Contribution of Geo-Spatial Technologies in Promoting Sustainable Agriculture and Irrigation Resources Study with Reference to Pali District (Rajasthan)

Sukhdev Meghwal* & Lalit Singh Jhala

Department of Geography, Jai Narain Vyas University, Jodhpur (Raj.)
*Corresponding author's email: spunawatgeo@gmail.com

Abstract

At present, due to the use of modern methods in the agricultural sector, there has been an unprecedented increase in agricultural production and its total area. Mainly the means of irrigation and improved seeds and chemical fertilizers have major contribution in this. Due to changes in the means of irrigation since the middle of the 20th century, agricultural production is continuously increasing and this is also necessary, because it is also necessary to increase agricultural production to meet the huge population of the world. But due to problems like environment it has been adversely affected.

The study area of this research area is Pali district situated in the middle of Rajasthan, west of the Aravalli Mountain range. Efforts are being made to expand new agricultural areas and irrigation facilities with the help of geospatial technology. Thus, in the past years, due to increase in agricultural production and increasing use of irrigation resources in the study area, along with economic development, social, cultural development, changes in the geographical area of the area have also been observed. Which is an indicator of the progress of this sector and the future of this sector is bright.

The contribution of geospatial technology has promoted sustainable agricultural production and irrigation methods. But due to some environmental problems caused by human causes, agriculture was also adversely affected.

Keywords Geospatial technology, irrigation means, agricultural production, economic development, improvement in living standards of people, increase in irrigated area, environmental problems.

Introduction

Remote sensing and geographical information systems used to analyse and visualize agricultural environments have proven to be very beneficial to the farming community as well as the industry. It plays a great role in agriculture around the world by helping farmers increase production, reduce costs and manage their land more efficiently. Geographic information systems (GIS) have been widely implemented and recognized as effective and powerful tools in detecting land cover and land use change. It is important to use remote sensing and GIS to understand crop health, extent of infection, potential yield and soil conditions. It is used to detect agricultural applications like crop identification, area estimation, crop condition assessment, soil moisture estimation, yield estimation, agricultural water management, agricultural meteorology etc.

India Agriculture is the backbone of the Indian economy. According to the 2011 census, 69 percent people live in rural areas, whose main occupation is agriculture. A study has shown that agriculture provides direct and indirect employment to about 60 percent people of the country. Agriculture is the most important employment and enterprise of Indians.

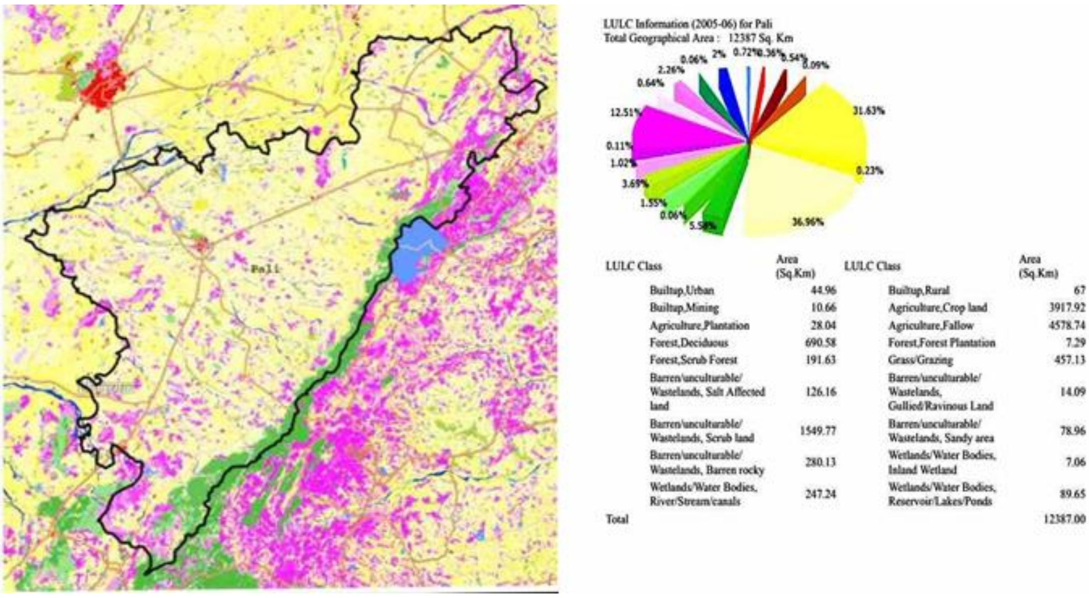
Green Revolution emerged in the year 1966-67. In the Green Revolution, the background has been prepared for the diversification and prosperity of rural life. Agricultural work started being carried out using modern techniques. Although the Green Revolution has led to rapid development in the agricultural sector, this development is not uniform but appears different in every part of the country. Many reasons are responsible behind this. These reasons mainly include the climate of the area, surface, development of irrigation means and many economic and social reasons. Pali district of Rajasthan has also not remained untouched by the many rapid changes taking place in Indian agriculture. Not only has there been a huge increase in mechanization, irrigation, use of chemical fertilizers, use of pesticides and high yielding seeds in agriculture here, but there has also been a lot of improvement in the methods and techniques of agriculture, geospatial technologies, Due to which agricultural productivity has increased.

Applications of remote sensing in agriculture which include major important points like; In addition to precision agriculture and irrigation management, biomass and yield estimation, vegetation vigor and drought stress monitoring, crop phonological development estimation, crop acreage estimation and crop land mapping, mapping of disturbance and land use land cover changes. GIS based mapping applications can help identify the location of crops grown across the country and optimize various variables, monitor the health of individual crops, estimate the yield from a given field, and maximize crop production. Able to identify needy areas and the underlying causes of food insecurity, using land-use and primary food crop statistics from data collected by a variety of devices, including mobile devices, GIS can play a vital role in efforts to end global hunger. Plays and is an integral part of automated field operations.

By using data collected from remote sensors and sensors mounted directly on farm machinery, farmers have improved decision-making capabilities to plan their farming operations to maximize yields. Previous crop yields, terrain characteristics, organic matter content, pH, moisture and soil nutrient levels all aid in proper preparation for precision farming. Combine harvesters equipped with GPS tracking units can measure crop yields along with crop quality values such as plant water content and chlorophyll levels in real time and at the exact location in the field from which they are harvested. Rapidly emerging remote sensing and geospatial technologies can play an important role in monitoring crop growth, identification and management of various types of stresses, regional yield estimation to maintain natural resources and agricultural productivity.

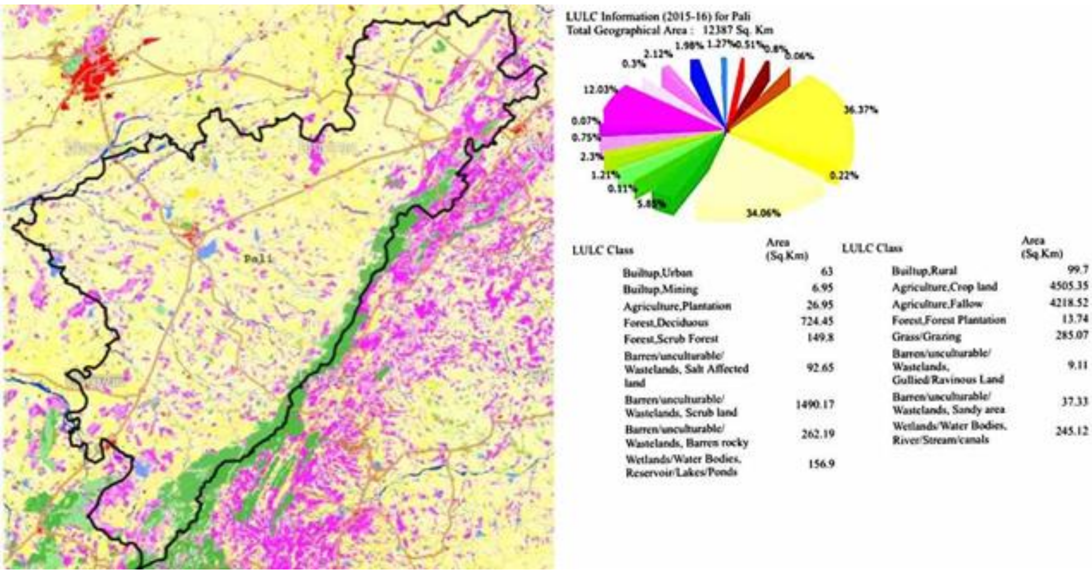
GIS and Remote Sensing Applications in Agriculture: Remote sensing (RS) and geographic information systems (GIS) play an important role in identifying crops and areas where cropping patterns change and are useful tools to conduct crop surveys and mapping. Reliable and timely information on the types of crops grown in an agriculture-based country, their area and expected yield is important for the government. Spectral information is an important aspect of remote sensing data for crop modelling and is strongly related to canopy parameters that are representative of crop health and crop growth stages. Crop-specific maps created by combining satellite image, survey data provide the layout of land and owners (farmers) which are helpful for agribusinesses such as seed and fertilizer companies.

GIS and remote sensing applications in Pali district have increased since 2005. And by finding new agricultural areas, new agricultural areas have become available to the farmers. GIS data of 2005 and 2015 shows how the agricultural sector has increased. Whereas in 2005-06, agricultural crop land was 3917.92 sq.km and agricultural fallow land was 4578.74 sq.km, in 2015-16, agricultural crop land was 4505.35 sq.km and agricultural fallow land was 4218.52 sq.km.



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup,Urban	44.96	Builtup,Rural	67
Builtup,Mining	10.66	Agriculture,Crop land	3917.92
Agriculture,Plantation	28.04	Agriculture,Fallow	4578.74
Forest,Deciduous	690.58	Forest,Forest Plantation	7.29
Forest,Scrub Forest	191.63	Grass/Grazing	457.13
Barren/unculturable/ Wastelands, Salt Affected land	126.16	Barren/unculturable/ Wastelands, Gullied/Ravinous Land	14.09
Barren/unculturable/ Wastelands, Scrub land	1549.77	Barren/unculturable/ Wastelands, Sandy area	78.96
Barren/unculturable/ Wastelands, Barren rocky	280.13	Wetlands/Water Bodies, Inland Wetland	7.06
Wetlands/Water Bodies, River/Stream/canals	247.24	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	89.65
Total			12387.00

Fig. 1 Land use and land cover map of Pali district (2005-2006), Rajasthan. (Source: Department of Science & Technology of Rajasthan 2005-06).



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup,Urban	63	Builtup,Rural	99.7
Builtup,Mining	6.95	Agriculture,Crop land	4505.35
Agriculture,Plantation	26.95	Agriculture,Fallow	4218.52
Forest,Deciduous	724.45	Forest,Forest Plantation	13.74
Forest,Scrub Forest	149.8	Grass/Grazing	285.07
Barren/unculturable/ Wastelands, Salt Affected land	92.65	Barren/unculturable/ Wastelands, Gullied/Ravinous Land	9.11
Barren/unculturable/ Wastelands, Scrub land	1490.17	Barren/unculturable/ Wastelands, Sandy area	37.33
Barren/unculturable/ Wastelands, Barren rocky	262.19	Wetlands/Water Bodies, River/Stream/canals	245.12
Wetlands/Water Bodies, Reservoir/Lakes/Ponds	156.9		

Fig. 2 Land use and land cover map of Pali district (2015-2016), Rajasthan. (Source: Department of Science & Technology of Rajasthan 2015-2016).

Analysis of crop yield, damaged crop area and forecasting: In rainfed areas of Pali district, it is common for crops to get damaged due to lack of rainfall or rainfall when crops are harvested, especially at the time of harvesting of Kharif crops. Disaggregated information on crop yields is an important input for production estimation. Each crop genotype has certain yield potential, which can be achieved with optimal conditions in the experimental field.

However, in the real world, crop yields depend on various parameters such as soil, weather and farming methods, such as sowing date, irrigation and fertiliser. Crop yields are also affected by biological stresses such as diseases and pests. Satellite based remote sensing provides a suitable option for crop status and yield assessment/forecasting, as it gives timely, accurate, concise and objective estimation of various crop parameters. After 2005, GIS use has continuously increased in the districts.

Nutrients and Water Stress: Plants require water, sunlight and adequate nutrients for proper growth and vitality. Macronutrients are found in greater quantities than micronutrients as basic substances for plant cell and tissue development. One of the most important areas where we can opt for the application of remote sensing and GIS through the application of precision farming is nutrient and water stress management. Detecting nutrient stress using remote sensing and GIS is important in site specific nutrient management and can reduce farming costs as well as increase fertilizer use efficiency. In arid regions, judicious use of water may be possible through the adaptation of precision technologies. For example, drip irrigation can be used to increase water use efficiency as well. Detecting crop water stress is important for efficient irrigation water management. Vegetation water stress using satellite monitoring is important for precision agriculture, timing irrigation to ensure that crops will not suffer from water stress and will produce yield under limited water conditions. Satellite data have the potential to provide spatial and temporal dynamics of crop growth status under water stress and its impact on productivity.

Flood watch: Remote sensing techniques in particular allow measurements from space to be obtained at spatial scales far beyond what can be covered by field-based instruments and methods. Flood satellite data have been used to gather information about floods at various temporal and spatial scales, particularly in the Jawai and Sukdi river basins, which are flooded by heavy rainfall during the monsoon season. Automated spacecraft technology has reduced the time to detect and respond to flood events to just a few hours. Remote sensing technology should be improved to improve warning systems for changes in river width, estimate rainfall amounts, and measure water release from dams.

Average production between 2000-2005 was 947.82 kg/Hect. 572.17 kg/Hect between 2005-2010. In 2007-08, 258852 tonnes of Kharif crops were produced while the production of Rabi crops was 260551 tonnes. Whereas in 2010-11, the production of Kharif crops was 375858 tonnes and under Rabi it was 287096 tonnes. In 2015-16 it was 279758 tonnes under Rabi. Whereas the production of Kharif crops was 270092 tonnes. In 2019-20, the production of Kharif crop was 545361 kg/Hect, while the production of Rabi crop was 359623 KG/Hect. This shows that activities like Green Revolution and improvement in remote sensing technology have led to a rapid increase in production.

Land use and land cover: Land use/land cover mapping involves identifying and hierarchically classifying surface features at different scales and plays a major role in the study of global change. Human activity causes environmental problems resulting in deforestation, loss of biodiversity, global warming affecting land use/land cover on a large scale. Therefore, important inputs for environmental management decision making and future planning can be provided by available data on land use/land cover. Increasing population and increasing socio-economic consequences, unplanned and uncontrolled changes in land use/land cover.

Land use/land cover changes generally occur due to mismanagement of agricultural, range and forest lands which causes serious environmental problems like drought, floods etc. Naturally occurring surface features (forests, mountains, rivers, etc.) are called land cover while features modified by humans are classified as land use (urban, rural settlements, canals, gardens, etc.). Land use and land cover mapping has always been very important in all geographical studies as it contains basic information about the features present on the surface along with their information on area, location, shape and pattern. Digital identification is the process required to identify variations associated with land use and land cover properties through geo-registered multi

Remote sensing and GIS are widely used in preparing information on land use and land cover of an area. Digital detection is the change related to land use and land cover properties in the context of geo-registered multi-temporal remote sensing data. Collaboration of remotely sensed data and field observations can accomplish land cover classification and change detection faster and cheaper than either alone.

Agro Metrological Application: Agriculture is highly influenced by climatic and metrological phenomena. Metrological data is collected by various spatial networks of point station observations. Traditional agro-metrological techniques have serious limitations in using their data for real-time agricultural monitoring and yield forecasting. Satellite metrology has allowed obtaining accurate and consistent measurements of many basic agricultural metrological parameters (e.g. surface albedo, surface temperature, evapotranspiration, solar radiation, precipitation).

Pest infestation: Application of remote sensing technologies is important and effective way to identify pest-infested, diseased and to detect, map, monitor the invaders. Spatial heterogeneity complicates trends in biological invasion studies; however, remote sensing with its broad approach has the potential to provide relevant information. Remote sensing applications provide critical data for detecting and mapping defoliation, characterizing disturbance patterns, etc. Remote sensing applications in monitoring and assessing insect defoliation have been used to relate variations in spectral responses to chlorosis, yellowing of leaves, and defoliation in a given leaf. These differences can be correlated, classified and interpreted over a period of time. Airborne remote sensing can achieve different spatial resolutions with different flight altitudes. Ground-based platforms are commonly used in detecting pest management, crop diseases, weed infestations as well as insect damage to crops and provide valuable information for management planning and decision making. Color infrared aerial photography has been used effectively with conventional cameras to characterize damage caused by many serious pests such as locusts.

Water resources management: In recent years, water resources are being experienced at global and regional levels and hence, need to be managed judiciously by applying cutting-edge technologies. Remote sensing is an effective tool for assessing and monitoring water resources. Hyper spectral remote sensing is emerging as a more intensive means to investigate spatial, spectral and temporal variations to obtain more accurate estimates of the information needed for water resource applications. The advent of microwave remote sensing has made it possible to estimate soil moisture availability from remote sensing data.

One of the most valuable natural resources is groundwater, which supports human health, ecological diversity and economic development. Over-exploitation of this vital resource is endangering our ecosystem and the lives of future generations. There has been a huge decline in the ground water level in the district in the last two decades. Applications of geographic information systems (GIS) and remote sensing (RS) technologies in groundwater hydrology have received cursory treatment. Good understanding of geographical location and related spatial information such as water sources, watersheds, terrain surface, land use, land cover, rainfall, temperature, humidity, soil condition and composition, geology, conditions on the atmosphere, human activities, environmental data, etc. are important for water management. Geographic information systems (GIS) and remote sensing (RS) technologies also describe the problems, importance, and sustainable management of groundwater and freshwater.

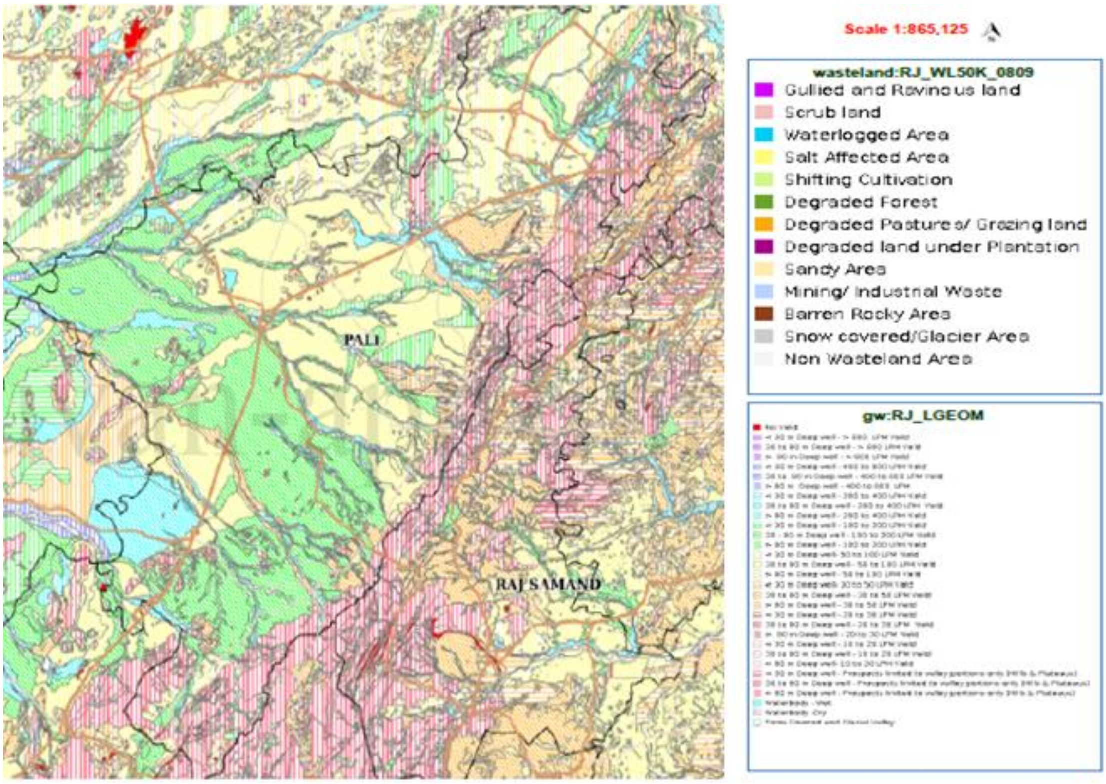


Fig. 3 Wasteland map of Pali district (2015-2016). (Source: Department of Science & Technology of Rajasthan 2015-16).

Conclusion and Suggestions

Like India, agriculture in the study area also faces three challenges – land, water and agricultural labour. After independence, continuous attention was given to agricultural sector development but due to lack of proper implementation of agricultural schemes, their success rate has been low. There are many problems related to agricultural land use in the district. The necessary suggestions for their solution are as follows:

- To improve agricultural land
- Consolidation of holdings
- Developing agricultural infrastructure
- Adoption of dry cropping system
- To help in changing the agricultural system
- Increasing the use of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies
- Making barren land cultivable
- Making arrangements for storage of agricultural produce
- Getting soil tested
- Emphasizing the use of organic fertilizers along with chemical fertilizers.
- Adoption of crop rotation system

- Spreading education
- Making optimum use of water
- To encourage agro-based industries
    - ➢ By establishing farmer training centers at the local level, farmers can be made progressive farmers by providing training facilities at the local level. So that they can do agricultural work with new information, new thinking and other energy.
    - ➢ If population growth is controlled, many agricultural problems will automatically go away.
    - ➢ To reduce the environmental impact on agriculture, the environmental impact can be reduced by adopting measures like water management in the fields, organic and mixed farming, development of new technologies in crop production, change in crop combination, agro-forestry etc.

References

Bahekar, B.W. And Bhole, B.D. (1997). Growth and Utilization of Irrigation on Akola District: Maharashtra, Journal Agriculture Economics Vol, 9 (12), 10.

Kingra PK, Majumder D, Chandra B, Viswavidyalaya K, Singh SP (2016) Application of Remote Sensing and GIS in Agriculture and Natural Resource Management Under Changing Climatic Conditions. Agricultural Research Journal 53(3): 295-302.

Shanmugapriya P, Rathika S, Ramesh T, Janaki P (2019) Applications of Remote Sensing in Agriculture - A Review. Int J Curr Microbiol App Sci 8(1): 2270–2283.

Of R (1994) Remote-Sensing and GIS Applications in Agrometeorology. pp. 1-35.

Diallo Y, Hu G, Wen X (2009) Applications of Remote Sensing in Land Use / Land Cover Change Detection in Puer and Simao Counties, Yunnan Province. 5(4): 157-166.

Rani DS, Venkatesh MN, Naga C, Sri S, Kumar KA (2018) Remote Sensing as Pest Forecasting Model in Agriculture. Int J Curr Microbiol App Sci 7(3): 2680–2689.

Acharya SM, Pawar SS, Wable NB (2018) Application of Remote Sensing & GIS in Agriculture. 6495(4): 63–65.

Reis S (2008) Analyzing Land Use/Land Cover Changes Using Remote Sensing and GIS in Rize, North-East Turkey. Sensors 8(10): 6188-6202.

Joshi C, Leeuw J De, Duren I C Van (2002) Remote Sensing and GIS Applications, (Graph 1).

https://www.google.com/search?q=pali+district+rajasthan&tbm

http://pali.rajasthan.gov.in/content/raj/pali/en/home.html

https://www.krishisewa.com/articles/miscellaneous/896-impact-of-changing-environment-on-agriculture.html

https://agriculture.rajasthan.gov.in/content/agriculture/hi/Agriculture/statistics.html

https://agricoop.nic.in/sites/default/files/RAJ31-Pali-28.08.12.pdf

Citation

Meghwal, S., Jhala, L.S. (2024). Contribution of Geo-Spatial Technologies in Promoting Sustainable Agriculture and Irrigation Resources Study with Reference to Pali District (Rajasthan). In: Dandabathula, G., Bera, A.K., Rao, S.S., Srivastav, S.K. (Eds.), Proceedings of the 43rd INCA International Conference, Jodhpur, 06–08 November 2023, pp. 374–380, ISBN 978-93-341-2277-0.