Water Resources and Irrigation Management Using GIS and Remote Sensing Techniques: Case of Multan District (Pakistan)

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Abstract Pakistan experiences extreme water scarcity, which has an impact on the sustainability of agricultural output. Irrigated agriculture could benefit from effective water management employing geographic information system (GIS) and remote sensing (RS) approaches. This study has shown that quantifying the transfer of soil-vegetation and atmosphere could aid in understanding rainfall estimation, evapotranspiration, soil fertality analysis, water status, planning and management of surface and groundwater resources with the combined GIS and RS approaches. These methods proved highly successful in mapping the present state of water resource availability and anticipating future requirements for agricultural use. In addition,

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researchers, field consultants, and lawmakers can benefit from the crucial and accurate information that remote sensing and GIS tools can provide regarding managing water resources. The land use land coner (LULC) shows that how the water bodies effected with the setelment area, vegetation cover and soil fertility. The GIS mappig for the waters status clearified the effect of rainfall, and evapotranspiration on the goundwater profile. The effect of the water resouces and irrigation management have all been proven with varying degrees of precision using RS. By identifying significant issues that can be resolved by RS and GIS applications in the real world, this research fills the gap that currently exists between academics and policymakers. GIS/RS technologies will be used to conduct analysis on the Multan district's, which is located in a hyper-arid environment. This study specifically explains how the practical implementation of remote sensing is of pivotal significance in water resources.

Keywords Water management · Remote sensing · Geographic information system · Hyper-arid region

1 Introduction

The irrigation system is the world's greatest user of fresh water. The production of 30–40% of the world's staple crops uses about 70% of all water (Bastiaanssen 1998). The main sources of consumable water are groundwater, rainfall, and surface water bodies like rivers, ponds, and lakes (Pande et al. 2023). However, there are too many competitors in the home, agricultural, infrastructure, and industrial sectors. As a result, water resources must be managed to satisfy future food demands with a restricted water supply. When water resources are sufficient and environmental pollution and degradation are not a concern, water managers may afford to be negligent in their management. Nevertheless, there won't be many areas in the twenty-first century where we have this luxury because of population expansion and the associated water demand for food, health, and the environment. Reliable information is required for management and planning, and accurate information on water resource utilization is currently limited (Bastiaanssen et al. 2000). When resources are limited, effective planning and decision-making at all levels are necessary. The key to making decisions in the modern global environment is gathering and assembling various kinds of data into a manner that can be used (Abdelhaleem et al. 2021). From the farm to the river basin, however, extensive managerial expertise and understanding are essential to enhance water productivity at all scales. Moreover, it can be feasible if the system can be measured quantitatively and qualitatively, which will justify the investments to enhance productivity and improve the irrigation system (Pande et al. 2021).

From the trivial, it is no easy task to provide dependable and precise measurements on a scale ranging from individual farmer's fields to vast river basins, including irrigated land covering millions of hectares. Nonetheless, frequent data on agricultural and hydrological land surface properties may be obtained from spatially remote sensing observations across massive swaths. During the past 20 years, remote sensing's ability to detect and track crop development and other relevant biophysical characteristics has significantly improved, while a number of problems still need to be fixed (Stewart et al. 1999; Rango and Shalaby 1998).

Although remote sensing technology is cutting-edge, its offshoots, such as Geographical Information System (GIS)/Land Information System (LIS), have grown significantly in significance and utility when it comes to remotely sensed data computer-aided analysis for resource management. The application sectors have accelerated as additional satellite platforms gather data on natural resources from the earth at 10 m spatial resolution. When defining the training regions for classification and updating databases for spatially and temporally dynamic phenomena evaluation, the integration of remotely sensed data with GIS can be helpful guidance (Walsh et al. 1990). Despite having a lot of potential, the application of GIS thematic overlays as a tool for remotely sensed data interpretation is not extensively used. Enhancement methods that improve the interpretability and thematic information extraction from images include ratioing, principal components analysis, spatial filtering, and contrast stretching. Multi-spectral classification facilitates the quantitative estimations of land cover types, land use patterns, and crop water consumption (Montesinos and Fernández 2012).

This research describes the combined use of satellite images and georeferenced overlays, using GIS. It also exhibits typical land and water usage applications of selected coastal, alluvial, and hard rock environments. Furthermore, this research presents potential remote sensing applications in irrigation and water resources management in Multan district, Pakistan. It provides scientists with background information on the developments in irrigation-related remote sensing.

2 Study Area

The Multan district in Pakistan was chosen as the research region for GIS and RS approaches, as illustrated in Fig. 1. The research region is located at latitude of 30.29°, longitutde of 71.47° and altitude of 123 m (Ahsen et al. 2020). The sidhnai canal is the primary irrigation water supply source for the Multan district, which has a large control area of 0.349 Mha (Khattak 2006).The Multan district spread over the four tehsil namely, multan city, multan sadar, shujabad and jalalpur pirwala. It is bounded on the west by the Chenab River. In summer (winter), the minimum and maximum temperatures are 26 and 50 °C (4.8 and 23.4 °C), respectively. The Multan experiences 25.6 °C on average each year. The Multan district is situated in desert terrain and receives about 200 mm of precipitation annually. Rabbi and Kharif are the two main growing seasons in Multan. The most significant crop during the Kharif season is cotton. It is sown in April to May, and it is harvested between October and December. The main crop during Rabbi season is wheat. From October to December, wheat is sown, and it is harvested from April to May (Hussain et al. 2020).

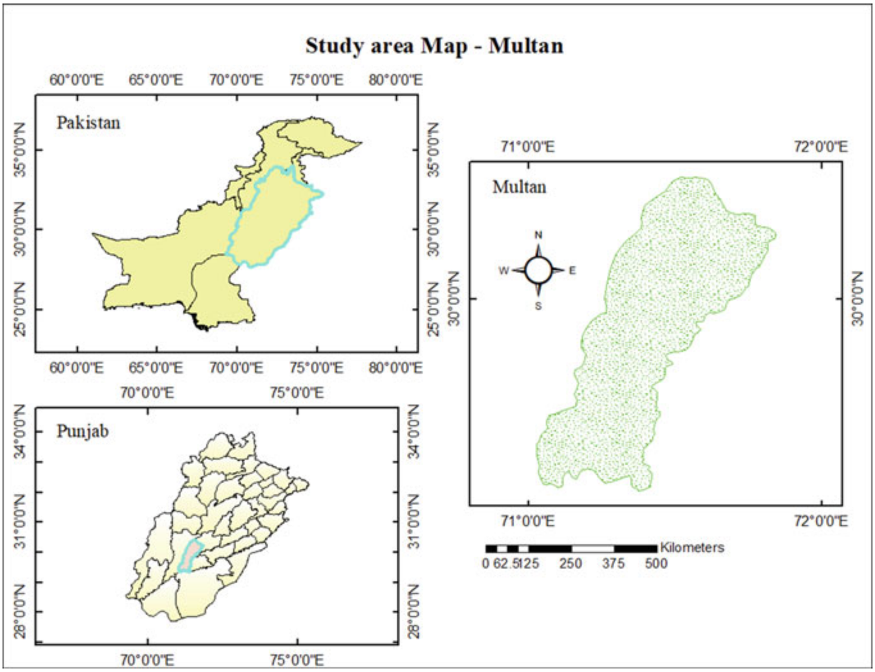


Fig. 1 GIS map for study area location

3 Materials and Methods

In June 2020, literature and reviews on different aspect of water resources and irrigation management using GIS and RS techniques were limited to global web searches using Google search engines. The literature study uncovered a few reports, research articles, and theses on the use of GIS in water and irrigation management that had been published or unpublished over the past two decades.

3.1 Remote Sensing and Its Approaches

Remote sensing is the collection of data (spectrum, topographical, or chronological) about real-world objects or locations without direct contact. As can be seen in Fig. 2, remote sensing utilises the electromagnetic spectrum to scan land, sea, and sky utilising electromagnetic waves (EMR) of different wavelength (visible, red, NIR, TIR, and microwave). Quantitative information on hydrological processes may be gleaned from the identification of the unique spectral features emitted by every item on Earth's surface at these wavelengths.

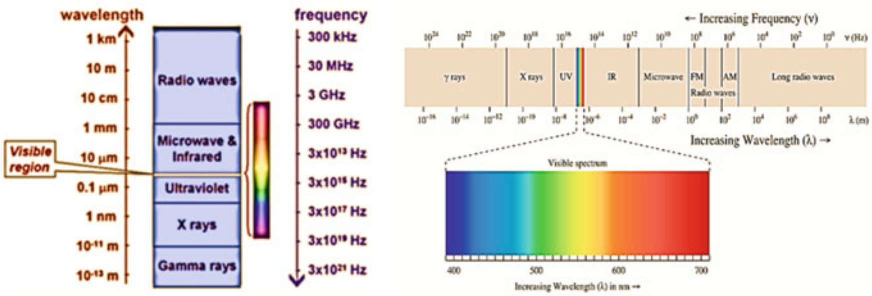


Fig. 2 Classification of EM spectrum frequency and wavelengths (Zhu et al. 2018)

Table 1 Polar orbiting satellite-based resolution categories characteristics (Jackson et al. 2010)

Resolution category	Pixel resolution (mm)	Swath width (mm)	Satellites
Very high	$0.5 * 10^3$–$2.5 * 10^3$	$5 * 10^3$–$40 * 10^3$	GeoEye, Ikonos, Worldview, Quick bird
High	$2.5 * 10^3$–$30 * 10^3$	$40 * 10^3$–$700 * 10^3$	RadarSat RapidEye, SPOT, LandSat, Aster, Chers, FormoSat, LISS
Moderate	$30 * 10^3$–$400 * 10^3$	$700 * 10^3$–$3000 * 10^3$	ASAR, MODIS, FY, AWIFS, MERIS
Low	$400 * 10^3$–$25{,}000 * 10^3$	$3000 * 10^3$	TRMM AMSRE,, MODIS, MERIS, FY, GRACE, ASAR, ASCAT

Several satellites circle the Earth, gathering information on climate and ecosystems. Table 1 shows the pixel sizes range from a few millimeters to kilometers, and the prediction accuracy ranges from three hours to many months. Projections of the 24 h rainfall at a dpi of 25 km since 1990 can help with this. Meteorological, terrestrial, and oceanic factors are monitored by the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E). Advanced Microwave Scanning Radiometer-Earth Observing System provides daily estimations of soil moisture at a 25 km pixel resolution (Jackson et al. 2010). AMSR-E and MODIS satellites at one-kilometergrids might be used to measure daily evapotranspiration. Additionally, MODIS, SPOT vegetation, land use, albedo, and biomass may all be estimated at a 1 km resolution.

3.1.1 Passive Remote Sensing Operation

Passive remote sensing (PRS) collects data by utilizing natural. Figure 3 shows how PRS sensors identify and monitor electromagnetic radiation, bounced or generated by entities that derive their power from the environment. Solar radiations are the

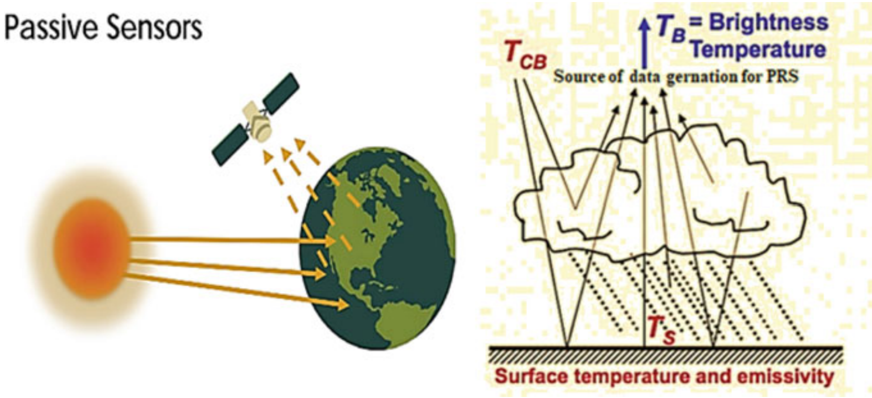


Fig. 3 Passive remote sensing operating system (Cheema and Bastiaanssen 2012)

main source for data collection for RS. The sun is the and largest energy source. Like thermal infrared wavelengths, optical wavelengths can be absorbed or reflected before being re-emitted. Passive sensors (PS), particularly those operating in the microwave range of the electromagnetic spectrum, can detect radiations emitted by Earth.

3.1.2 Active Remote Sensing

The sensors in active remote sensing are powered by independent sources. As seen in Fig. 4, radar is an example. They radiate in the direction of the item being examined while also detecting and recording radiances coming from it. Active sensors provide the advantage of taking measurements at any time of day or year. Active sensors are frequently employed at wavelengths where the sun's output is insufficient. In the case of these devices, there are significant energy requirements for greater illumination of the target. Active sensors include synthetic aperture radar (SAR), laser scanning earth observation (LASER), and European remote sensing satellites (ERS).

3.2 Geographic Information System (GIS)

The term "GIS" refers to a computerised system for managing and analysing geographical information (Fischer and Nijkamp 1992).Typically, GIS is defined as "an organised collection of dataset, applications, hardware, software, and trained personnel capable of acquiring, processing, maintaining, and analysing the geographically reference dataset and delivering output both in statistical and visual form," as seen in Fig. 5. In its broadest sense, a geographic information system (GIS) is a tool for

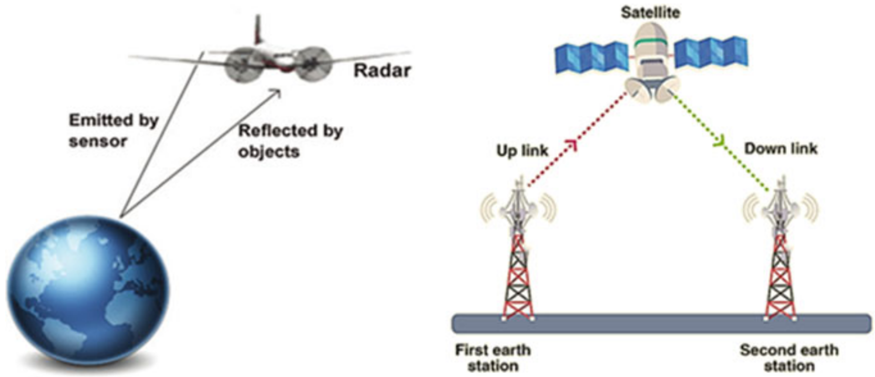


Fig. 4 Active remote sensing operation system (Islam et al. 2022)

conducting interactive searches, performing geographical analyses, and modifying existing information.

The main purposes of geographic information system are problem-solving and decision-making. Similar to other information systems, a geographic information system offers the following four capabilities for handling geospatial information:

- Input
- Data management
- Manipulation and analysis
- Output

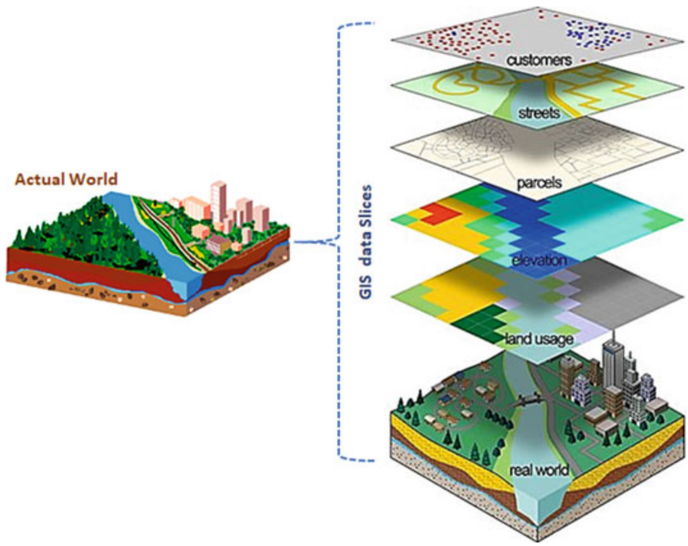


Fig. 5 GIS classification for data collection (Acharya and Lee 2019)

Table 2 GIS applications

Agriculture	Water resources management	Urban and rural planning
Crop growth climate constraints	Soil water-holding capacity map	Planning and zoning
Soil resources availability, assessment, and planning	Map of groundwater table depth	Infrastructure planning
Crops/cropping pattern pattern potential	Water stress assessment and demand mapping for crops	Land information system
Estimating crop productivity losses and locating potential hazards	Irrigation scheduling	Percale mapping
Agro-ecosystem characterization	Estimating water logging condition	Assessment of property tax based on current land usage

Additionally, a geographic information system is built for the purpose of gathering, storing, and analysing things and phenomena in which geography is a key aspect or analytical component. Geographic information systems (GIS) are distinguished by their capabilities for spatial searching and the superimposition of (map) layers. Using a GIS, it is possible to create a temporal and spatial map of crop/land by combining, like, a map of crop potential with a map of the ground/surface water condition. Table 2 represents the use of GIS in various sectors. Since complexity in real-world situations is great (for example, in agriculture, data on soil, land, crops, climatic condition, water, forest, cattle, fish stocks, and socioeconomic characteristics are necessary for making decisions), and since the physical computer capability to alter data is restricted and time-consuming, geographic information systems (GIS) are an ideal planning tool for resource managers (Knox and Weatherfield 1999).

Hydrological data may be obtained from satellites. High to moderate resolution satellite imagery offers essential information on numerous hydrological components for water resource management methods in terms of irrigation water concerns.

4 Satellite Image Processing

4.1 Spatial Land Use and Land Cover (LULC)

A LULC dataset must include information on water consumer and revenues in food, woods, hydroelectric power, ecological benefits, etc. The crops cultivated in the areas must be recognized in order to allocate water wisely. This can be done by selecting appropriate land uses. The distribution of soil and vegetative covers is reflected in the various vegetation indices. NDVI is the most trustworthy method for digital image processing (Allawai and Ahmed 2020). This study used the normalised difference vegetation index (NDVI) technique to analyse satellite datasets of Multan

Table 3 Explanation of remote sensing data used in spatial

Explanation	Remote sensing data of 2020
Satellite	Landsat 8
Sensor type	OLI_TIRS
Resolution	30 m
Cloud cover	5.3
Projection	UTM43N
Sun azimuth	109.3074943
Sun elevation	68.78002522
Spectral bands	B2 Blue: 0.45–0.51 B3 Green: 0.53–0.59 B4 Red: 0.64–0.67 B5 NIR: 0.85–0.88
Acquisition date	26 June

district in search of indicators of different land-use types. Classifying the 2020 Landsat data using NDVI yielded more accurate findings. Pixel-by-pixel values of the normalised difference vegetation index were calculated using the visible and near-infrared (NIR) spectrums of the sattelite images.

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}} \tag{1}$$

where RED represents visible red reflectance (600–700 nm) and NIR represents near infrared reflectance (750–1300 nm). Table 3 lists the visible-to-infrared spectrum and picture properties. The NDVI value varied from –1 to 1. Values closer to 1 were associated with more intense vegetated areas, whereas values closer to 0 were associated with less or no greenery. Water was represented by negative values (Zaidi et al. 2017).

4.2 Image Classification

In this investigation, NDVI measurements were used for unsupervised classification. Table 4 lists the designated classifications, which include waterbody, settlements, barren land, crop land, spare, and dense vegetations. It can be seen in Fig. 6 that the blue areas represent water, the red areas represent human settlement, the orange areas represent barren land, the light green areas represent cropland, the moderate green areas reflect sparse vegetation, and the dark green areas represent dense vegetation. ERDAS Imagine was used to activate the Iterative Self-Organizing Data Analysis Technique Algorithm (ISODATA) clustering algorithm to group pixels with comparable attributes without any sample classes (Nelson et al. 2020). Pixel-by-pixel identifiers based on the DN values of various topographical elements are used to divide the region into six distinct categories.

Table 4 Unsupervised classification-based classes

Classes	Description
Waterbodies	Freshwater lakes, ponds, rivers, and oceans
Settlements	A variety of human-made structures, such as towns, cities, villages, and residential and commercial roadways, are included in this category
Barren land	Areas of the Earth's surface that are bare soil or incapable of supporting plant life
Crop land	Crops and grasslands
Dense vegetation	A huge region that is covered with mature trees and other flora
Spare vegetation	Low-density tree cover that precludes using the area as a forest

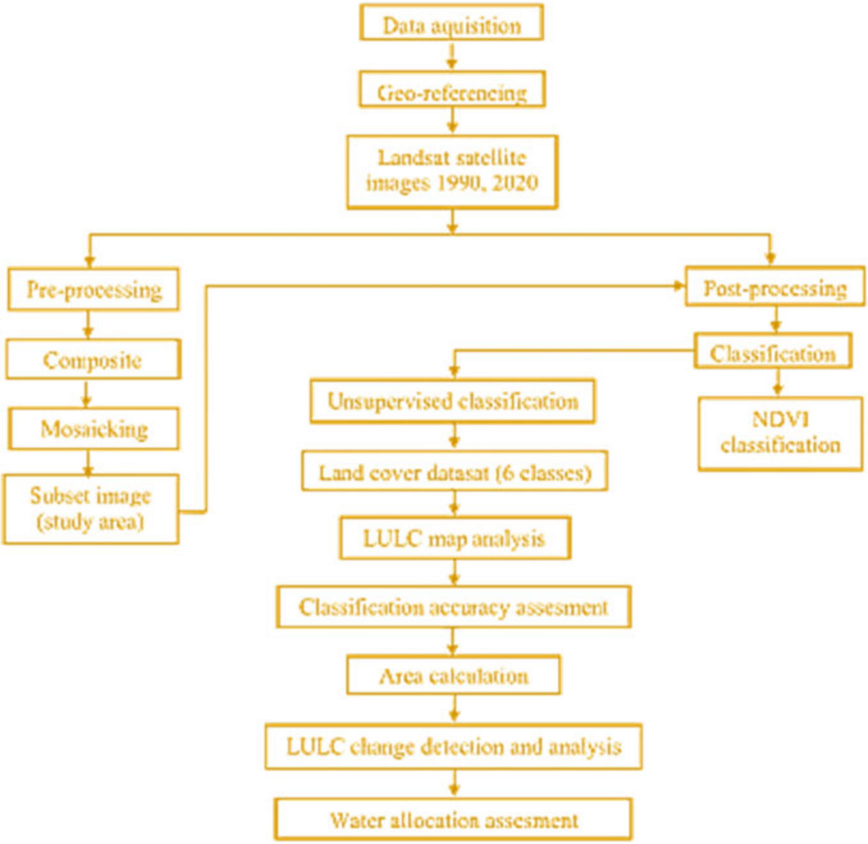


Fig. 6 Flowchart for the LUCL change detection and water allocation assisment (Dogru et al. 2020)

4.3 Water Allocation Assessment

Allocating water supplies has been identified as a top water management issue in response to rising demand, especially in the agricultural sector. In order to irrigate their crops, farmers need access to an adequate supply of water (Li et al. 2020). Most areas, including the Multan district, use the warabandi method to help farmers provide enough water for their crops. Due to rapid urbanisation and the rise of large businesses, the country's land usage and land cover have been shifting at an unprecedented rate. The high rate of change in land cover has resulted in an equal rate of change in water bodies, which in turn has led to water allocation issues (Saeidian et al. 2019).

The GIS assists in determinining area under various land-use classes and describes the classes along with their area in the Multan as shown in Fig. 7. In 1990, about 8.9% area of Multan District was under waterbody that remains 1.4% in 2020, 26.2% was under settlements that increase upto 51.5% in 2020, 2.6% was under barren land and increase upto 12.7% in 2020, 15.5% was under crop land and 20.1% in 2020, 13.4%area was covered by spare vegetation which decrease 11.7% in 2020, and 33.3% was under dense vegetation that highly effected with settlement area and remain 2.6% of the total area (Fig. 8).

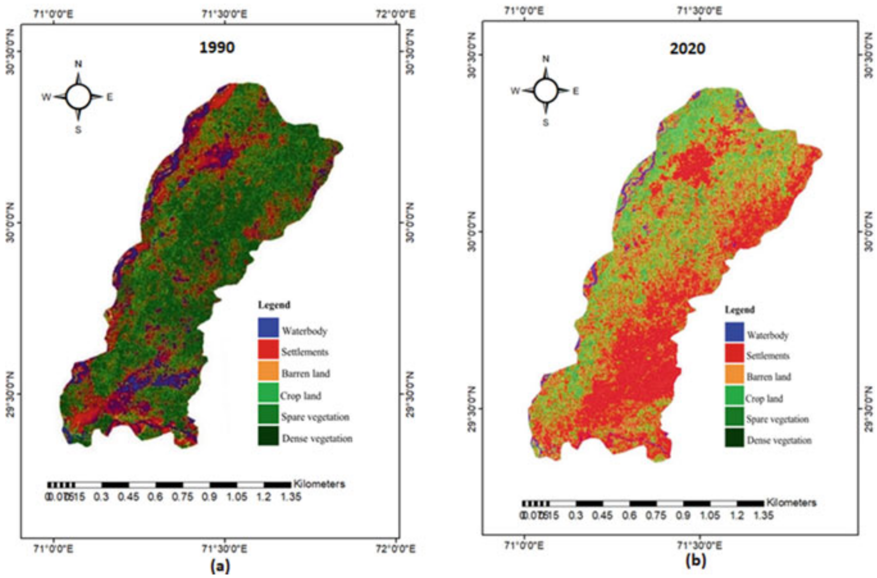


Fig. 7 LULC Map of Multan **a** for 1990 **b** for 2020 (Naeem et al. 2022)

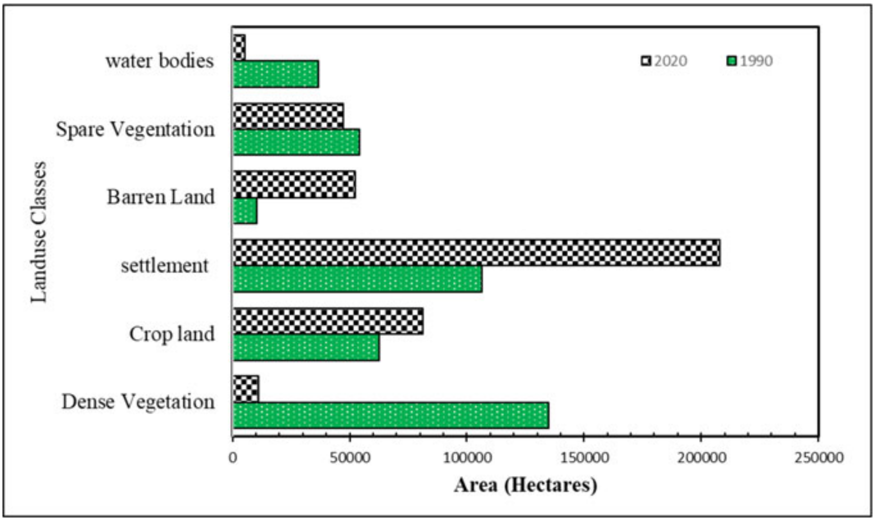


Fig. 8 Multan district land use area distribution (Naeem et al. 2022)

4.4 *Spatio-Temporal Precipitation*

Rainfall quantification is the first step in any water resource analysis. Rainfall in time and space may be measured using satellite-based sensors. They are a good option for measuring rainfall. With the help of its satellite, the Tropical Rainfall Measuring Mission (TRMM) can estimate global precipitation every three hours, and the data is available for free download. However, these projections are also inaccurate (Wang et al. 2005). Figure 9 represent the rainfall precipitation in the Multan district. As a result, these estimations need to be revised before they can be used in the evaluation and administration of water supplies. Estimates of TRMM rainfall (product 3B43) can be calibrated using low density rain gauge observations using one of two methods. Both regression analysis and spatial differential analysis can be used. Nash Sutcliffe efficiency is improved by 81 and 86% with the two methods, respectively.

Despite having a lower spatial resolution than competing gridded products, the TRMM provides more comprehensive regional coverage and a finer temporal precision. Even when using onboard sensors to infer rain, there remains room for error (Hossain et al. 2006). Lack of precipitation detection, erroneous detection, and biases cause these uncertainties (Tobin and Bennett 2010). There are monthly temporal inaccuracies of 8 to 12% and monthly sampling errors of 30% in TRMM rainfall estimates. If such flaws are not corrected, they might lead to incorrect applications (Gebremichael et al. 2010). To reduce such inaccuracies, TRMM satellite estimations require area-specific calibration.

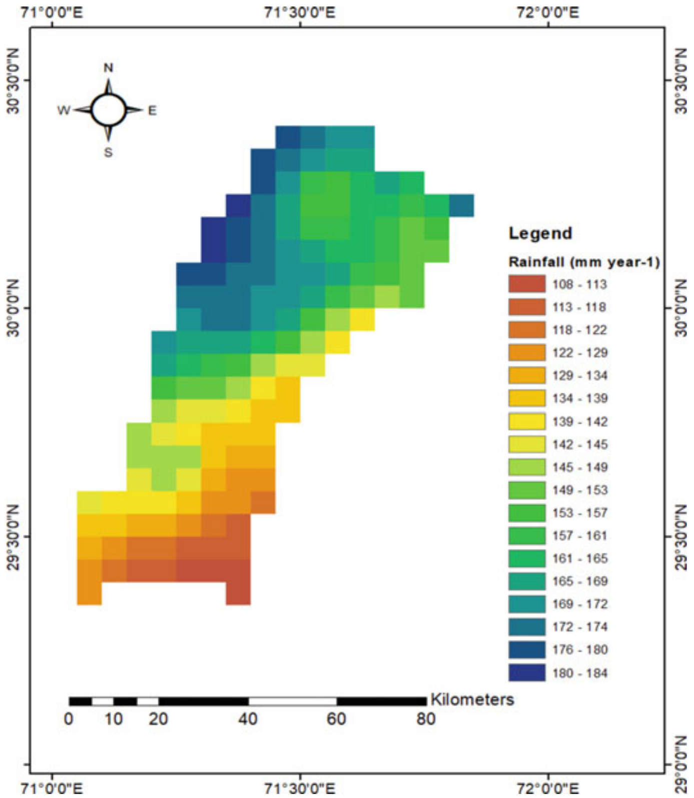


Fig. 9 Spatial distribution of calibrated TRMM rainfall for 2020

4.5 Evapotranspiration (ET_o) Spatial Distribution Map

Traditional point measurements, innovative modelling, and regionally distributed remote sensing estimations are only some of the methods used to calculate ET_o. Lysimeters, Bowen ratios, heat pulse velocity, eddy correlation, and surface renewal are often used to measure ET_o in both plants and fields. The accuracy of these old tools, however, is less than 90% (Prasad and Mahadev 2006). Furthermore, considerable manpower, equipment costs, and coverage issues are seen as major barriers to implementing these strategies on a broad scale. Routine meteorological data cannot be used to calculate the real rate of evapotranspiration. With simple tools, rain can be easily detected, while ET_o from terrestrial surfaces cannot (unless locations have energy balance equipment). Therefore, a novel Penman–Monteith approach (Calvache et al. 2015) has been evaluated, which gives geographic estimates of evapotranspiration using satellite observations as well as a surface energy balance. Surface energy balance can be represented as (Cheema and Bastiaanssen 2012)

$$R_n - G = \lambda E + H \tag{2}$$

where, Rn denotes net radiation (Wm^{-2}), G denotes soil heat flow (Wm^{-2}), E denotes latent heat flux (Wm^{-2}), and H denotes sensible heat flux (Wm^{-2}) (Cheema and Bastiaanssen 2012)

$$E = \frac{\Delta\left(R_{n,soil} - G\right) + \rho c_p \left[\frac{\Delta_e}{\gamma_{n,soil}}\right]}{\Delta + \gamma\left[1 + \frac{r_{soil}}{r_{a,soil}}\right]} \tag{3}$$

$$T = \frac{\Delta\left(R_{n,canopy}\right) + \rho c_p \left[\frac{\Delta_e}{\gamma_{n,canopy}}\right]}{\Delta + \gamma\left[1 + \frac{r_{canopy}}{r_{a,canopy}}\right]} \tag{4}$$

where E and T represent evaporation and transpiration (Wm^{-2}). When considering the relationship between air temperature (Tair, °C) and saturation vapour pressure (Psat), the slope of the saturation vapour pressure curve (mbar K^{-1}) is denoted as (es, mbar). The density of air is measured in kilogrammes per cubic metre, and the vapour pressure deficit is denoted by e (mbar). Dry air has a specific heat capacity of 104 J kg^{-1} K^{-1}, or cp. The value for the psychometric constant is (mbar K^{-1}). The net radiations at the soil, Rn, and the canopy, Rn, are denoted by the symbols Rn and Rn. Canopy and soil resistances are respectively denoted by the symbols rsoil and rcanopy. Two types of aerodynamic resistance are defined here: soil (ra, soil) and canopy (ra, canopy).

The units of resistance are s m^{-1}. E and T fluxes (W m^{-2}) are transformed to rates (mm d^{-1}) using a temperature-dependent LHV function.

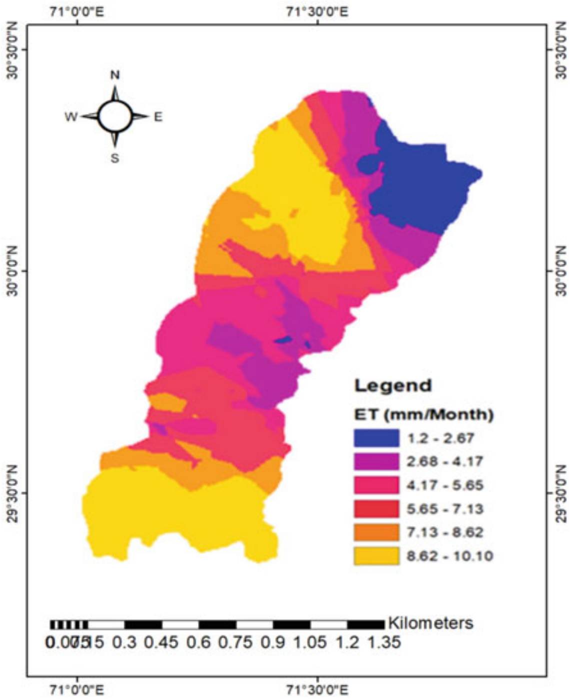
There are other different ET_o algorithms described in the literature, but this one stands out because it provides reliable, weather-independent estimations of ET_o all year round. The predicted ET_o at 1 km dpi was closely correlated with lysimeter, Bowen ratio, and remote sensing observations (R2 of 0.70–0.76 at annual time scale; RMSE of 0.29- and 0.45-mm d^{-1}). It was shown that the ET_o fluxes at the pixel scale can be calculated on daily, 8-day, or monthly time periods.

Figure 10 shows that the Multan evapotranspiration rang from 1.2 to 10.1 mm/year in 2020. Areas in the northwest and lower south have higher ET_o (8.62–10.1). The ET_o range 7.13–8.62 was found center of the northwest and below the center of east to west side however the lowest range (1.2–2.67) of the ET_o was shown in the northeast sides.

4.6 Soil Fertility Status

The ability of the soil to provide vital nutrients to plants is known as soil fertility. Currently, identifying of four factors (Organic matter, pH, Electric Conductivity

Fig. 10 Evapotranspiration (ET_o) in Multan



(EC), Phosphorus (P) that can be used to estimate soil fertility (Javed et al. 2022). We set the range in line with the soil fertility state by measuring the values of these parameters using remote sensing at various locations within the study region. From the map we can clearly see that soil fertility is changing over the different regions of Multan. Figure 11 represents that the Organic Matter map shows that the central area of Multan, North–West & North–East area of Multan Saddar and small area from central Jalapur Pir wala is low fertile, area of Multan Saddar around the Multan city and area around the central Jalapur pur Wala has medium fertile soil and the total area of Shujabad, Eastern area from center of Multan saddar and northern area of Jalalpur Pir wala has high fertile soil as shown in due to its high pH, Ec, P, ranges in these region.

4.7 Groundwater Status

Surface water supply for agricultural purposes is quite low, but water demand is extremely high. The groundwater is extracted by the farmer for agricultural growth. Water availability in Kharif 2020–21 remained at 65.1 million acre-feet (MAF), a slight decrease of 0.2% from 65.2 MAF in Kharif 2019–20. In comparison to Rabi

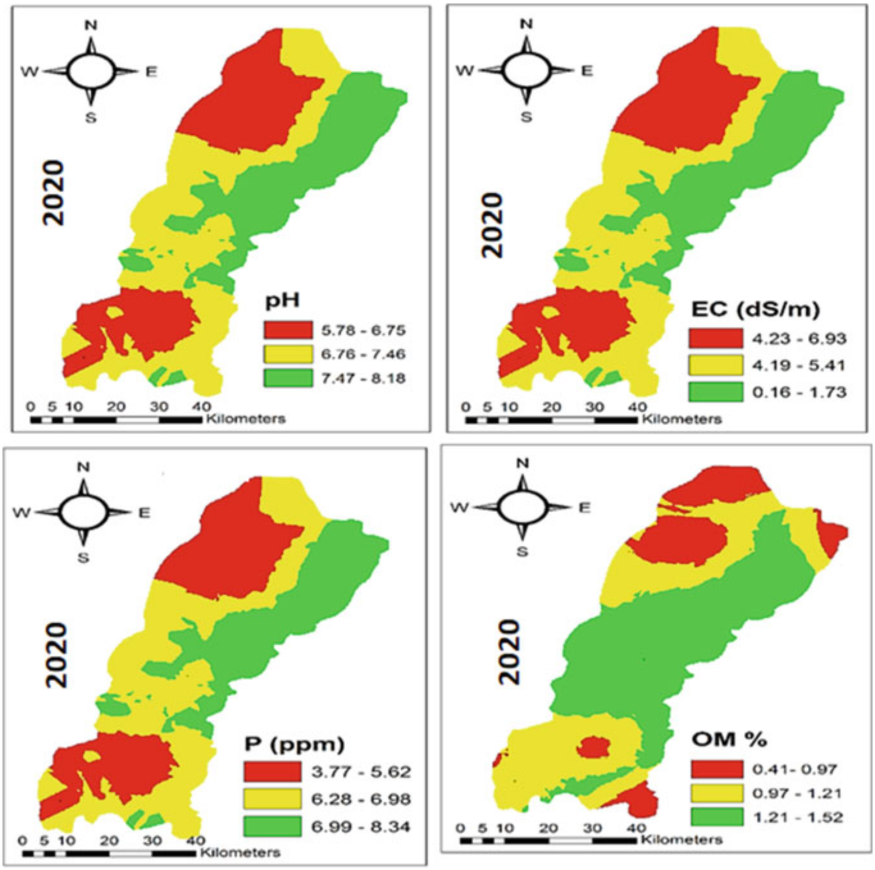


Fig. 11 Soil fertility status in Multan

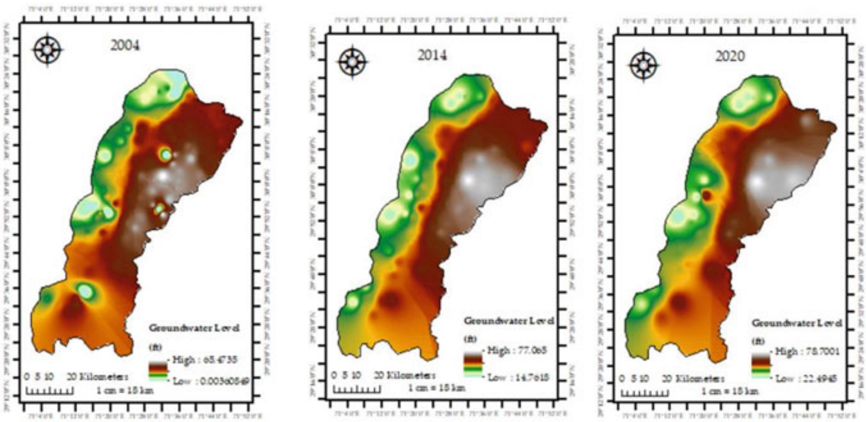


Fig. 12 Groundwater status of Multan City (Imran et al. 2022)

2019–20, Rabi 2020–21 got 31.2 MAF, an increase of 6.9%. The total number of tube-wells was less than 30,000 until the 1960s; today, there are more than 1 million (Watto and Mugera 2015). Over 80% of groundwater is extracted through small capacity private tubewells making it extremely difficult to establish control of the resource (Imran et al. 2022). Groundwater depletion is commonly defined as long-term water-level commonly defined continuous groundwater pumping. The study analyze the season-vise data of 16 years from 2004 to 2020. The outcomes are based on data from 101 observation wells with varying depths to the water table and more extraction of groundwater developed the depletion of groundwater. The GIS programme was used to process the pointed data, and the Inverse Distance Weighted method was employed to interpolate the missing data points (IDW). The interpolated data was then divided into groups based on well depth (Imran et al. 2022). The results depicted about 1.59 ft groundwater depletion rate per year presented in Fig. 11. Results depicted that the farmers in the upper area of the Multan region have taken more water from the surface water as well as groundwater whereas farmers can't easily uptake the surface and groundwater from the lower area with ultimately lower yield compared to upper area farmers (Fig. 12).

4.8 Accuracy Assessment

In remote sensing, accuracy is determined by whether or not the data collected from remote sensing accurately depicts what is really on the ground. It is basically comparison between user accuracy (actual field condition) and producer accuracy (values from remote sensing and software). ERDAS Imagine Software is one of the best tool which is very important for the accuracy assessment. It's useful because it streamlines the processes of radar processing, basic vector analysis, LIDAR analysis, and RS photogrammetry. Using a simple raster-based interface, ERDAS IMAGINE can extract data from imagery and compare it to the present. To determine the accuracy of producer with respect to user data, we select 53 points from the map which was develop from GIS and check the behavior of soil at these points that in which class these lie and what is frequency of these values individually. First, we check the producer values for year 2020, we found that 31 points out of total 53 were lie in high fertile class, 12 lie in medium and 10 lie in Low fertile class. Now, we select 53 points in all four tehsils (Multan Saddar, Multan City, Shujabad & Jalal Pur Pir wala) of district Multan and collect samples of soil from there along with their coordinates at that location and then analyze them in Soil and Water Testing Laboratory, Multan. After analysis, these user points were classified as 26 points lie in high fertile class, 13 points lie in medium fertile class and 14 points lie in low fertile class. When we compare both these points then we get correct points for each class where both (producer and user) match each other as high fertile class is same at 22 points, medium at 10 points and low fertile class matches at 8 points. With the help of these values, we get the User and Producer Accuracy and then finally determine the overall accuracy as 75.47% which means the 75% of our values determined with the help of RS and GIS are same as found in the actual field by soil sample analysis. Which is acceptable and show the accuracy that RS and GIS techniques are feasible to determine the soil fertility of any area without physical contact to that place.

5 Conclusion

Pakistan experiences extreme water scarcity, which has an impact on agricultural output sustainability. This study has shown that quantifying the transfer of soil-vegetation and atmosphere could aid in understanding with GIS, the RS approaches, how crop growth and water management are related. This is useful for crop categorization, rainfall estimation, soil moisture analysis, and planning and management of surface and groundwater resources. The results shows that settlement has increased by 25% because of development of Multan. The area under dense vegetation has been decreased by 30% because of changes in barren land and settlements. The total annual mean rainfall in the basin calculated was 187 mm yr^{-1} (or 213 km3 yr^{-1}). The lowest value was 108 mm yr^{-1} and the highest value was 184 mm yr^{-1}. The total ET of the Multan district was 140 mm yr^{-1}. It is also important to gain knowledge of net water producing (R > ETo) and water consuming areas (ET > R). The waters stuts shows that the due to less vegetation area and more ETo ground water pumping incerae which reduce the ground water table from 65 to 75 ft. This study specifically explained how the practical implementation of accurate and precise information provided by remote sensing is a pivotal significance in water resources.

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