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Analysing the Land Use Land cover by using Multi–Spectral Remote Sensing Data in Tehri Garhwal, Uttarakhand

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Abstract

Land use and land cover (LULC) changed drastically throughout the time frame, today there are various factors which is responsible for changes in agricultural land use, anthropogenic and natural factors both have reasons for it, anthropogenic factors like infrastructural development, agricultural activities, recreation activities play major role, natural factors like forest fires, climate change mainly responsible, The investigation studies in modifications in LULC, More than two decades, researcher prepared LULC maps with the assistance of multi-spectral remote sensing Landsat 5 series data used for preparing maps of 2001 and 2011, 2021 map created with Sentinel 2 series data, two decades maps of LULC gives picture about variations in land cover and use, 2001 taken as base year of study, LULC in mountainous regions of Tehri Garhwal different from plain regions, cropping pattern is different, agricultural productivity is different, Seven major LULC types (Crop land, Built Up Area, Forest cover, Water, Range land, Snow Cover and bare Grounds) built-up areas have steadily increased during the past 20 years, demonstrating substantial infrastructural development and urbanization, Crop land is consistently declining, snow cover continuing decline from 2001 to 2021 indicating signifies a move away from conventional agricultural uses, Planning for urbanization must integrate economic expansion with preservation of the environment., addressing the reduction in snow cover and its ripple consequences requires mitigation as well as adaptation measures, such as encouraging sustainable behaviours and renewable energy.

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Introduction

Human depends on land and water resources for the fulfilment of their own needs thus land plays an important role as natural resource for the developmental point of view.[1] Land is the foundation of all terrestrial ecosystem services and an essential

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natural resource for human survival.[2] Globally, LULC changes are now recognized as the primary factor influencing changes in ecosystem services, and Tehri Garhwal is seeing significant changes throughout the district.[3] Growth in the population and economic development have increased changes in LULC throughout span; these changes may potentially occur more quickly, fundamental elements of the Earth system, (LULC) are closely related to human activities and the environment. LULC is important for changes in land use and environmental conditions globally, influencing human livelihood and productive endeavours.[4] incorporating the results of interactions between people and the environment in a specific location that are impacted by societal processes and climate change-related issues, the use of land for any purpose, including agriculture, development, conservation, recreation, wildlife habitats, urban areas, and other uses, is referred to as land use and land cover, or LULC.[5,6]

The material manifestations of environmental and human processes and their interconnections mediated by land availability are the shifts in land use across different geographical and temporal domains, LULC refers to the utilization of land for various purposes such as Any activity that involves agriculture, wildlife habitats, conservation, development, recreation, or urban areas.[5] The Tehri Garhwal district's LULC modification is essential for the application of ecological preservation and equitable resource management strategies, upholding equilibrium between environmentally friendly behaviors and economic growth is crucial.[7,8] While land use and management changes have increased household income, they have also resulted in a loss of forest cover and an increase in the intensity of biomass removal from forests. Because the productivity of farms depends on forests, the continuous depletion of forest resources will lead to low agricultural returns to local communities as well as a loss of the advantages that forests and ecosystem services provide to the world's population.[9,10] It is difficult to link land cover and utilization with human livelihood response as Land use land cover can also originate from other causes.[11] Alterations to the (LULC) is critical for environmental change as well as social, economic, and regional development, it is evident that if preventive measures are not planned for, the trend of converting forest and agricultural land to built-up areas would continue and have a negative impact on the local ecology, to plan and establish control measures, it is necessary to understand the proportion of land use and how it varies over time.[12-14]

LULC changes in the Bhilangana basin after the construction of the Tehri dam in the Garhwal Himalaya is the key objective of this research, this research suggests a reduction in cropland, scrubland, and forests, while afforestation increases forest cover in response,[16] major shifts have been noted between 1992 and 2022, with an increase in populated areas, open space, and aquatic bodies and a decrease in areas covered by snow and vegetation in the Garhwal region of Uttarakhand.[17]

The objectives of the investigation analyse the changes of (LULC) in the District Tehri Garhwal over a long-time frame. First, there is an intention to develop LULC maps for a period of more than two decades; it utterly serving as an instrument that shows how LULC have changed from 2001 to 2021 through remote sensing (RS) and geospatial data. In addition, a comprehensive review of LULC patterns across three decades is essential since it will help reveal major shifts in different categories such as cropland, built up areas, forest cover among others. This therefore provides significant insights into the causative factors of transition in land use such as urbanization, abandonment of agriculture as well as climate changes which are expected to inform future strategies for managing natural resources in this part of world. Therefore, we can see how important this study is for future policy makers on land management.

Materials and Methods

Study Area

The Tehri Garhwal district is found between longitudes 77º56' and 79º04' E and latitudes 30º03' and 30º53' N, and Survey of India toposheet numbers 53J and 53N include the district., the district Tehri Garhwal is almost entirely covered in mountains with enormous surface undulations (Figure 1). The district is divided into numerous river valleys on its western side, with the Yamuna River dividing it from the Jaunsar region of Dehradun district, and Bhagirathi touches Uttarkashi close to Nagun village. The district's general slope is from north to south,

and altitude increases with increasing height, The climate of the Tehri Garhwal district is sub-temperate to temperate, as elevation increases, the climate becomes colder; at lower elevations, the climate is pleasant all year round; in the winter, it is extremely cold; in the summer, it is pleasant; and during the rainy season, it becomes cooler, several small and big streams, rivers, Gads, and Gaderas can be found in the district. The most significant river is the Bhagirathi, which splits the district into two parts in the middle. Other significant rivers include the Bhilangana, Alaknanda, Ganga, and Yamuna,

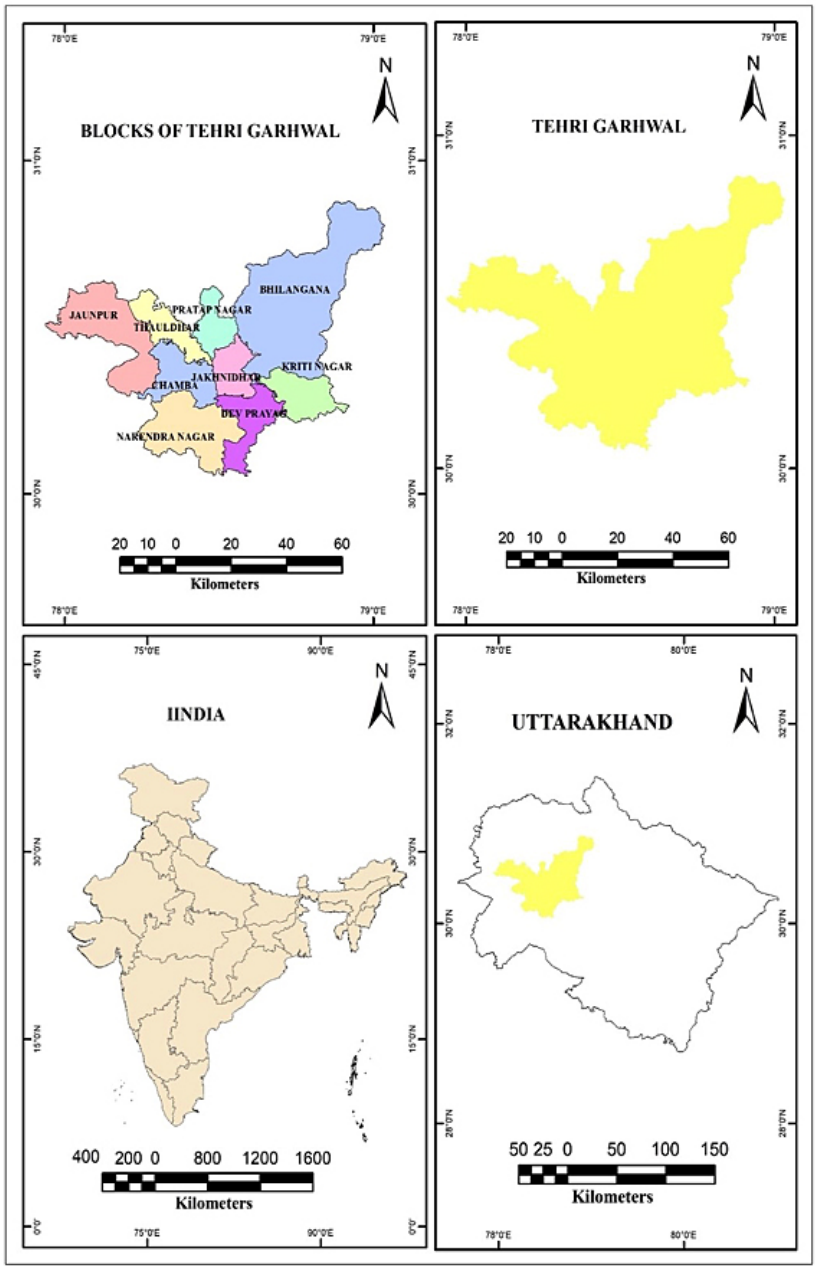

Fig. 1: Location Map of Tehri Garhwal
Source: Prepared by Author

The total population of district Tehri Garhwal is 616,409 in which total male population is 297,986 and total female population is 320,945. The district's total rural population is 548,792 and urban population is 70,139 (11.33%).the total number of Literate people in the district is 407,994 (76.36%) in which 227,406 (89.76%) is male and 180,588 (64.28%) (Census 2011) is female in the district schedule class population is 102,130 (16.64) and schedule Tribe population is 8750 the population density of district is 170 sq.km, decadal growth rate from 2001 to 2011 is 2.35%, the sex ratio of district is 1077 female on per thousand male.[15]

The population variance across district can also be attributed to factors such as geographic features (plains versus mountainous areas), the availability of natural resources, economic opportunities, or cultural aspects that influence the densities and locations of people. The population figurers can assist in deciding where to focus development efforts, improve services, and create long-term growth strategies. In order to ensure that the particular needs and opportunities of each block are effectively fulfilled, it is imperative to comprehend the population dynamics inside these blocks while formulating customized policies and allocating resources, the data of study area has been taken from Census of India 2011 and District handbook 2021.

Data Source

Landsat 5 spatial resolution is 30 meters, which means that each pixel in the image covers a 30 × 30meter region, with a 10 m × 10 m area represented by each pixel, Sentinel 2 increased resolution of 10 m allows for the recording of finer details in the image, data from Sentinel 2 and Landsat 5 satellite images, displaying various acquisition dates and resolutions (Table 1).

Table 1: Data sets examined in this research

Map Year	Satellite Sensor	Path/Row	Acquisition Date	Spatial Resolution
2001	Landsat 5	72/61	May 2001	30 M
2011	Landsat 5	71/91	April 2011	30 M
2021	Sentinel 2	44R	May 2021	10 M

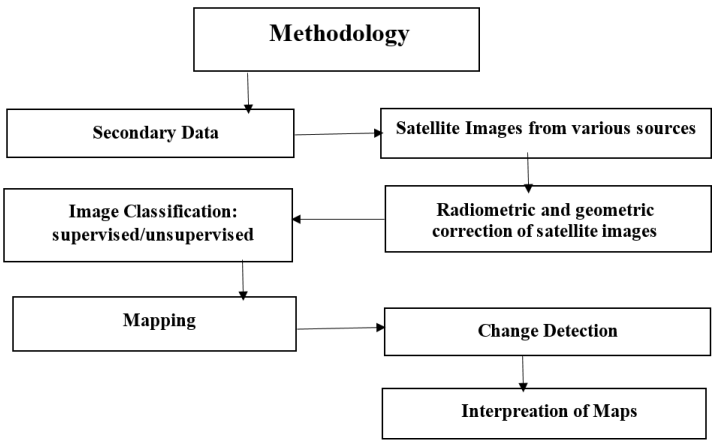

Fig. 2: Flowchart of the Research Methodology

Methodology

This research is mainly based on Secondary data sources from varied sources, multi-spectral remote sensing satellites data used for preparing LULC maps, radiometric and geometric corrections of satellites images require, after that Supervised classification performed for generating maps, Base year of the study is 2001, after those two more maps

of 2011, 2021 is prepared, landsat 5 series data used for the preparing map for 2001 and 2011, and 2021 map is prepared with the data of Sentinel 2, Remote Sensing data will take from USGS, and radiometric and geometric correction will be done (Figure 2).

Then image classification and supervised classification, then land use Land Cover Maps is prepared by researcher, Maps will be used for detecting changes over two decades (2001 to 2021).

Results

From 2001 to 2021, there were remarkable modifications in land use as well as land cover in Tehri Garhwal district represented in figures 3, 4 and 5. In 2001, forest cover was predominant to a large extent, covering 1928.64 sq. km accounting for 52.95% of the total area while rangelands occupied 33.73% (1228.63 sq. km). Built-up areas were little, constituting only 2.98% of land (108.82 sq. km) whereas cropland made up 2.93% (106.74sq.km). Furthermore, water bodies, snow coverage as well as bare grounds took even lesser portions; precisely at 1.4% 3.79% and 2.14% respectively thereby indicating that the area depended mostly on its forests and rangelands with little agricultural or urban developments involved within it (Figure 3; Table 2).

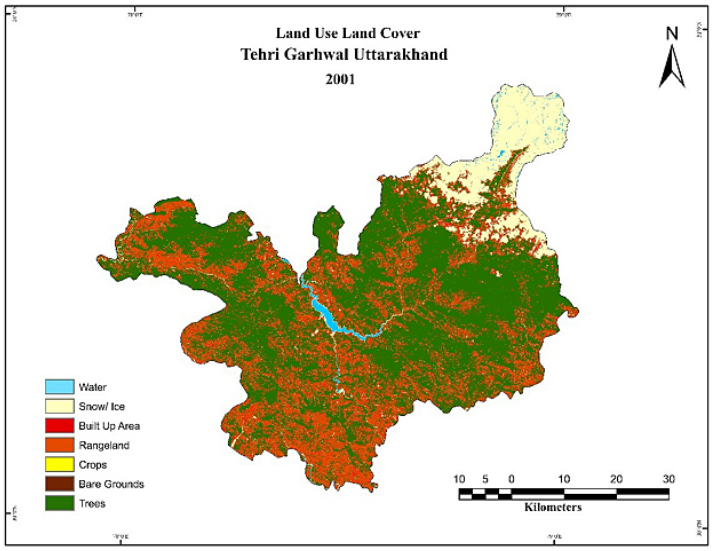

Fig. 3: Land use Land Cover, 2001
Source: Prepared by Author,

By 2011, several shifts in land use had occurred. The forest area increased to 2004.5 sq. km (55%), meaning there was some growth while rangeland fell to 1174.18 sq km (32.23%). In terms of built-up areas, it reportedly grew from 122.45 sq km (3.36%) implying that it had started showing signs of urbanization, Other changes include decreased snow cover and bare grounds but also increased water bodies covering an area approximately equal to 62.06 km squared (1.7%). This could be due to various factors such as water management or even tomorrow's construction of the Tehri dam; and these changes point to a lively relationship between progression and environmental aspects where urban spaces are created at the expense of agriculture lands and natural sceneries (Figure 4; Table 2)

Unsurprisingly, urban expansion and changes in natural land cover continued the same trends as what was experienced in the previous decade. The built-up areas rose by 134.8 sq. km (3.7%), implying sustained growth of urbanization and infrastructure. Forest cover decreased slightly by 1948.2 sq. km (53.49%); additionally, there was a further decline in cropland by 89.25 sq. km (2.45%), these two figures reflect ongoing decrease in agricultural activity all over again. The snow cover dropped to 104 sq.km (2.85%) which signifies continuous influence

of climate change on internodes The rangeland experienced recovery again and increased up to12222.2sq.km (33.55%) this can probably be attributed to alterations within land management or less human pressure onto these locations altogether On the other hand there was a fall in surface water from56.82sq.km (1.56%) as a result of urban water consumption or other environmental reasons (Figure 5; Table 2).

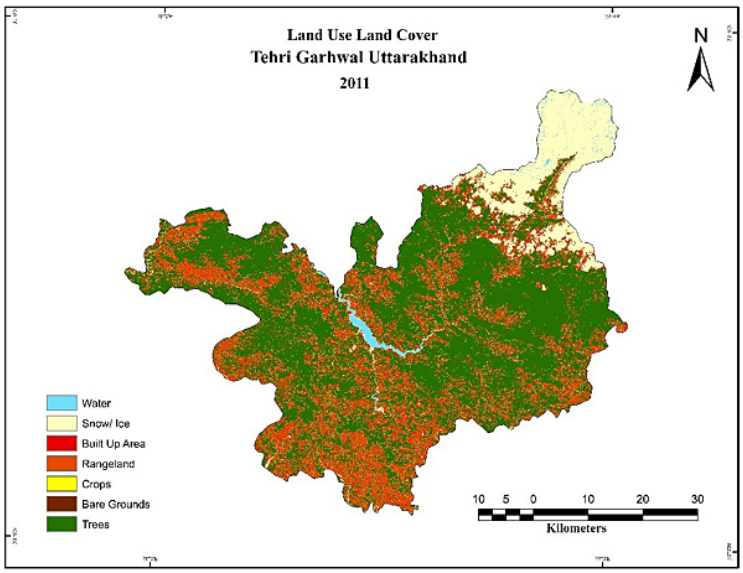

Fig. 4: Land use Land Cover, 2011
Source: Prepared by Author,

Table 2: Land use and Land cover of 2001, 2011 and 2021

Land Use land Cover	2001		2011		2021	
	Area in Sq. KM.	Percentage (Total area)	Area in Sq. KM.	Percentage (Total area)	Area in Sq. KM.	Percentage (Total area)
Water Bodies	52.78	1.4%	62.06	1.7%	56.82	1.56%
Forest Cover	1928.64	52.95%	2004.5	55%	1948.2	53.49%
Crop land	106.74	2.93%	92	2.52%	89.25	2.45%
Built Up Area	108.82	2.98%	122.45	3.36%	134.8	3.70%
Bare Grounds	78.24	2.14%	68.5	1.8%	76.8	2.1%
Snow Cover	138.15	3.79%	118.26	3.24%	104	2.85%
Range Land	1228.63	33.73%	1174.18	32.23%	1222.2	33.55%
Total	3642	100	3642	100	3642	100

From 2001 to 2021, Tehri Garhwal's LULC variations indicate a transitional period characterized by urbanization and infrastructural development where constructed spaces expanded continuously over twenty years. On the other hand, agricultural land and snow cover have been declining consistently capturing movement away from subsistence farming, as well as climate change impacts.

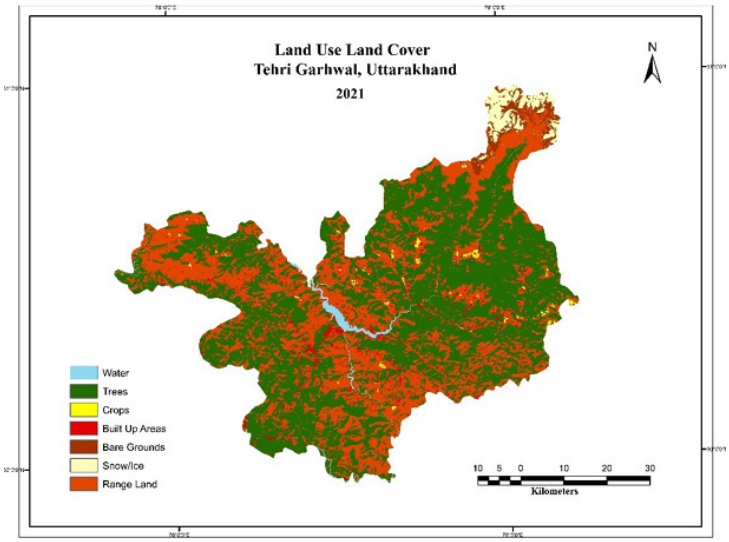

Fig. 5: Land use Land Cover, 2021
Source: Prepared by Author,

Although forest cover rose in the beginning, it seemed to drop by 2021 which denotes multifaceted relationship between ecological conservation undertakings and deforestation forces. Such modifications bring out the necessity for sustainable land use policy that accommodates both development needs together with environment protection.

Table 3: Land use Land cover change detection

LULC Classification	2001	2011	2021	Change (2001-2011)	Change (2011-2021)
Water Bodies	52.78	62.06	56.82	9.28	-5.24
Forest Cover	1928.64	2004.5	1948.2	75.91	-56.35
Crop land	106.74	92	89.25	-14.74	-2.75
Built Up Area	108.82	122.45	134.8	13.95	12.35
Bare Grounds	78.24	68.5	76.8	-9.74	8.3
Snow Cover	138.15	118.26	104	-19.89	-14.26
Range Land	1228.63	1174.18	1222.2	-54.45	48.02

Discussion

Land Use Land Cover Change Detection and Analysis

LULC data from three distinct years—2001, 2011 and 2021 to be shown in the table 3. A distinctive of LULC categories, such as crop land, Infrastructure, forest cover, water, range land, snow cover, and bare grounds, are represented by table in Sq.km.

The area of Crop Land is decreasing over time, The noteworthy decrease of -13.85% between 2001 and 2011 implies a decrease in arable land, probably as a result of urban growth, land conversion for alternative purposes, or environmental conditions that may have rendered farming less feasible, from 2011 to 2021, the decline rate is -2.99, which is slower. The Built Up Area between the years 2001–2021 the 12.35% increase is a result of infrastructural development and urbanization, as more land was converted for other uses between 2011 and 2021. Growth persisted during this time, albeit at a somewhat slower rate.

Forest cover changes between 2001 and 2011 of 3.93% and 2011 and 2021 of -2.81%, The drop can indicate that pressures from deforestation. The significant rise in water bodies between 2001 and 2011 might have been caused by the building of the Tehri Dam on the Bhagirathi River. However, water extraction for agricultural or urban usage may have contributed to the decline in water bodies from 2011 to 2021 (-8.45%).

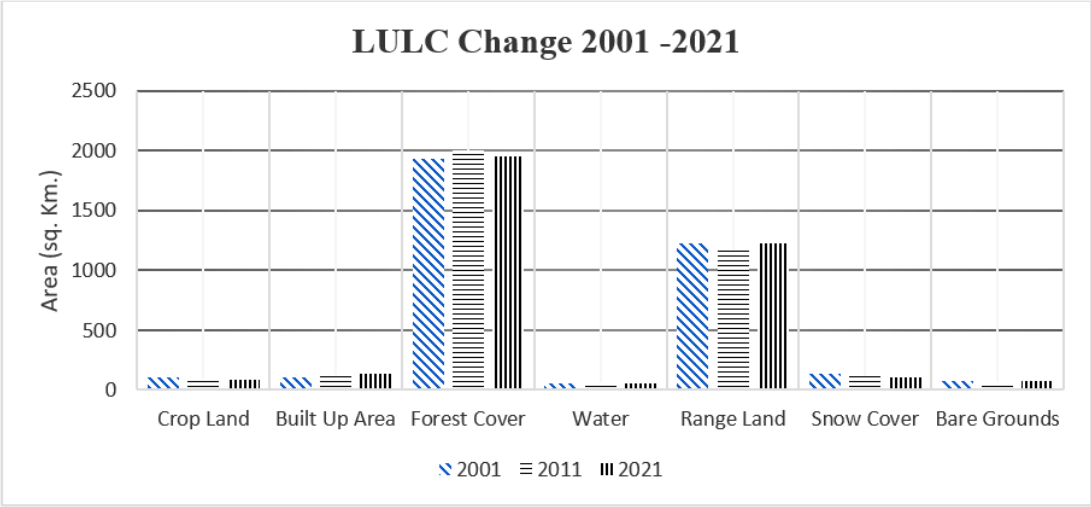

Fig. 6: Land use Land cover change (2001 -2021)

Range land changed by -4.43% between 2001 and 2011, showing 4.10 rise in range land from 2011 to 2021 that could be a sign of attempts to restore the land or a move back toward less intensive land use. The amount of snow cover decreases by -14.06% between 2011 and 2021 and by -14.40% between 2001 and 2011. With snow cover continuing to decline, the decrease confirms the continued consequences of climate change and could have major ramifications for ecosystems that rely on snowmelt and water resources. Bare Grounds decreased by -12.45% from 2001 to 2011, but increased by 12.12% from 2011 to 2021 (Figure 5).

Water bodies increased between during first decade, but decreased in the second decade, While the recent drop may point to droughts or other water management factors, the increase may be explained by new water storage like Building up of Tehri Dam, forest cover was a significant increase between 2001 and 2011 , followed by a decline between 2011 and 2021, Reforestation or conservation initiatives may be the cause of the increase, whereas land conversion or deforestation may be the cause of the decrease. Crop Land Consistently decreased over both decades A move away from agriculture, potential urban growth, or natural succession is suggested by the decline, Built up area Steady increase over both decades, reflects the infrastructural growth and urbanization that are characteristic of cities that are growing in population, Bare Grounds Declined between 2001 and 2011 but increased again from 2011 to 2021, Land reclamation, urban growth, and natural processes like erosion could all have an impact on changes, snow cover steadily declined over the course of the two decades, indicating the effects of global climate change, including melting snowpack and rising temperatures, Range land Decreased between 2001 and 2011 but increased significantly from 2011 to 2021, The alterations could point to changes in land management techniques or the restoration of natural ecosystems, The consistent rise in residential areas and urbanization is a sign of urban expansion, and the declining amount of crop land, Water bodies show fluctuations that could be tied to climatic or hydrological changes, Snow cover decline aligns with global warming, while changes in range land and bare grounds suggest dynamic land use practices.

LULC changes throughout time can have significant consequences on livelihoods, local ecosystems, agriculture, and urban development, A consistent decrease in snow cover is probably a result of climate change, which also affects river flow patterns, threatens cold-adapted species, and reduces the amount of water available from glacier melt, despite rangeland's steady state indicates areas with sustained grazing, variations may indicate overgrazing or land degradation in particular locations, The continuing depletion of arable land points to be decreased agricultural viability, Farmers may find it difficult to maintain their means of subsistence, especially if their land is put to other purposes without providing them with other sources of income, the loss of crops and snow cover combined with urbanization points to a shift away from agriculturally based livelihoods and toward jobs in cities or services for developing tourisms.

land use planning, conservation strategies in the area is able to reconcile sustainable livelihoods, urban growth, agricultural productivity, and environmental preservation, encourage handicrafts, ecotourism, and small businesses in rural regions to generate alternate sources of income, enhance technical investigation and preservation initiatives to track and lessen the influences of climate change on snow cover and glaciers, needs to Promote water-saving measures to deal with decreased glacial runoff, use sustainable farming methods (such as crop rotation and agroforestry) and drought-tolerant crops to increase output on declining cropland, assist people to switch to high-value crops and embrace sustainable practices by offering financial incentives and subsidies, governments incorporate GIS and remote sensing tools to track LULC changes in real time and evaluate the efficacy of policies.

Conclusion

The researcher examines LULC over two decades in Tehri Garhwal district of Uttarakhand; the number of urban centers has been steadily rising, reflecting significant urbanization and infrastructure development over the past two decades. This growth suggests ongoing expansion of cities and towns, The consistent reduction in Crop Land indicates a shift away from traditional agricultural uses, he significant decrease in Snow Cover over the 20 years points to the impacts of climate change, with warmer temperatures likely reducing snow accumulation, The fluctuating trends in Forest Cover, Water bodies, and Range Land suggest dynamic changes in the environment, likely driven by a combination of human activities and natural factors. significant land use changes, driven by urbanization, environmental management, and climate factors. These changes highlight the need for sustainable planning and conservation efforts to balance development with environmental preservation, government needs to addressed the changes in LULC in the district.

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The author(s) do not have any conflict of interest.

Data Availability Statement

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Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

- **Veer Singh:** Conceptualization, Methodology, Map Making, Writing
- **Raiz Ahmed:** Data collection, Writing
- **Ashwani:** Writing, Drafting, Review and Editing
- **Anshul Tyagi:** Visualization, Data collection
- **Anita Rudola:** Supervision, Final Drafting

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