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# Analyzing Water Status and Land use and Land Cover in the Jakhnidhar Block of District Tehri Garhwal, Uttarakhand

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## ABSTRACT

Analyzing land use and land cover (LULC) is essential to comprehending how human activity and natural resources are distributed spatially, especially in geographically diverse and environmentally sensitive areas. The LULC patterns in Jakhnidhar block, which is situated in the Tehri Garhwal area of Uttarakhand, India, are the main subject of this study. The block, which covers 354 square kilometers, has a varied land use profile that has been influenced by the rough topography of the Himalayas. With 42.1% of the land covered by vegetation, the area is dominated by vegetation, which emphasizes the biodiversity and biological richness of the area. Rangelands make up 34.6%, which is indicative of their contribution to pastoral livelihoods. 13.2% of the total is made up of water bodies, highlighting the significance of hydrological resources in supporting home and agricultural demands, Nevertheless, just 3.1% of the land is used for agriculture due to high hills and dispersed landholdings, which pose problems for both economic sustainability and food security. Baregrounds, which represent degraded or unproductive land, make up 2.4% of the land, whereas built-up areas, which indicate moderate infrastructural development and human settlement, make up 4.6%. With a focus on the importance of effective resource management, soil conservation, and water accessibility, this study critically assesses the consequences of these patterns for sustainable development, a framework for well-informed land-use planning in Himalayan regions is provided by this research, which integrates LULC data with geographical and socioeconomic aspects. The results highlight how crucial it is to strike a balance between development and conservation in order to maintain ecological stability and raise living standards in the Jakhnidhar block.

**Keywords:** Land Use Land Cover, Water Stress, Average land holding size, Built up area, Rangeland

## INTRODUCTION

Water scarcity has a significant influence on agriculture in Uttarakhand's mountainous regions because farming there is mostly dependent on rainfall and spring-fed irrigation systems. Water supply for irrigation has drastically decreased as a result of natural springs drying up due to deforestation, changes in land use, and inadequate recharge from unpredictable rainfall (Vizzuality, n.d.) a key component of hill agriculture, traditional terraced farming is becoming more susceptible to these changes, which will result in decreased output (Sati and Kumar, 2023), further, many farmers are forced to leave land fallow or switch to less water-intensive crops due to seasonal water shortages during crucial planting and growth seasons, which frequently jeopardizes revenue and food security (Kumari, 2021), the issue has been made worse by climate change, as rivers and streams that support irrigation are experiencing reduced snowfall. Although there have been initiatives to encourage rainwater gathering, revive old water conservation methods, and introduce drought-resistant crop varieties,

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the problems of guaranteeing agriculture's sustainable supply to water still exist. For mountain communities, where farming is still the major source of income, resolving these problems is essential (Phondani *et al*., 2020)

Understanding the relationship between natural resources and human activity requires an understanding of land use and land cover (LULC), especially in areas with diverse topographies and delicate ecosystems. For sustainable planning and resource management, LULC analysis offers vital insights into the spatial patterns of vegetation, water bodies, agriculture, and urbanization (Lambin *et al.*, 2001), Steep topography, a changing climate, and socioeconomic activity all interact to produce LULC patterns in the Himalayan region, including the Jakhnidhar block in Uttarakhand. The region's ecological richness is reflected in the predominance of vegetation and rangelands, while the restricted areas of built-up and agricultural land emphasize the limitations imposed by the topography. Both natural and man-made variables can cause changes in LULC, which have profound effects on hydrology, biodiversity, and community livelihoods (Gautam *et al.,* 2003).

Agricultural activities in Uttarakhand's Jakhnidhar block are greatly impacted by the water situation because of the area's mountainous environment and reliance on rains and springs. Jakhnidhar, like a large portion of the Tehri Garhwal area, depends on springs and other traditional water sources for irrigation. (Singh and Bhatnagar, 2012), nonetheless, seasonal variations in spring discharge rates frequently result in water scarcity during dry spells. Rain-fed agriculture has become the norm for many farmers as a result, which has reduced crop output and diversity (Shukla *et al.*, 2024) the complex topography and climate of Uttarakhand's Jakhnidhar Block influence agriculture techniques. Conventional subsistence crops such as foxtail millet, finger millet, and barnyard millet are grown in reduced amounts. these crops are prized for their nutritional content and ability to adapt to mountainous terrain (Rana and Bisht, 2023), traditionally produced crops include wheat, maize, and pulses; in some places, people are trying their hands with medicinal herbs and aromatic plants. Assisted by regional programs like demonstration plots, which assist farmers in reintroducing and maintaining these heritage crops, efforts to recover traditional crops, like foxtail millet, have showed potential. Jakhnidhar's agricultural environment also includes vegetables like potatoes and tomatoes, as well as fruits like guava and litchi (Chandra, 2024)Insufficient water supply, displacement from rural areas, and tiny and dispersed landholdings are among the ongoing challenges. To fully realize Uttarakhand's agricultural potential, these issues must be resolved through infrastructural development, better market access, and policy support (Pandey and Kumar, 2024)

**Study Area:**

The hilly landscape of Jakhnidhar Block, which is a part of Tehri Garhwal in Uttarakhand, is characteristic of the Himalayan area. The majority of the communities in the block are rural in nature, with small-scale business and agriculture serving as the main sources of income. Because of its elevation, the region has a varied climate, which influences the variety of plants and farming methods, Natural springs and streams are vital sources of water for farming and drinking. Seasonal variations in water supplies, however, may necessitate local management initiatives to guarantee sustainability. The area also benefits from being close to the Tehri Dam, which provides water and electrical power for the area but has issues with environmental effects and displacement (Fig. 1).

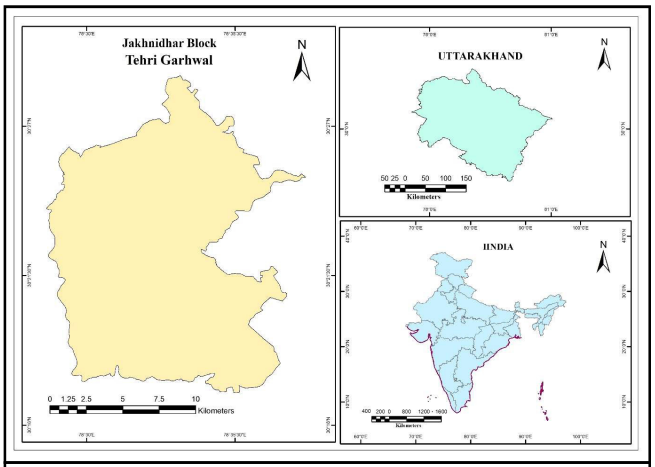


**Fig. 1 : Location Map of Jakhnidhar Block**

According to the 2011 Census, the Jakhnidhar block in Tehri Garhwal, Uttarakhand, is home of 32,753 people. The exceptionally high sex ratio of 1,185 females per 1,000 males indicates that women dominate men. There is a noticeable gender disparity in schooling, as evidenced by the region's comparatively high literacy rate of 77.4%, with male literacy at 90.88% and female literacy at 66.52%, The majority of the population (97.14%) is Hindu,

with only 2.7% of Muslims and other religious groups. Only 0.2% of the population is made up of Scheduled Tribes, compared to 18% of Scheduled Castes. With 4,085, the child population (0–6 years) is substantial.

**Objective:**

- To analyze Land use Land cover of 2023 by using Sentinel 2 satellite series data.
- To analyze relationship between Land Use and Land Cover and Water stress in Jakhnidhar block.

## METHODOLOGY

Both primary and secondary sources serve as a basis for the study. The primary data for this study came from field surveys, while secondary data came from Esri Earth Explorer using data from the Sentinel-2 series of satellites. interviews with various stakeholders, targeted group discussions, and structured questionnaires was used to gather primary data from the study. Water stress maps were created by gathering data from field surveys, and the researcher classified four types of water stress based on water availability: high water stress, medium water stress, low water stress, and land use land cover map of 2023 prepared withhigh resolution 10-meter data which obtained from Esri Earth Explorer using sentinel-2 series data, The researcher used structured questionnaires and data collection techniques to gather information from field surveys in the study area and examined the effects of land use, land cover, and cropping patterns on livelihood. Collection: A thorough questionnaire was created and used to gather primary data for the study. Additionally, indirect oral investigation techniques and observation methods were employed.

## RESULTS AND DISCUSSION

**Land Use and Land Cover of Jakhnidhar Block:**

The various applications of the 354 square kilometers of land in the Jakhnidhar block of the Tehri Garhwal district of Uttarakhand are shown by the Land Use Land Cover (LULC) data. The environment is dominated by vegetation, which makes about 42.1% of the total area (149.03 sq. km). This draws attention to the area's abundant woodland and native vegetation, which are essential for environmental stability and biodiversity (Fig. 2).

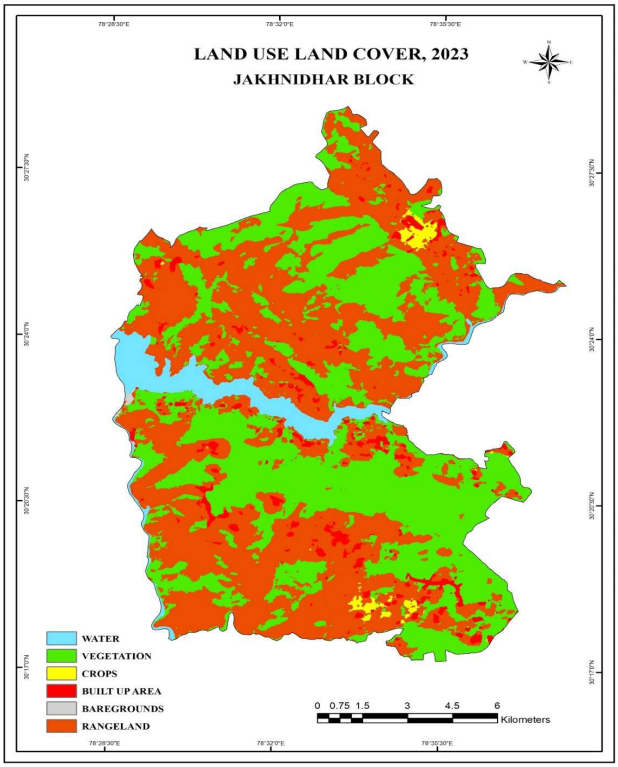


**Fig. 2 : Land use Land Cover, 2023**

The block's agricultural and pastoral activities are reflected in the second-largest category, rangelands, which make up 122.48 sq. km (34.6%) and are used as grazing pastures and open spaces. With 46.72 sq. km (13.2%) devoted to water bodies, including as rivers, streams, and reservoirs, the region is hydrologically significant, the development footprint inside this predominantly rural block is demonstrated by the 16.28 sq. km (4.6%) of built-up areas, which include infrastructure and communities. 10.97 sq. km (3.1%) of land is covered by crops, demonstrating the little yet crucial contribution that agriculture makes to local livelihoods. 8.49 sq. km (2.4%) are baregrounds, which

**Table 1 : Area of Land use and Land Cover**

| Land Use Land Cover | Area in Sq. Km. | Percentage |
|---|---|---|
| Water | 46.72 | 13.2% |
| Vegetation | 149.03 | 42.1% |
| Crops | 10.97 | 3.1% |
| Baregrounds | 8.49 | 2.4% |
| Built Up Area | 16.28 | 4.6% |
| Rangeland | 122.48 | 34.6% |
| Total | 354 | 100% |

are areas of terrain that are either completely bare or only lightly vegetated (Table 1).

The land use patterns of the Jakhnidhar Block are significantly shaped by its topography, which is marked by steep slopes, delicate soils, and a range of heights. These physical limitations are reflected in the small agricultural area, where terraced farming is the main method of agriculture. The prevalence of rangelands and forests emphasizes the need for natural resources, but these ecosystems are nonetheless at risk from overuse and climate change, Water security is a critical issue because, despite their importance, water bodies are vulnerable to periodic rainfall and glacial melt. Furthermore, the absence of large built-up areas indicates the necessity of planning for sustainable development, which strikes a balance between community growth and natural preservation,the complex interactions between natural and man-made land uses in the Jakhnidhar block highlight the necessity of a well-rounded development strategy that places an emphasis on socioeconomic advancement and ecological preservation. This study attempts to offer a framework for sustainable land management that is suited to the particular requirements of this Himalayan region by examining LULC patterns.

**Water Stress Map :**

The Table 2 illustrates how landholding sizes, water stress, and intimacy to water sources interact to shape the agricultural landscape and sustainability of livelihoods in six villages within the Jakhnidhar block (Fig. 3).

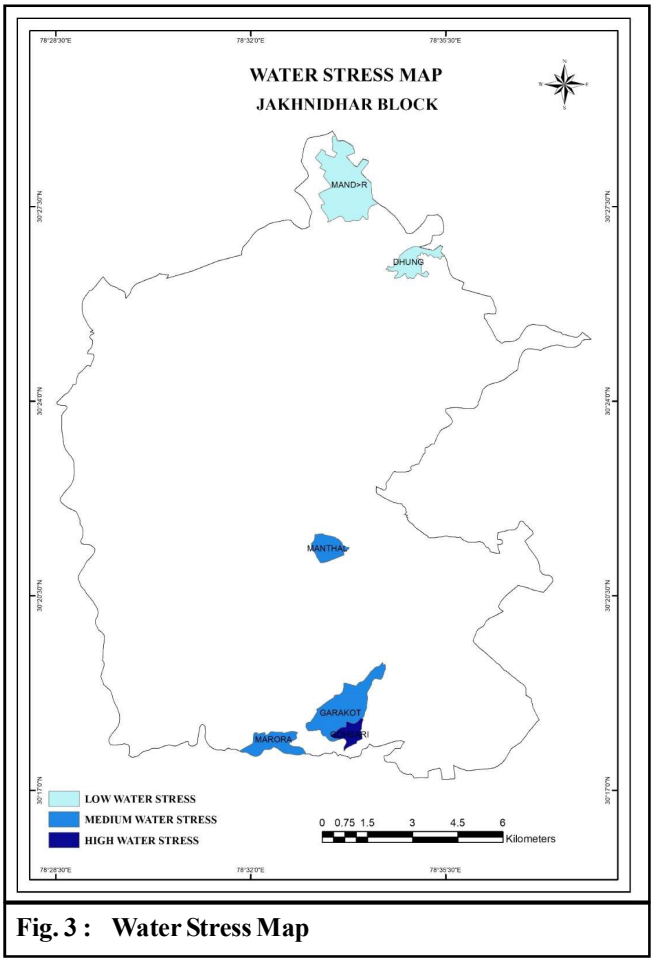


**Fig. 3 : Water Stress Map**

**Agriculture and Situation of Water:**

***Low Water Stress Villages:***

The fact that these villages are smaller than two kilometers from water sources is advantageous. Because of the reduced water stress, irrigation is more reliable, allowing for more stable farming methods. These settlements have a comparatively higher potential for farming, particularly the cultivation of water-intensive crops, due to their average landholdings of 1.1–1.3 hectares.

***Medium Water Stress Villages:***

Moderate water stress and water sources that are 1-3 km apart present more difficulties for these villages. Agricultural efficiency is probably impacted by the longer distance since irrigation and water collection require more time and effort. The landholding sizes range from 0.8 to 1.2 hectares on average, although agricultural choices are limited by water availability, which could result in

**Table 2 : Water Stress in Jakhnidhar Block**

| Sr. No. | Name of Village | Water Stress | Distance from source of water | Average Land Holding Size (Hectare) |
|---|---|---|---|---|
| 1. | Mandar | Low water Stress | Less than 1 km | 1.3 |
| 2. | Dhung | Low Water Stress | Between 1 to 2 Km | 1.1 |
| 3. | Garakot | Medium Water Stress | Between 1 to 2 Km | 1.2 |
| 4. | Manthal | Medium Water Stress | Between 2 to 3 Km | 0.8 |
| 5. | Marora | Medium Water Stress | Between 1 to 2 Km | 1.1 |
| 6. | Gohsari | High Water Stress | Between 2 to 3 Km | 0.7 |

low yields or a dependence on rainfed land.

***High Water Stress Villages:***

High water stress and an adequate supply more than two kilometers away present serious agricultural issues for Gohsari. The community is particularly vulnerable because it has the smallest average landholding size (0.7 hectares). Due to severe irrigation restrictions caused by limited water availability, farmers are forced to grow less productive, drought-resistant crops or possibly give up farming entirely (Fig. 4).

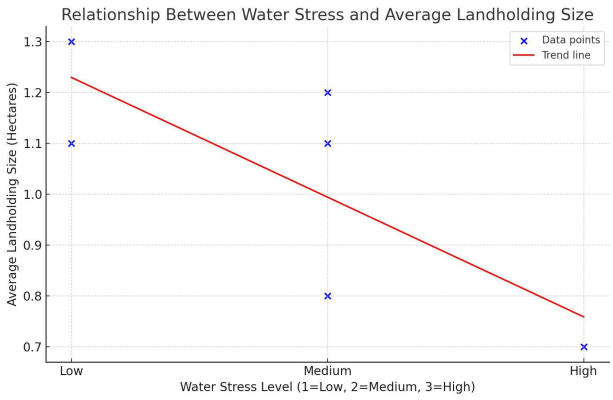


**Fig. 4 : Relationship Between Water Stress and Average Landholding Size**

There is a significant negative association (r = -0.76) between average landholding sizes and water stress levels. This indicates that the average landholding size tends to decrease as water stress increases (from low to high), According to the investigation, one important factor affecting landholding sizes in the Jakhnidhar block is the availability of water. Reducing the negative impacts of water stress on land usage and agricultural productivity may be possible by using better irrigation, rainwater collection, and water-efficient farming techniques.

**Landholding Size and Productivity:**

The table shows that small and dispersed landholdings are typical in the Jakhnidhar block. There is little room for large-scale farming or mechanization because the typical land size is between 0.7 and 1.3 hectares, Manthal and Gohsari, two villages with lesser landholdings, are especially at a disadvantage. The small holdings would restrict production and profitability, keeping farmers in subsistence-level agriculture even if water were more readily available, the majority of households in these villages probably make their living mostly from agriculture. However, their capacity to diversify crops or implement higher-value agricultural methods is constrained by their modest land holdings and water constraint, promote the production of high-value, drought-resistant crops that use less water and provide higher market returns, such as pulses and millets, encourage cooperative farming concepts to bring disparate landholdings together so that farmers can share advantages and pool resources, encourage the adoption of contemporary farming equipment that is appropriate for tiny farms by offering subsidies or other incentives.

The difficulties and limitations common to Himalayan agricultural systems are reflected in the average landholding size in the communities of the Jakhnidhar block. According to the data, the average landholding size varies from 1.3 hectares in Mandar, a hamlet with greater access to resources and less water stress, to 0.7 hectares in Gohsari, an area with considerable water stress. Small and dispersed agricultural plots are common in the six communities under analysis, with an average landholding size of about 1 hectare, these smaller landholdings are typical of subsistence farming, where the terrain, lack of irrigation infrastructure, and accessibility to water frequently limit agricultural productivity. Given that small land sizes prevent crop diversification, mechanization, and the adoption of contemporary agricultural techniques, this pattern highlights the socioeconomic difficulties that farmers in the area confront. Jakhnidhar block's agricultural livelihoods can be improved by increasing land productivity through agroforestry, collaborative farming practices, and the introduction of high-value, low-water-requirement crops.

**Conclusion:**

The potential and difficulties present in the topography of the Jakhnidhar block are highlighted by the LULC statistics. The little agricultural land and populated regions are a reflection of the limitations imposed by the rough terrain, even if greenery and rangelands predominate. The block can protect its ecological wealth while utilizing its natural resources for development by emphasizing sustainable practices, The combination of landholding size, distance from water sources, and water stress poses serious problems for Jakhnidhar block's agriculture. While villages with smaller plots and high-water stress suffer severe limitations, those

with greater landholdings and low water stress are better positioned for agricultural productivity. In this geographically limited area, addressing these discrepancies through targeted interventions can improve livelihoods and agricultural sustainability.

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