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Original Article

Canal Irrigation and Its Impact on Ground Water Quality and Agriculture Land Use Land Cover: A Case Study of Purandar Upsa Jal Shinchan, Maharashtra.

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Abstract

The sustainability of agricultural development in a water-stressed country like India largely depends upon assured irrigation and the judicious management of water resources. In semi-arid regions of India, where rainfall variability and recurrent droughts affect agricultural productivity, canal irrigation projects have been introduced to stabilize crop production and enhance rural livelihoods. The present study examines the impact of canal irrigation on groundwater quality and agricultural land use dynamics in the command area of the ***Purandar Upsa Jal Shinchan*** *project in Maharashtra. The study area, located in the drought-prone semi-arid tract of western Maharashtra, has historically depended on monsoon rainfall and groundwater extraction for agriculture. The introduction of lift canal irrigation has significantly modified irrigation practices, cropping patterns, and water resource utilization in the region. The research integrates hydro-chemical analysis of groundwater samples with geospatial techniques such as Remote Sensing and GIS to assess changes in groundwater quality parameters and LULC patterns over a defined temporal framework. Key water quality indicators—including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), and major cations and anions—were analysed to evaluate the suitability of groundwater for irrigation and drinking purposes. Simultaneously, satellite imagery was used to map changes in agricultural land, fallow land, irrigated areas, and built-up zones before and after the implementation of canal irrigation. Preliminary findings indicate that canal irrigation has increased cropping intensity and facilitated diversification toward water-intensive and high-value crops. The study underscores the need for integrated water resource management, conjunctive use of surface and groundwater, and regular monitoring of groundwater quality to ensure long-term sustainability.*

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Keywords: *Canal Irrigation, Groundwater Quality, Land Use Land Cover (LULC), Lift Irrigation, Sustainable Agriculture.*

Study Area

The Purandar tehsil occupies the geographical coordinates between 73^0 57’ 17” E to 74^0 00’ 18” E longitude and 18^0 16’ 12” N to 18^0 17’ 55” N latitude. Purandar is a taluka in the Pune district of Maharashtra. The study area is located in South Eastern and eastern parts of Purandar Taluka of Pune district of Maharashtra state (Survey of India Toposheet Nos. 47/J/7/NW and 47/J/7/NE). Pune city at a distance of about 65 km and approachable in all seasons by road.

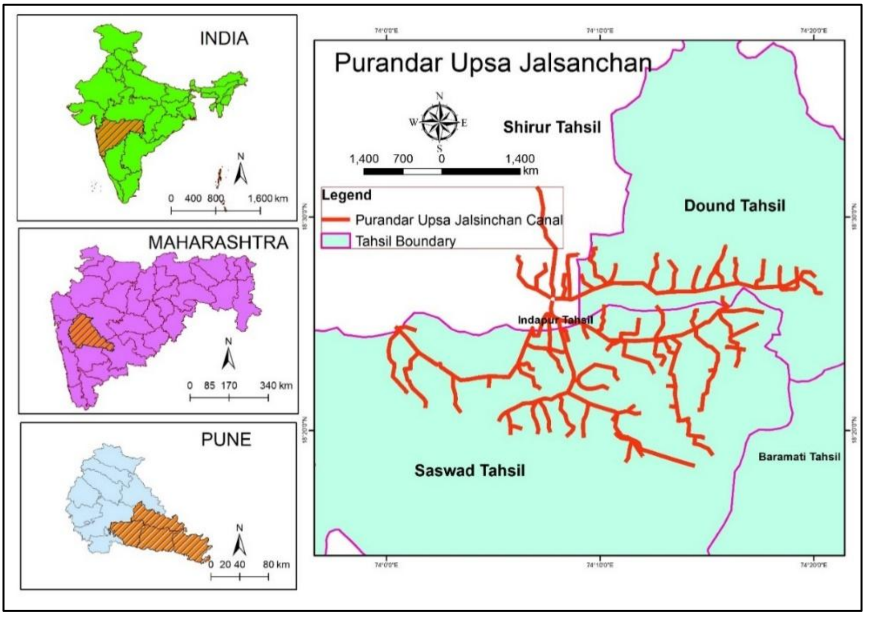


Figure No: Location Map of the Study Area

having latitude 18º 21’, 30” N and longitude 74º 18’, 00” E. The total geographical area is 965.35 ha. The geographical area of the Purandar is 1,101.65 sq. km. This area receives an average annual rainfall of 544 mm. The maximum temperature during summer goes up to 40°C, while the lowest temperature during winter goes up to 9.5°C the traverses in the area supported by the study of surface exposures and the well sections and earlier published work.6 indicate that, the study area is covered by basaltic lava flows of Deccan Trap, which belong to Upper Cretaceous - Lower Eocene age.

Objectives

1. To analyse land use land cover changes in study area
2. The assessment of ground water quality of study area
3. To suggest sustainable plan for the farmers of the study area

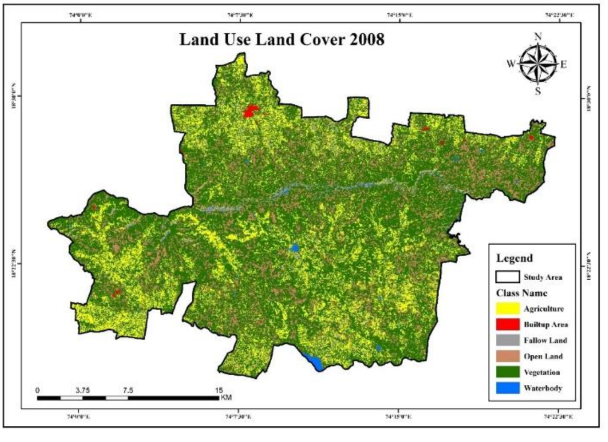
Methodology

The present study adopts an integrated methodological framework combining geospatial techniques, field investigations, laboratory analysis, and statistical interpretation to assess Land Use/Land Cover (LULC) changes, groundwater quality status, and to propose sustainable agricultural planning for the study area under the Purandar Upsa Jal Shinchan project in Maharashtra.The integrated use of Remote Sensing, GIS, hydro-chemical analysis, and field-based socio-agricultural surveys ensures a comprehensive assessment of groundwater quality and agricultural LULC dynamics. This multidisciplinary approach provides a scientific basis for recommending sustainable agricultural practices in the canal command area of Maharashtra.The combination of these methods makes it possible to vividly define the achieved research goals, which refer to the basic natural and social characteristics of the considered geo-space and opportunities for agricultural development. For the data collection related to the analysis of population and settlement, wise agricultural practices we used the statistical method, i.e. Government offices, Census of India. Furthermore, many written documents available on the internet were studied. By introducing the method of analysis, the complex notions in research were deconstructed to bring out conclusions to their simpler components. The synthesis methods were included as a way of systematization of knowledge according to the laws of formal logic, and process of theoretical knowledge in the direction of specific to general. (Rajović and Bulatović, 2013)

Analysis and Discussion

The land use in 2008 reflects a region that is largely rural and agricultural, with vast natural areas (vegetation) still intact. Urbanization was minimal, as indicated by the very small proportion of built-up areas. The significant presence of vegetation suggests a relatively healthy natural environment at the time, with considerable forested or vegetative cover. There was likely a balance between agriculture and nature, with open land and fallow land playing roles in land use management, allowing for sustainability in farming practices. This data paints a picture of a landscape primarily shaped by agriculture, with large areas of natural vegetation and minimal urbanization at that point in time.

Figure No 2: LULC Map 2008 of the Study Area



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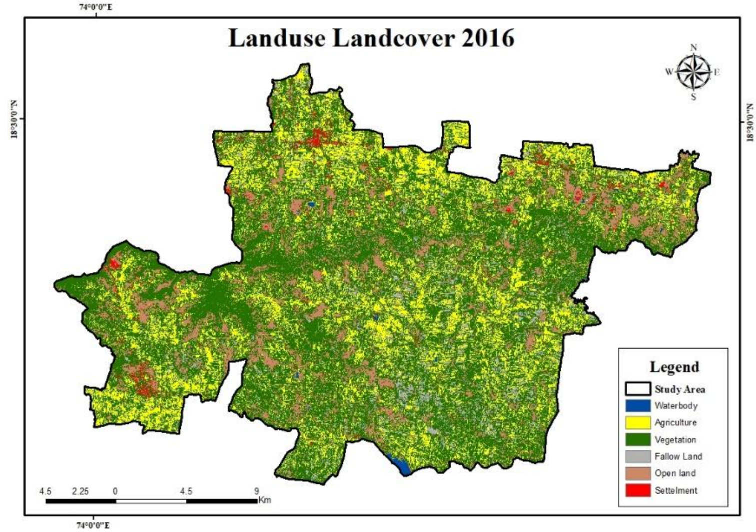

Figure No 3: LULC Map 2016 of the Study Area

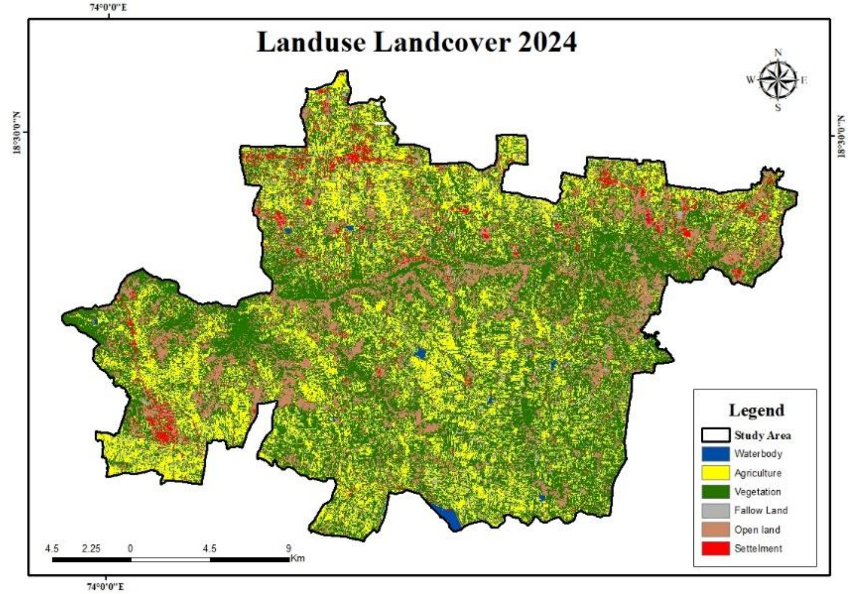

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Figure No 4: LULC Map 2024 of the Study Area

Table No 1: LULC of Area of Study Area in Percentage

Class Name	Area 2008 (ha)	2008 (%)	Area 2016 (ha)	2016 (%)	Area 2024 (ha)	2024 (%)
Agriculture	9536.6	16.4	11890.6	20.4	14532.1	24.9
Built-up Area	217.255	0.3	600.817	1.0	1598.02	2.7
Fallow Land	1852.02	3.1	4132.89	7.1	3277.37	5.6
Open Land	9226.26	15.8	7816.17	13.4	9952.72	17.1
Vegetation	37050.25	63.7	33441.2	57.5	28400.7	48.8
Waterbody	218.15	0.3	218.864	0.3	339.627	0.5
Total	**58100.54**	**100**	**58100.54**	**100**	**58100.54**	**100**

In 2016, the land use patterns show a region that is primarily dominated by vegetation and agriculture, with a significant portion of the land being left fallow. The built-up areas were relatively small, indicating limited urbanization. The presence of significant open land and the modest proportion of water bodies suggest that there were still substantial natural and undeveloped spaces within the region. This analysis highlights the region's land use priorities in 2016, with a strong reliance on agriculture, coupled with an abundance of natural vegetation. However, this balance could be under pressure from future urbanization and agricultural expansion. The limited built-up area points to potential for future urban growth, but also to the ongoing dominance of agriculture in the region's socio-economic structure. In 2024, land use has shifted significantly from 2016, with substantial increases in agriculture and built-up areas, and a corresponding decrease in vegetation. The region appears to be undergoing rapid urbanization, as seen in the growth of built-up land, but at the same time, it is grappling with the environmental consequences of agricultural expansion and the loss of natural habitats. The expansion of open land and the increase in waterbodies suggest a mixed landscape that includes both natural land conservation efforts and infrastructure development. The reduction in fallow land also indicates a move towards more intensive land use practices, which may be causing environmental strain in the form of soil degradation or loss of biodiversity. These shifts point to the increasing pressures of urbanization, agriculture, and infrastructure on natural resources and ecosystems, suggesting that balancing economic development with environmental conservation will be crucial in the coming years. The transformation of land use patterns reflects a decline in fallow land and expansion of irrigated agriculture, demonstrating both positive agricultural growth and emerging environmental concerns.

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Analysis of Water sample

Water is an essential natural resource for all forms of life. It plays a vital role in drinking, agriculture, industry, and recreation. However, due to various human and natural activities, water bodies are increasingly getting contaminated. Therefore, the assessment of water quality is crucial to ensure its suitability for a specific purpose.

Table No 2: Standard Water Quality Table (DO, BOD, and pH)

Parameter	Unit	Very Good / Pristine	Fair / Moderately Polluted	Poor / Polluted	Very Poor / Heavily Polluted
DO	mg/L	8 - 10+	4 - 7	2 - 4	< 2
BOD	mg/L	< 1 - 2	3 - 5	6 - 9	> 10
P^H	Units	6.5 - 8.5	6.0 - 6.5 or 8.5 - 9.0	< 6.0 or > 9.0	< 4.0 or > 10.0

Table No 3: Water Sample Data of Study area

Sr. no.	Village Name	P^H	Temp.	DO	BOD
1	Koregaon Mul	7	32	7.6 mg/L	40mg/L
2	Shindawane	7	32	7.8 mg/L	20mg/L
3	Vitthalban	7	32	7.8 mg/L	40mg/L
4	Malshiras	7	32	8 mg/L	110mg/L
5	Pimpri	7	32	9.6 mg/L	220mg/L
6	Kolvihire	7	32	8.6 mg/L	120mg/L
7	Waghapur (pumping station)	7	32	7.2 mg/L	40mg/L

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8	Saswad road	7	32	7.4 mg/L	20mg/L
9	Udachiwadi	7	32	8.4 mg/L	60mg/L
10	Vanpuri	7	32	8.2 mg/L	40mg/L

Water quality analysis involves evaluating the physical, chemical, and biological characteristics of a water sample. It helps to determine whether the water is safe for consumption, irrigation, industrial applications, or sustaining aquatic life. The data obtained from water quality analysis is compared with standard permissible limits set by organizations such as the World Health Organization (WHO), Environmental Protection Agency (EPA), and Bureau of Indian Standards (BIS).

Interpretation of water samples

Koregaon Mul records a neutral pH (7) and temperature of 32°C. The DO level (7.6 mg/L) indicates satisfactory oxygen availability. However, the BOD value (40 mg/L) suggests moderate organic contamination. The water quality is acceptable but reflects the presence of biodegradable organic matter, possibly from agricultural runoff or domestic activities. At Shindawane, the DO value is 7.8 mg/L, which is adequate and reflects stable water conditions. The BOD level (20 mg/L) is comparatively lower than most other villages, indicating relatively better groundwater quality with minimal organic pollution. Vitthalban shows a DO concentration of 7.8 mg/L, similar to Shindawane. However, the BOD level (40 mg/L) is higher, suggesting moderate organic load in groundwater. Though oxygen availability is sufficient, the organic content requires monitoring.

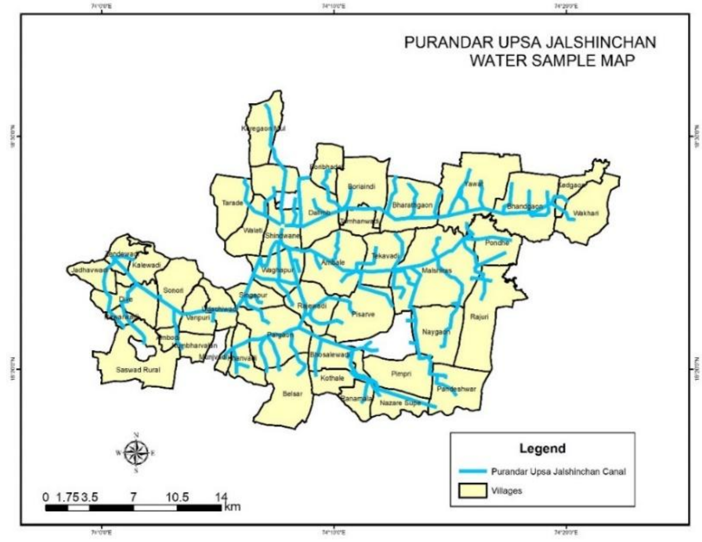

Figure No 5: Water Sample Map of the Study Area

Malshiras records a DO value of 8 mg/L, which is satisfactory. However, the BOD level (110 mg/L) is significantly high, indicating considerable organic contamination. Such elevated BOD levels may be associated with intensive agricultural practices or wastewater infiltration, posing potential risks to groundwater sustainability. Pimpri exhibits the highest DO concentration (9.6 mg/L), reflecting well-oxygenated groundwater. Despite this, it also shows the highest BOD value (220 mg/L), indicating severe organic pollution. The coexistence of high DO and extremely high BOD suggests active recharge or mixing processes, but the high organic load requires urgent attention and management.

Kolvihire has a DO level of 8.6 mg/L, indicating good oxygen conditions. However, the BOD value (120 mg/L) is notably high, suggesting substantial organic contamination. This indicates potential anthropogenic impacts, likely from agricultural or domestic sources. Waghapur, the DO concentration is 7.2 mg/L, the lowest among all sites, though still within a moderate range. The BOD value (40 mg/L) indicates moderate organic pollution. The pumping activities may influence water quality through increased mixing or localized contamination. Saswad Road records a DO level of 7.4 mg/L and a relatively low BOD value (20 mg/L). This suggests comparatively better groundwater quality with limited organic pollution and stable environmental conditions.

Udachiwadi shows a DO concentration of 8.4 mg/L, which is favorable. The BOD value (60 mg/L) indicates moderate to high organic content. While oxygen levels remain adequate, the elevated BOD suggests the influence of anthropogenic activities.

Vanpuri has a DO value of 8.2 mg/L and a BOD level of 40 mg/L. The oxygen concentration is satisfactory, but the moderate BOD reflects the presence of biodegradable organic matter. Continued monitoring is advisable to prevent further deterioration. All villages exhibit neutral pH and uniform temperature, indicating similar hydro-climatic conditions across the study area. However, significant variation in BOD values highlights localized sources of organic contamination. Villages such as Pimpri, Kolvihire, and Malshiras show critical levels of organic pollution and require immediate management strategies. In contrast, Shindawane and Saswad Road demonstrate relatively better groundwater quality. The findings emphasize the need for regular groundwater monitoring, improved wastewater management, and sustainable agricultural practices to maintain long-term water quality in the study region. It also indicates that seepage from canals and excessive irrigation practices have contributed to localized groundwater table rise and moderate changes in groundwater salinity in certain pockets. Effective institutional coordination and farmer awareness are essential to balance agricultural productivity with environmental conservation in canal command areas.

Suggestions

Irrigation Management Planning-

Since all villages show neutral pH and uniform temperature, groundwater is generally suitable for irrigation from a chemical balance perspective. However, villages such as **Pimpri, Kolvihire, and Malshiras**, where BOD levels are critically high, require controlled irrigation practices. Continuous use of organically contaminated water may:

- Alter soil microbial activity
- Increase organic residue accumulation in soils

- Reduce long-term soil productivity

Adoption of drip irrigation systems and periodic soil testing should be implemented in high-BOD villages to prevent soil degradation.

Wastewater and Drainage Management

High BOD values indicate localized organic pollution, likely from:

- Domestic wastewater discharge
- Agricultural runoff (fertilizers, livestock waste)
- Poor drainage infrastructure

Construction of decentralized wastewater treatment units in critically affected villages.

Agricultural Practice Modification

In villages with high BOD (Pimpri, Kolvihire, Malshiras), agricultural inputs may be contributing to organic loading.

- Encourage organic farming with controlled compost application.
- Reduce excessive use of chemical fertilizers and promote integrated nutrient management.
- Implement buffer strips and vegetative barriers to reduce runoff into recharge zones.

Public Health and Community Awareness

Although DO levels remain moderate to good, high BOD may indicate potential microbial contamination risks.

- Awareness programs regarding safe water usage.
- Promotion of basic water treatment methods (filtration, boiling) for domestic use.
- Regular health check-up camps in high-risk villages.

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