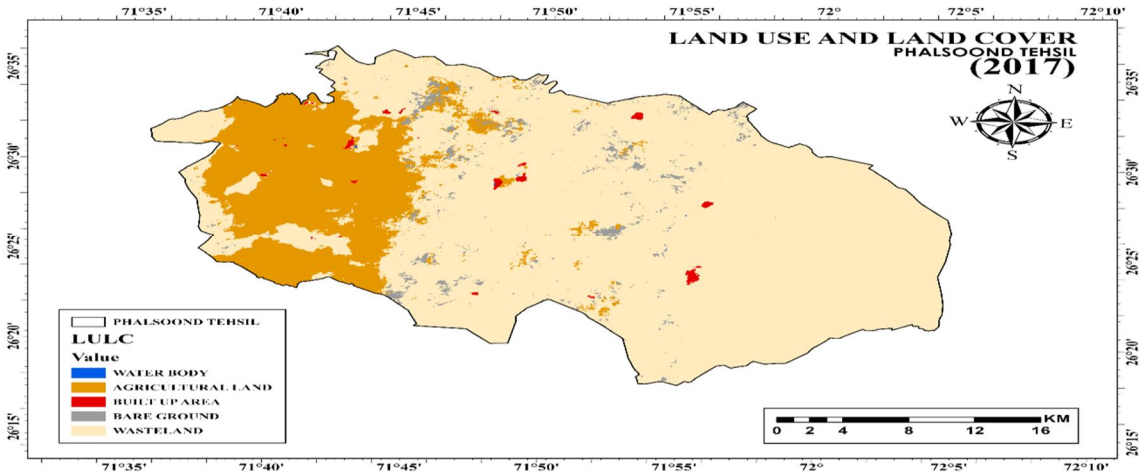


Figure 1: Land use and land cover Classification (2017)

The overall land use land cover pattern of 2017 in Phalsoond tehsil showed wasteland as main feature which is due to limited agriculture and built-up area and shock data base on which the land usage changed procedure.



Map 2 : Land Use and Land Cover Classification of Phalsoond Tehsil (2017)

B. Land Use and Land Cover Classification of Phalsoond Tehsil (2024)

According to the Land Use/Land Cover (LULC) analysis conducted on Phalsoond Tehsil in 2024, wasteland continued to be the most common land cover with an area of 726.86 km² accounting for 71.41% of the total area. Its percentage, however, decreased from previous years indicating the utilization or transformation of wasteland into other land uses. Lands area used for agriculture rose significantly: 280.52 km² (27.81%) – growth in agricultural area, possibly
due to better water supply and agricultural development.

Sr. No.	LULC Class		Area (km²)	Percentage (%)
1.	Water Body		0.13	0.01
2.	Agricultural Land		280.52	27.81
3.	Built-up Area		7.73	0.77
4.	Bare Ground		0.03	0.00
5.	Wasteland	726.86	71.41	
	Total	1015.27	100.00	

Table 2 : Land Use/Land Cover Statistics of Phalsoond Tehsil, Jaisalmer District (2024)

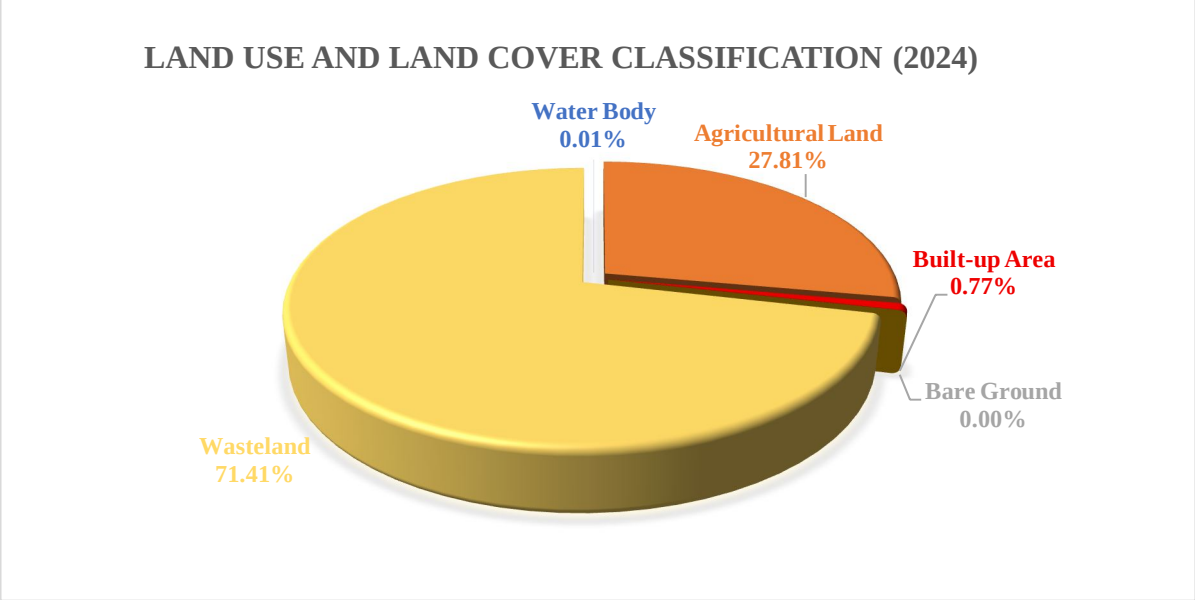
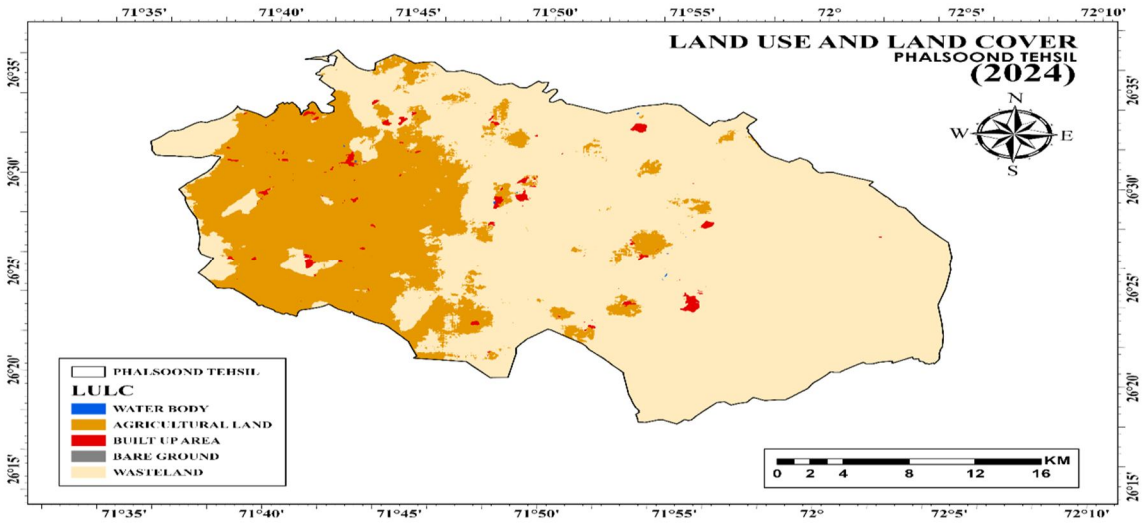


Figure 2: Land use and land cover classification (2024)

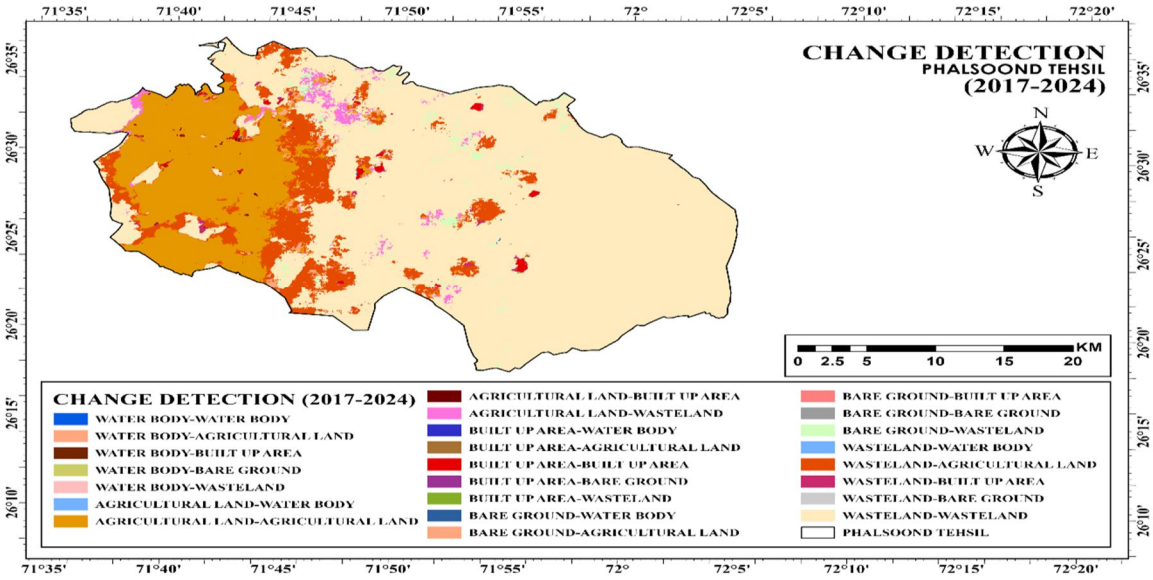
The built-up area grew to 7.73 km², making up 0.77% of the territory, which implies that the settlements and infrastructure have been developed gradually. The percentage of bare ground was practically insignificant (only 0.03 km^2), and also the area of water bodies was relatively small (0.13 km^2, 0.01%) and continued to be a very small part of the study area. The overall LULC pattern observed in 2024 indicates a gradual transition from wasteland towards agricultural and built-up areas, reflecting the impact of human activities on altering the landscape. The gradual trend towards a shift in use from wasteland to agricultural and built-up areas suggests that human activities have influenced the transformation of land resources in the arid landscape of Phalsoond Tehsil, underscoring the need for sustainable management of these resources.



Map 3 : Land Use and Land Cover Classification of Phalsoond Tehsil (2024)

C. Change Detection

Singh defined change detection as ‘‘the process of identifying differences in the state of an object or phenomenon by observing it at different times” (Singh, 1989). Land use/land cover (LULC) landscape change is observed to a large extent in the Phalsoond tehsil in 2024 compared to 2017, due to anthropogenic role and environmental change. This most prominent land use change was in wasteland areas that were converted into agricultural lands (94.76 km²). The significant increase in cultivated area suggests agriculture activity is in expansion, possibly made easier because of better irrigation measures, irrigation from ground water and population increase to agriculture activities in arid lands. Other major changes were the following: cover of bare ground to wasteland (12.19 km²); and agriculture to wasteland (13.44 km²). These changes indicate that some agricultural land might still be in the face of environmental issues such as land degradation, cultivated field abandonment, loss of land productive capacity or climatic stress. However, reclamation of bare ground into agricultural land (6.08 km²) shows that there is some land use improvement and reclamation activities. There was some growth but not a lot, in the built-up area. Around the same extent (3.70 km^2) was built up with just a small fraction of new built-up area from wasteland (3.22 km^2) and agriculture land (0.79 km^2). There wasn't any significant alteration in the waters during the study. A few small (< 0.10 km²) sub-drain transitions were seen between water and other land cover categories which were indicative of both very few surface water resources and relative stability.



Map 4 : Change Detection 2017-2024

Overall, land set aside for agriculture on Wasteland demonstrates the highest level of land transformation process that have happened in Phalsoond Tehsil during 2017-2024 while the settlements grew at a low rate. Although development activities have been increasing, the existence of the great wasteland suggests that desert is still prevailing in the area. The findings highlighted the importance of agriculture development, sustainable use of the land resources, to avoid land degradation and improve the long-term ecological stability of the desert ecosystem.

V. DISCUSSION

The current study was focused on the Land Use/Land Cover (LULC) changes taking place in Phalsoond Tehsil of Jaisalmer District, Rajasthan during 2017-2024, was assessed by analysing the data from Sentinel-2 satellite with 10 m spatial resolution and GIS techniques. The results show significant variations in land use, which are mostly related to the agricultural expansion, to the gradual settlement growth and to the change of wasteland to productive land. The analysis has shown that wasteland is the predominant land cover that has been reduced from 779.07 km² (78.28%) in 2017 to 726.86 km² (71.41%) in 2024. The change detection matrix indicates that the greatest land change in the study period was the conversion of 94.76 km^2 of wasteland to agricultural land. The shift indicates the potential for better irrigation infrastructure, groundwater and vision policies in agriculture encouraging a shift of activity to desertified areas. There has been a significant improvement in aggregated area with improvement in agricultural land areas from 193.86 km² in 2017 to 280.52 km² in 2024. This growth has potential benefits for food security and the livelihoods of people living in rural areas, but has also posed concerns about how the groundwater resources are being used, and the long-term ecological health of the region. Under this type of climate, intensive production on agricultural lands with inadequate land management may lead to deterioration of the productive capacity of the soil and water scarcity. Besides, agricultural development observed would require the use of efficient irrigation technology, soil and land management practices, as well as sustainable land usage policies.

The built-up area experienced moderate growth as well, from 3.89 km^2 to 7.73 km^2, over the study period. The proportion of built-up land as a whole is still low, but this increase is indicative of rural development, the provision of renewable infrastructure i.e solar plant and the effect of socio-economic improvements. The study also finds extremely small water bodies, at 0.01% of G.A. in both the years. This discovery is indicative of the continuous shortages of surface water in the Thar Desert and thus accentuates the reliance on groundwater and seasonal rains in the area. Therefore, water resource conservation should continue to be a key issue in the development of sustainable agriculture and resilience building to climatic changes.

The overall findings indicate a progressive transition from a landscape of a wasteland to more and more agriculturalized one, and of a not too sustained infrastructural development. Applying Remote Sensing and GIS techniques have shown to be efficient to detect and quantify these changes, and to provide environmental monitoring with reliable spatial information. The results provide useful scientific data for local land use planning and help to develop sustainable strategies to manage the resources of the dryland areas of western Rajasthan. More studies should be conducted in the future that integrate socio-economic and climate variables, for a better understanding of the process of land transformation and its implications for regional sustainability.

VI. CONCLUSION

The spatio-temporal analysis of Land Use and Land Cover (LULC) was carried out in Phalsoond Tehsil, Jaisalmer District, Rajasthan over the period 2017-2024 upon the image of Sentinel-2 (10 m spatial resolution) with the help of Geographic Information System (GIS) analysis technique. The analysis reveals significant land changes that took place in the study area, both due to anthropogenic activities and to environmental conditions. The change that was most notable was the growth of agriculture area, slowly rising built up area and a decreasing wasteland. Minor changes in water bodies and transitions between bare ground also reflect dynamic land resources along this arid landscape. These changes are all indicative of an increasing intensity of intervention by humans, as well as changing patterns of land use in Phalsoond Tehsil.

The results highlight the need for geospatial technologies to offer an efficient and reliable method to monitor land use dynamics through space and time, in a scientifically robust way. Multi-temporal Sentinel-2 imagery combined with spatial GIS-based analyses allowed for accurate identification of land cover change, quantification of the extent of change, and visualization of land cover change, helping to evidence-based assess environmental change. From a planning point of view, this process of ‘wasteland’ changing to agriculture and built-up areas of land are representative of socio-economic developments and not just the landscapes of the past; however, these changes also raise planning concerns regarding development in a land that is environmentally sustainable. Conserving fragile ecosystems, efficiently managing water resources, soil protection action and applying climate proof methods for agriculture is sustainable land-use planning.

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This synthesized LULC database has potential applications as a useful decision support tool for planners, policy makers, and resource managers to create strategies for sustainable land management and region development in western Rajasthan.

Nonetheless, the study may be limited in regard to several aspects. Remotely sensed images classification uncertainty and relatively limited temporal coverage (2017-2024) can affect the long-term land use trends. The application of higher-resolution satellite data, advanced machine learning classification algorithms, climate and hydrological data, and socio-economic indicators should include additional factors for better understanding the complexity of the drivers of land transformation, which will be beneficial for future research. The role of continuous monitoring of land resources is even more critical in an arid terrain like western Rajasthan where owing to the variability in climate and the rising human pressure, the landscape can change quickly. These comprehensive evaluations will enhance the management of the environment, fine-tune policies, and help to utilize land resources sustainably in the face of climate and development pressures.

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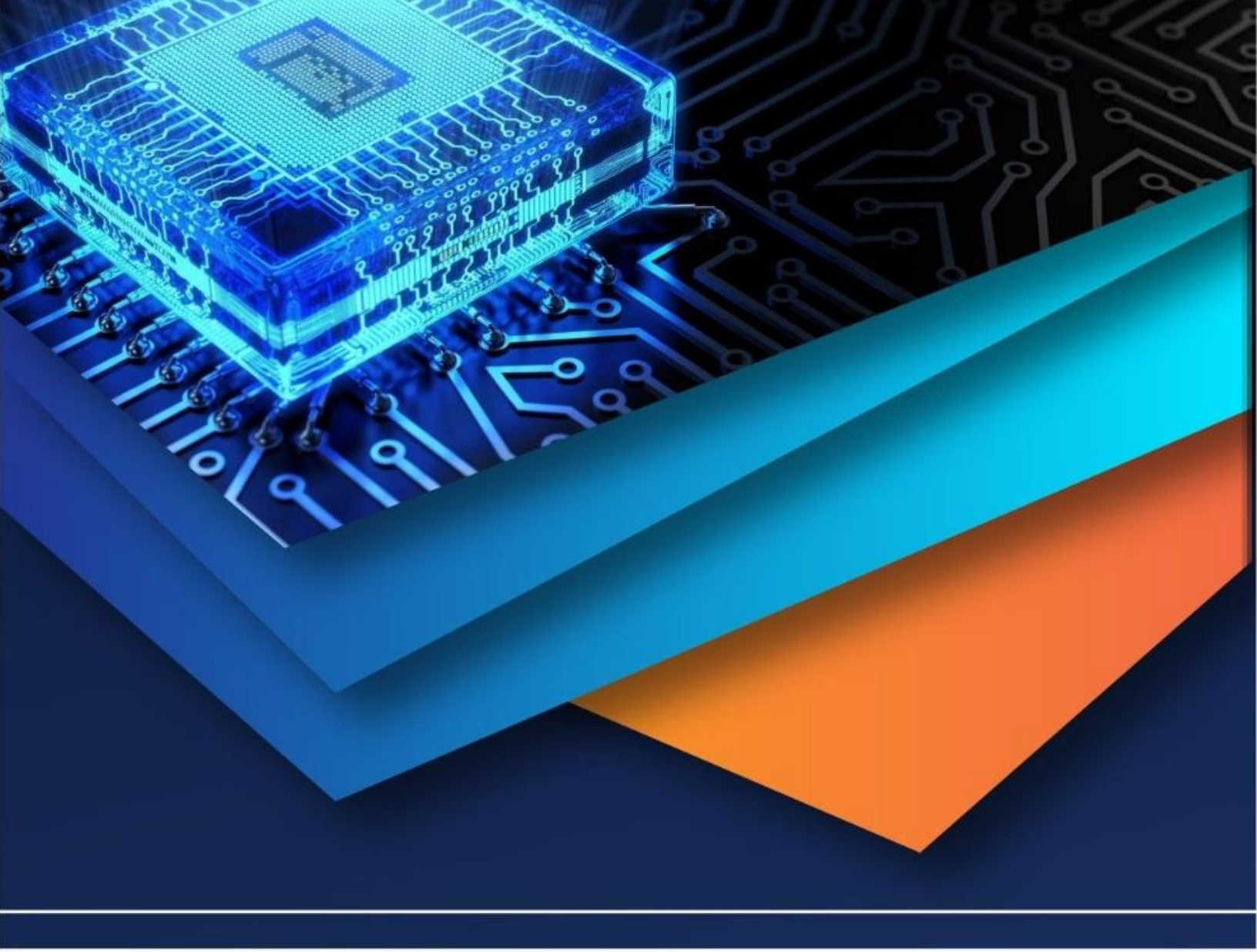

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