

Remote Sensing and GIS Tools Used for Change Detection Techniques in Chamoli District, Uttarakhand, India

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ABSTRACT: The study was undertaken to investigate the use of remote sensing and GIS techniques for vegetation types and land use change detection in Chamoli district of Uttarakhand, India. The US Army topographic maps on 2:50, 000 scale and Landsat MSS of 1976 and Landsat TM 2006 satellite remote sensing data were used. The topographic maps were georeferenced and digitized in Arc-GIS ver. 10.1. As per the analysis of digitized topographic maps the total forest area of Chamoli district were 1963.92 km² (24.54%) and non-forest area 6060.07 km² (75.54 %). The Landsat MSS 1976 and TM 2006 satellite data were radiometrically corrected and the study area was extracted using the boundary of study area. In 1976, the forest cover was 3966.40 km² (49.39%) and in 2006 it decreased to 3709.12 km² (46.19 %). The total forest cover change was observed from 1976 to 2006 was 257.28 km². The maximum change of 7767.00 km² (96.72 %) was noticed in agriculture to wasteland, followed by forest to agriculture 21.72 km² (0.27 %), forest to wasteland 156.85 km² (1.95 %) and forest to snow 80.35 km² (1.00 %). The study demonstrates the use of temporal resolution, satellite data in forest/vegetation type mapping and temporal monitoring at an operational level.

KEYWORDS: Vegetation types and land use, Change detection, GIS, Remote Sensing, Chamoli district, Uttarakhand.

I. INTRODUCTION

Vegetation types and land use is an important component to understand global land status [1]. It shows the present, as well as past status of the earth surface. Vegetation types and land use are two separate terminologies, which are often used interchangeably [2]. Land cover is a basic parameter which evaluates the content of earth surface as an important factor that affects the condition and functioning of ecosystem [3]. Land cover is a biophysical parameter of the Earth surface, which can be used to estimate the interaction of biodiversity with the surrounding environment. Nowadays, vegetation types and land use analysis plays an important role in the field of Environmental Science and Natural Resource Management System. The Land cover reflects the biophysical of state in the Earth surface, including the soil material, vegetation and water. Vegetation types and land use refers to utilization of land resources by human beings and land cover changes often reflects the most significant impact on environment due to excessive human activities. Vegetation types and land use is dynamic process in nature is provides a comprehensive understanding the interaction and relationship of anthropogenic activities with the environment [4]. Vegetation types and land use changes also involve the modification, either direct or indirect, of a natural habitats and their impact on the Ecology of the area [5]. Vegetation types and land use change has become a central component in current strategies for managing natural resource and monitoring environmental changes [6]. Vegetation types and land use pattern of a region gives information about the natural and socio-economic factors, human livelihood and development [7]. Land resource is also delimiting due to very high demand of agricultural products and increasing population pressure day by day. Hence, information of vegetation types and land use and possibilities of their optimal use are essential for the selection,

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planning and implementation of the vegetation types and land use schemes to meet the increasing human needs and welfare. This also provides the information for managing dynamics of vegetation types and land use and meeting the demands of increasing human population. Vegetation types and land use change detection is the process of identifying difference in the state of an object/ phenomenon by observing it at different time period [8]. Change detection in vegetation types and land use can be performed on temporal scale such as decades to assess landscape changes caused due to anthropogenic activities on the land [9]. Satellite based high temporal resolution, precise spectral bandwidths, and accurate georeference procedure is contributed to increase use of satellite data for change detection analysis [10]. Processing of multi-temporal images and change detection techniques has been developed in the past three decades. Change information of the Earth's surfaces is becoming more and more important in monitoring of the local, regional and global environment at landscape level. Remote Sensing and Geographical Information System (GIS) provides a modern technology in the issues of ecosystem management [11, 12]. The technique has been used extensively in the tropics for generating valuable information on the forest cover, vegetation types and land use changes [13]. Now-a-days advanced geospatial technologies have further improved the efficiency of mapping of vegetation types and land use at landscape level. Thus, integration of these techniques forms a potential tool for vegetation types and land use change. The economic significance of agriculture has decreased in many parts of Europe over the last decades [14, 15]. These anthropogenic activities are due to rapid growth of human population and demands of food resources [16]. Vegetation types and land use changes have been recognized as important drivers of global environment change [17]. The inventory of forest resources for vegetation types assessment and land use change detection in the rugged topography in hill areas is not an easy task and it is a time-consuming process. Vegetation types and land use change has recently been identified to be a key research area in landscape ecology [18]. In the present study, the documented information on the environmental variables and human impacts in Chamoli district were collected in a GIS domain. Earlier related work carried out in the area was aimed at setting up a multi-temporal database. In addition, ground truthing data were gathered to establish a correlation between the vegetation types and patterns in the spectral characteristics of satellite images.

II. MATERIAL AND METHODS

2.1 STUDY AREA

Chamoli district is the second largest district of Uttarakhand state of India (Figure 1). The administrative headquarter of the district is Gopeshwar. The study area lies between 79° to 80° E and 30° to 31° N. It is bounded by the Tibet region to the north and by the Uttarakhand districts of Pithoragarh and Bageshwar to the east, Almora to the south, Garhwal to the southwest, Rudraprayag to the west, and Uttarkashi to the northwest. Administratively the district is divided into six tehsils: Joshimath, Chamoli, Karnaprayag, Pokhari, Gairsain and Tharali. Further it is divided into nine development blocks: Joshimath, Dasoli, Pokhari, Ghat, Karnaprayag, Tharali, Narayanbagar, Dewal and Gairsain. The elevation of the district ranges from 800-8000 msl. The winter season is from November to March. The rainfall is heaviest in the monsoon from June to September when 70 to 80 percent of the annual precipitation is accounted for in the southern half of the district and 55 to 65 percent in the northern half [19]. The major river in the study area is Alaknanda and Ramganga. The main tributaries of in the study area: Dhauli ganga, Birhi ganga, Nandakini and Pindar etc. The major crops grown in the area are rice, wheat, potato, pulses, millets and seasonal vegetables.

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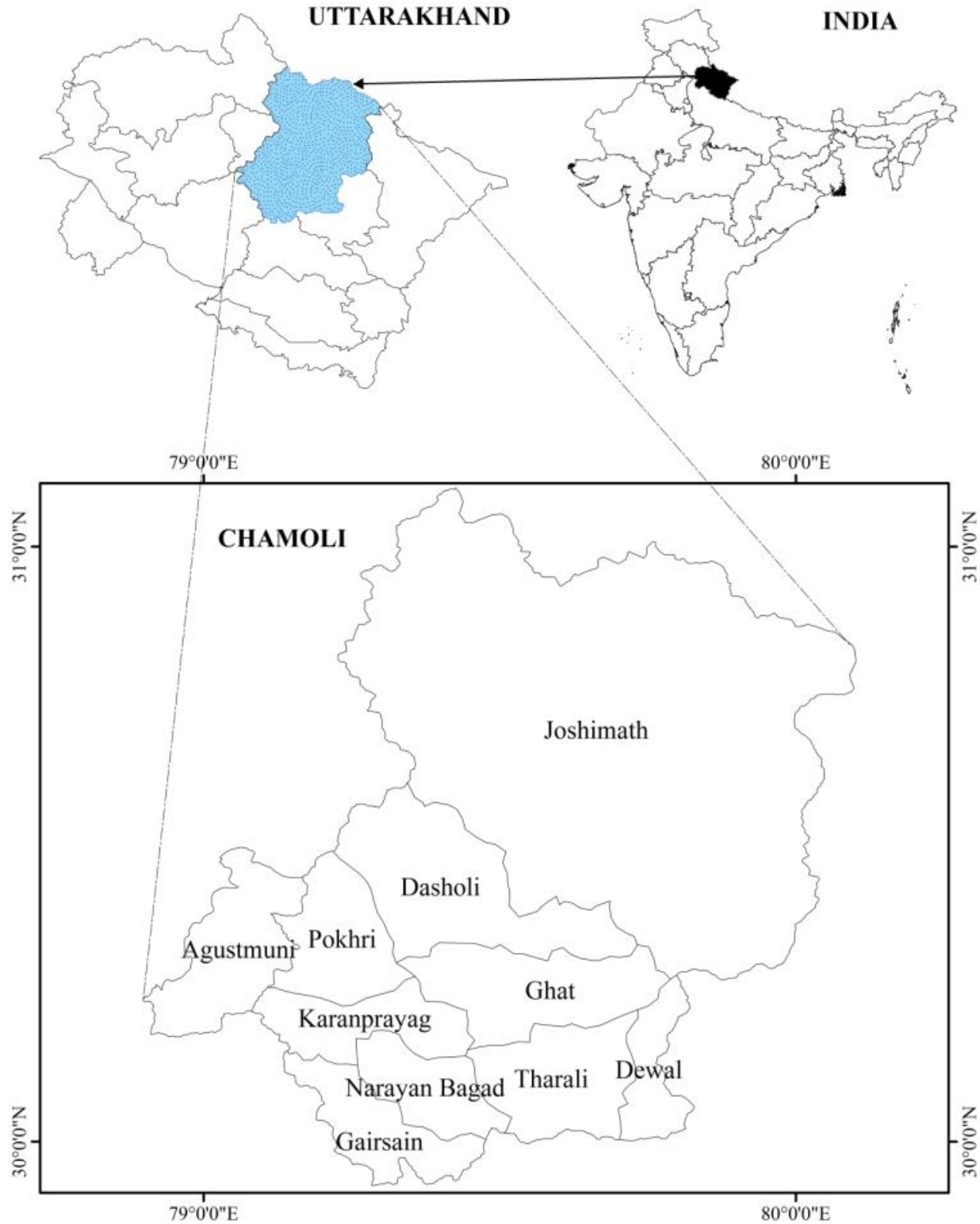


Figure 1: Location of the study area.

2.2 SATELLITE DATA AND ITS PROCESSING

The U.S. Army Topographic map on 1:2, 50, 000 scale was procured from University of Texas at Austin (www.lib.utexas.edu). The topographic maps were georeferenced and mosaic in ERDAS Imagine *ver.* 9.3 with feather overlay function. The district boundary was digitized using mosaic of topographic maps in polygon mode. The Landsat MSS satellite data with spatial resolution 30m was procured from United States Geological Survey (www.usgs.gov.in) (Table 1).

Table 1: Description of satellite imagery used in the present study.

S. No.	Satellite	Sensor	Path	Row	Date	Spatial Resolution (m)	Band
1.	-do-	MSS	156	39	1976-11-19	60	4
2.	-do-	MSS	156	39	2006-11-19	60	4

The satellite data was radiometrically corrected using ERDAS Imagine software *ver.* 9.3. The histogram equalization, contrast enhancement, noise correction, dark pixel subtraction and haze correction was done. The study area extracted using study area boundary. Supervised classification was used to produce land cover map from the Landsat MSS data. Defining of the training sites, extraction of signatures from the image and then classification of the image was done. The complete methodology showed in the Figure 2.

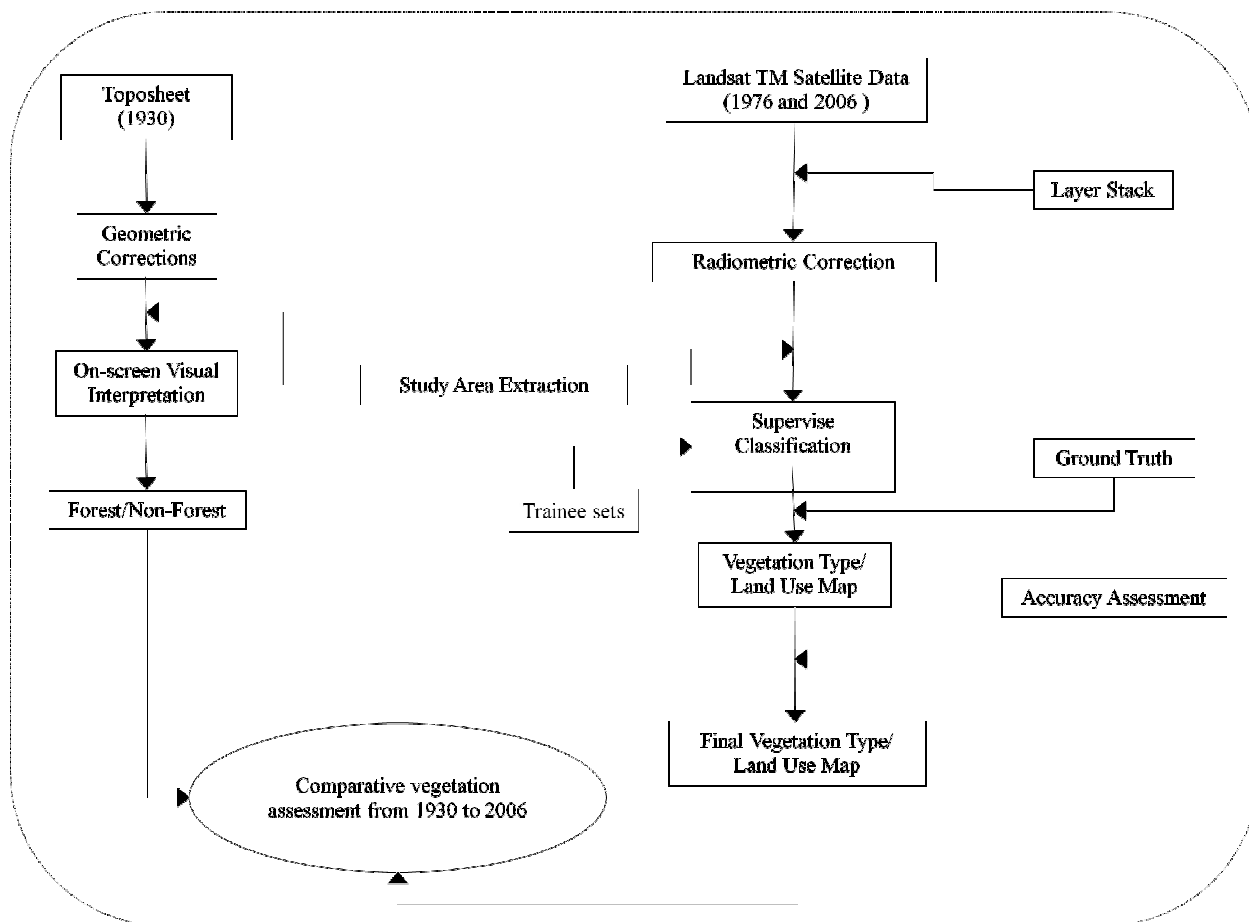


Figure 2: The Methodology.

The features of training sites were digitized. Three training sites were selected for this purpose. This procedure assures both the accuracy of classification and the true interpretation of the results. After the training site areas digitization, the statistical characterizations of the information were created. These were called signatures. Finally, the classification methods were applied. All the classification techniques like the maximum likelihood classification (MLC), parallelepiped and minimum distance to mean classification were applied for the images and the best classification technique was then chosen. It was observed that MLC has good results as compared to other two techniques. To determine the accuracy of classification, a simple testing pixel was selected on the ground truth reference data. In thematic mapping from remotely sensed data, the accuracy, and the degree of 'correctness' of a map or classification was also calculated [20].

III. RESULT AND DISCUSSIONS

The digitized U.S. Army topographic maps were analyzed in forest and non-forest categories (Figure 3). In 1930, the forest area was 1963.92 km² (24.45%) and non forest was 6066.07 km² (75.54 %) (Figure 4) (Table 2). The vegetation types and land use map was prepared using Satellite Landsat MSS data of 1976 (Figure 5) and 2006 (Figure 6). In 1976 and 2006, the maximum area was covered by forest and snow cover (Figure 7), but the forest cover was less in 2006 (Figure 8) (Table 3).

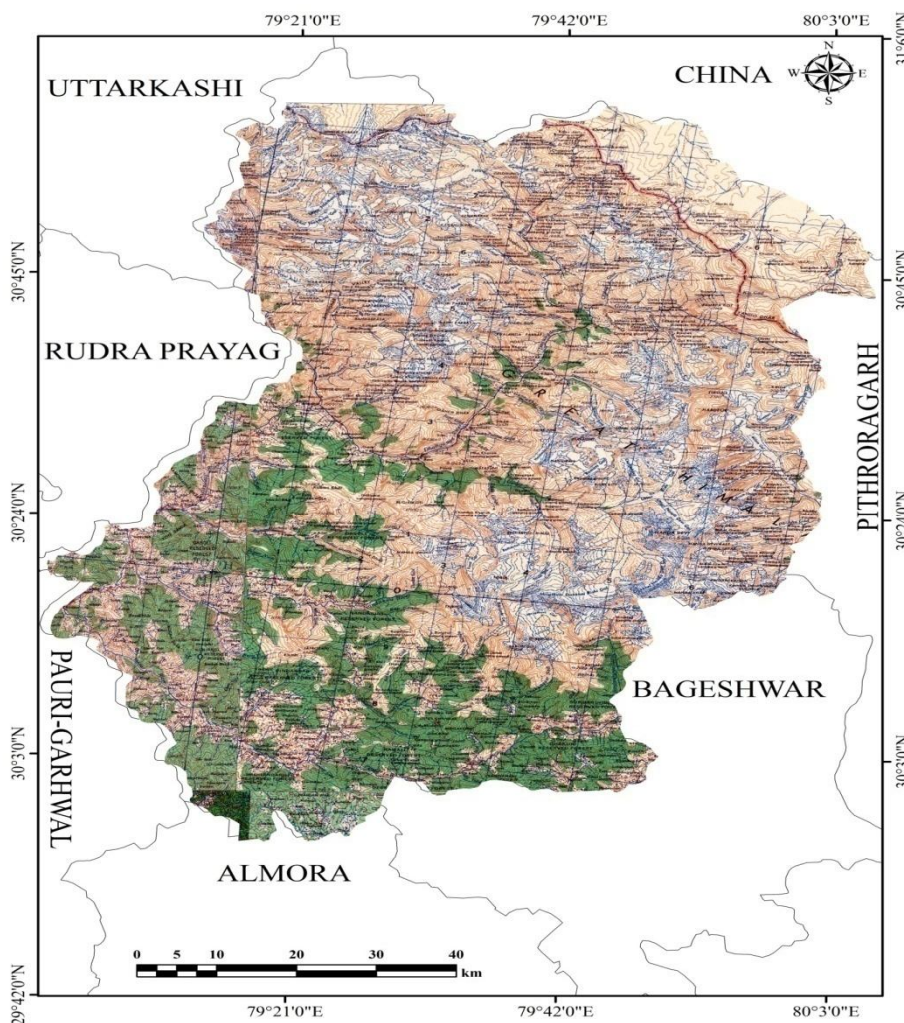


Figure 3: US Army topographic map.

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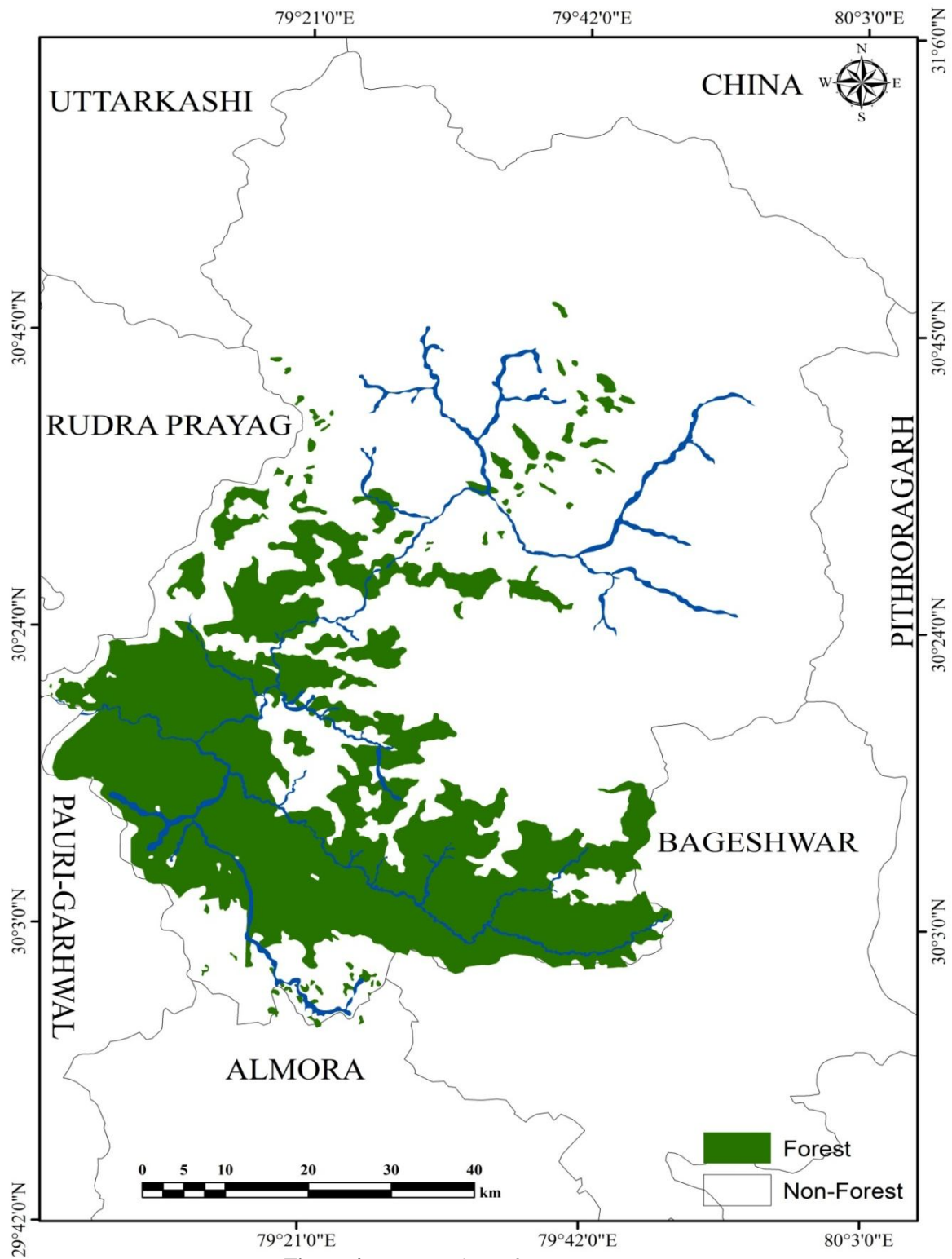


Figure 4: Forest and non-forest map.

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Table 2: Forest and non-forest categories in the topographic maps

S.No.	Vegetation types and land use map	Area (km ²)	Area (%)
1.	Forest	1963.92	24.45
2.	Non-forest	6066.07	75.54
Total		8030.00	100.00

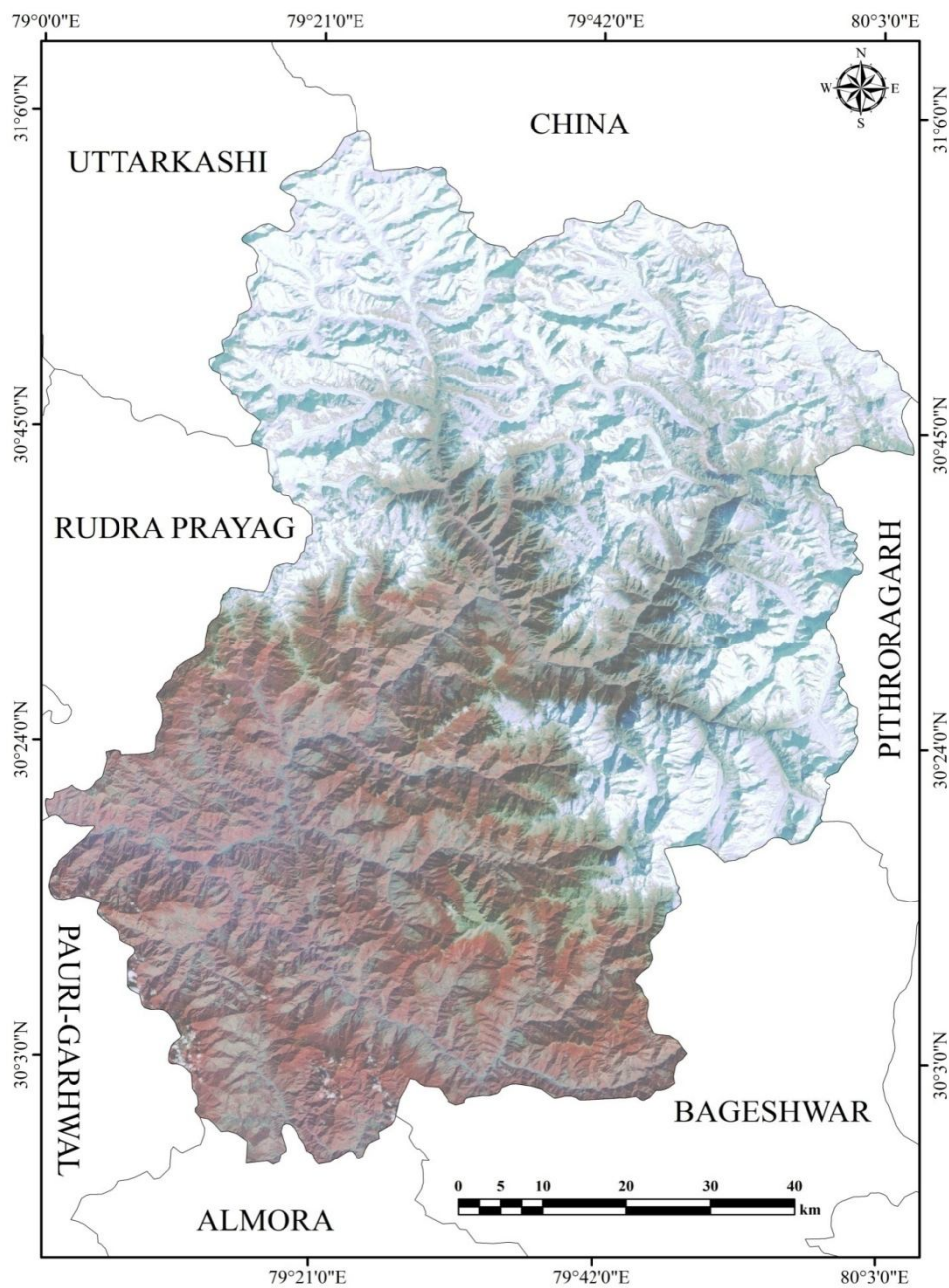


Figure 5: Landsat MSS False Color Composite map of 1976.

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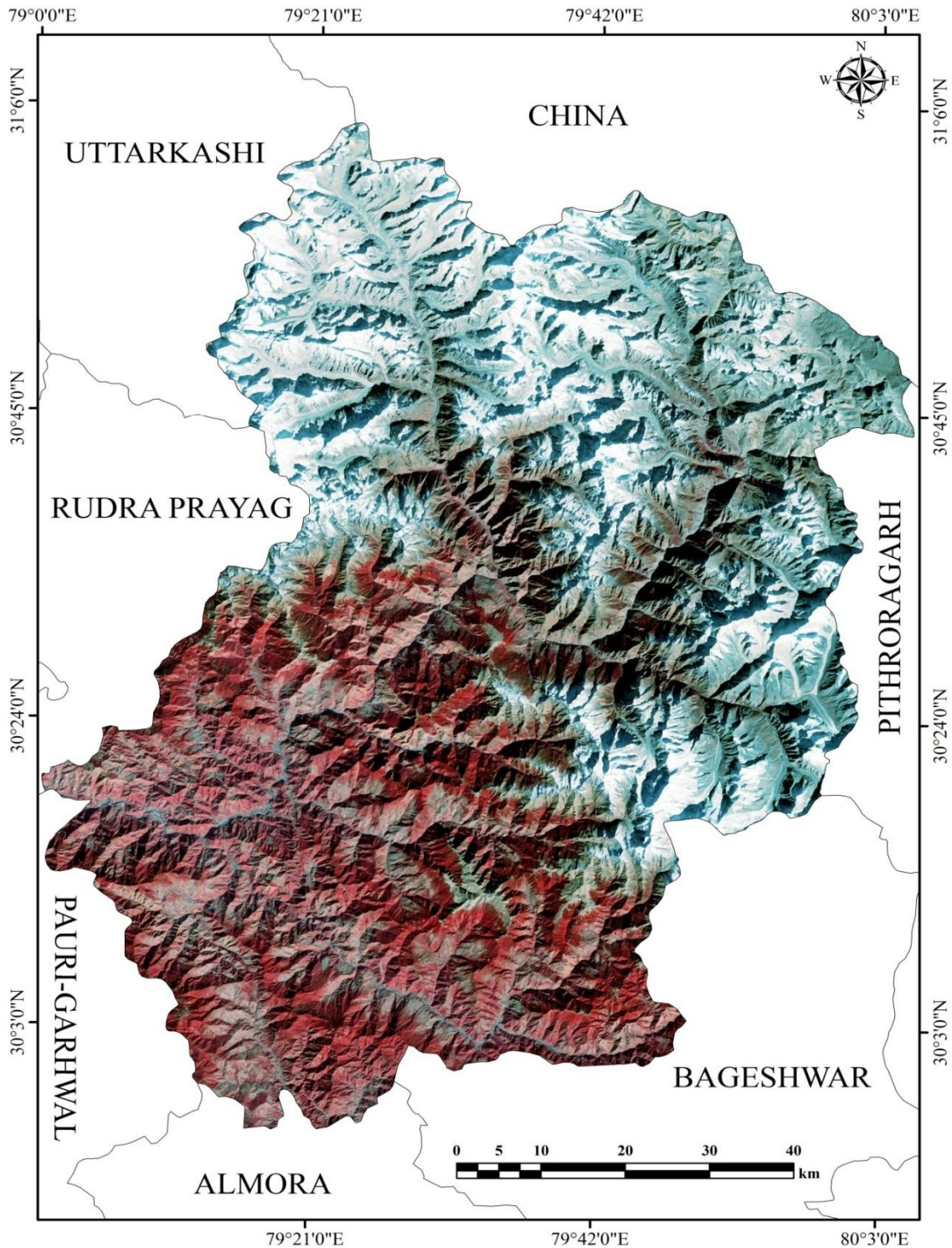


Figure 6: Landsat TM False Color Composite map of 2006.

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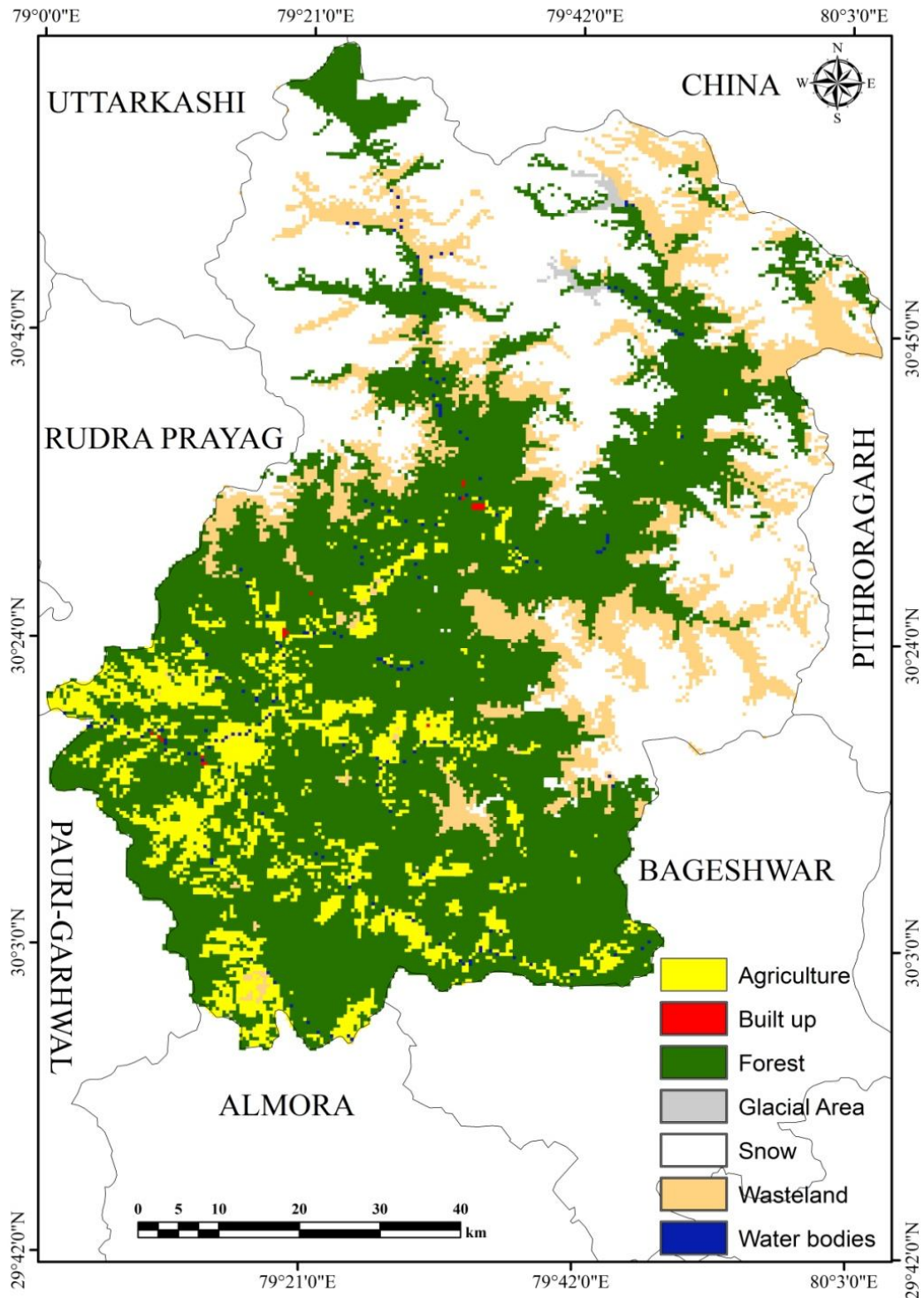


Figure 7: Vegetation types and land use map of 1976.

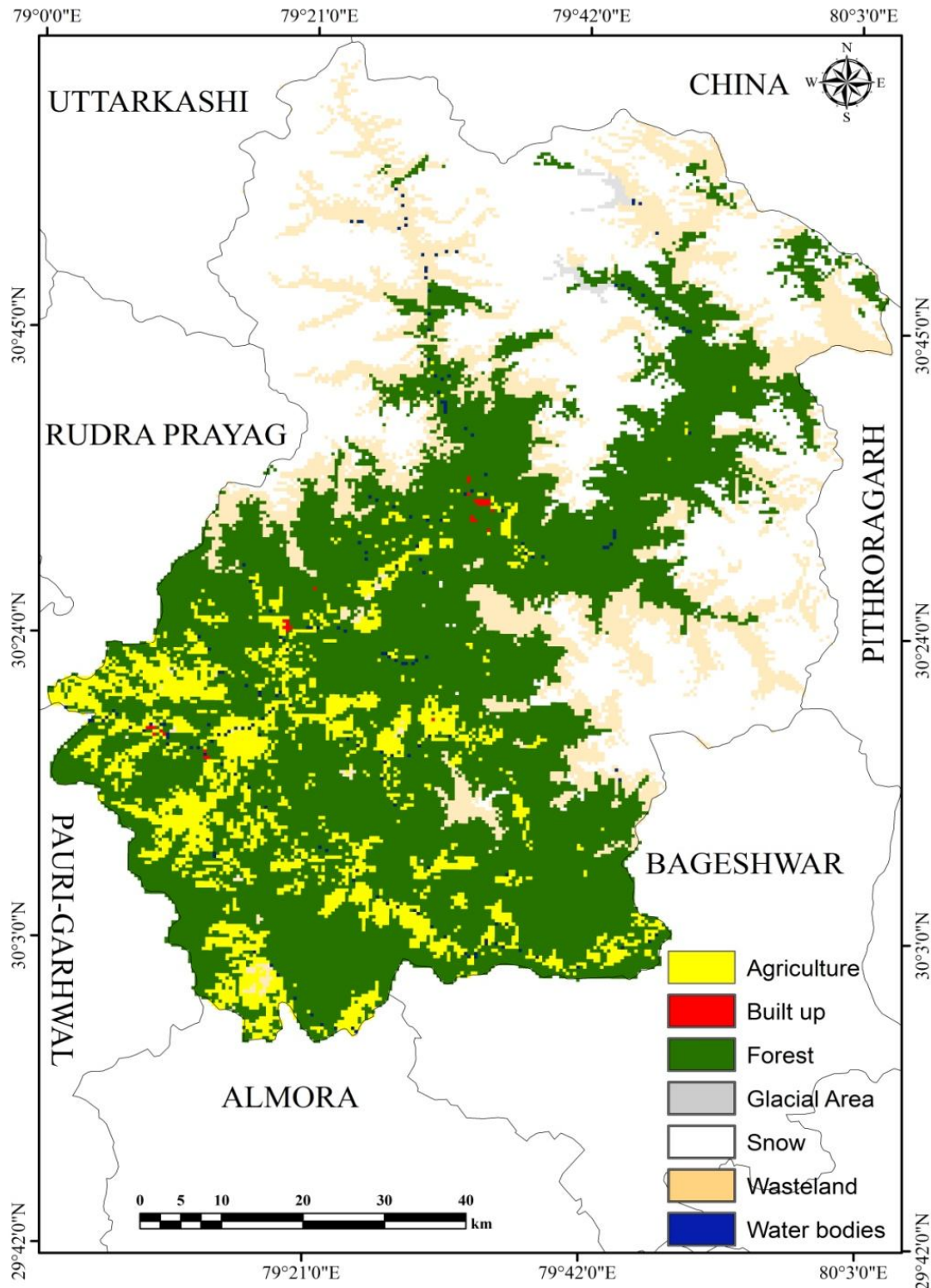


Figure 8: Vegetation types and land use map of 2006.

Table 3: Area covered under different vegetation types and land use categories in 1976 and 2006.

Vegetation types and land use	1976		2006	
	Area (km ²)	Area (%)	Area (km ²)	Area (%)
Agriculture	618.94	7.70	643.78	8.01
Built up	3.81	0.04	5.43	0.06
Forest	3966.40	49.39	3709.12	46.19
Glacial Area	20.30	0.25	19.83	0.24
Snow	2426.66	30.22	2500.82	31.14
Wasteland	966.98	12.04	1124.25	14.00
Water bodies	26.88	0.33	26.74	0.33
Total	8030.00	100.00	8030.00	100.00

The vegetation change was observed from 1976 to 2006 (Figure 9). During this period maximum change was observed in agriculture to wasteland (54.66%) followed by forest to wasteland (18.60%), snow to wasteland (10.59%) and forest to snow (9.53) (Table 4).

Table 4: Vegetation types and land use change from one to other classes.

Vegetation types and land use change	Area (km ²)	Area (%)
Agriculture to wasteland	7767.00	96.72
Forest to agriculture	21.72	0.27
Forest to built up	1.07	0.01
Forest to snow	80.35	1.00
Forest to wasteland	156.85	1.95
Snow to wasteland	3.01	0.04
Total	8030.00	100.00

This can be made easier only through the high spectral, spatial and temporal resolution qualities of remote sensing techniques. Indeed, the precise database pertaining to forest cover information is an imperative input of formulating various management plans and also remote sensing technology can be effectively utilized for change detection and monitoring activities [21]. As per Macleod & Congalton (1998) [22] remote sensing and GIS techniques consider the following four aspects of change detection techniques. These are: (1) detect the changes, (2) identify the nature of change, (3) measure the aerial extent of change and (4) assess the spatial pattern of change. The basic principle of change detection using remote sensing is that the changes in spectral signatures commensurate with the change in Vegetation types and land use. The detailed procedure is to superimpose two period maps to find out the change. Moreover, the process of change detection is premised on the ability to measure temporal impacts [23]. Change detection is the process of identifying different areas in the state of an object or phenomenon by observing it in different times [24]. Meanwhile, it is evident that change detection can be precisely calculated using remote sensing and GIS technology due to its high volume spatial and non-spatial data handling capability. It would also help us to do overlay process with multiple vector layers under single umbrella [25, 26]. Some other researchers have identified that the increase in forest cover has resulted in increased rainfall [27, 28] and decrease in forest cover has direct relationship with socioeconomic status [29]. Hence an attempt has been made to analyze the forest cover changes to seek a sustainable balance in the hill ecosystem. Vegetation types and land use change is primarily driven by socioeconomic factors and significantly governs landscape structure, function, and dynamics [30, 31].

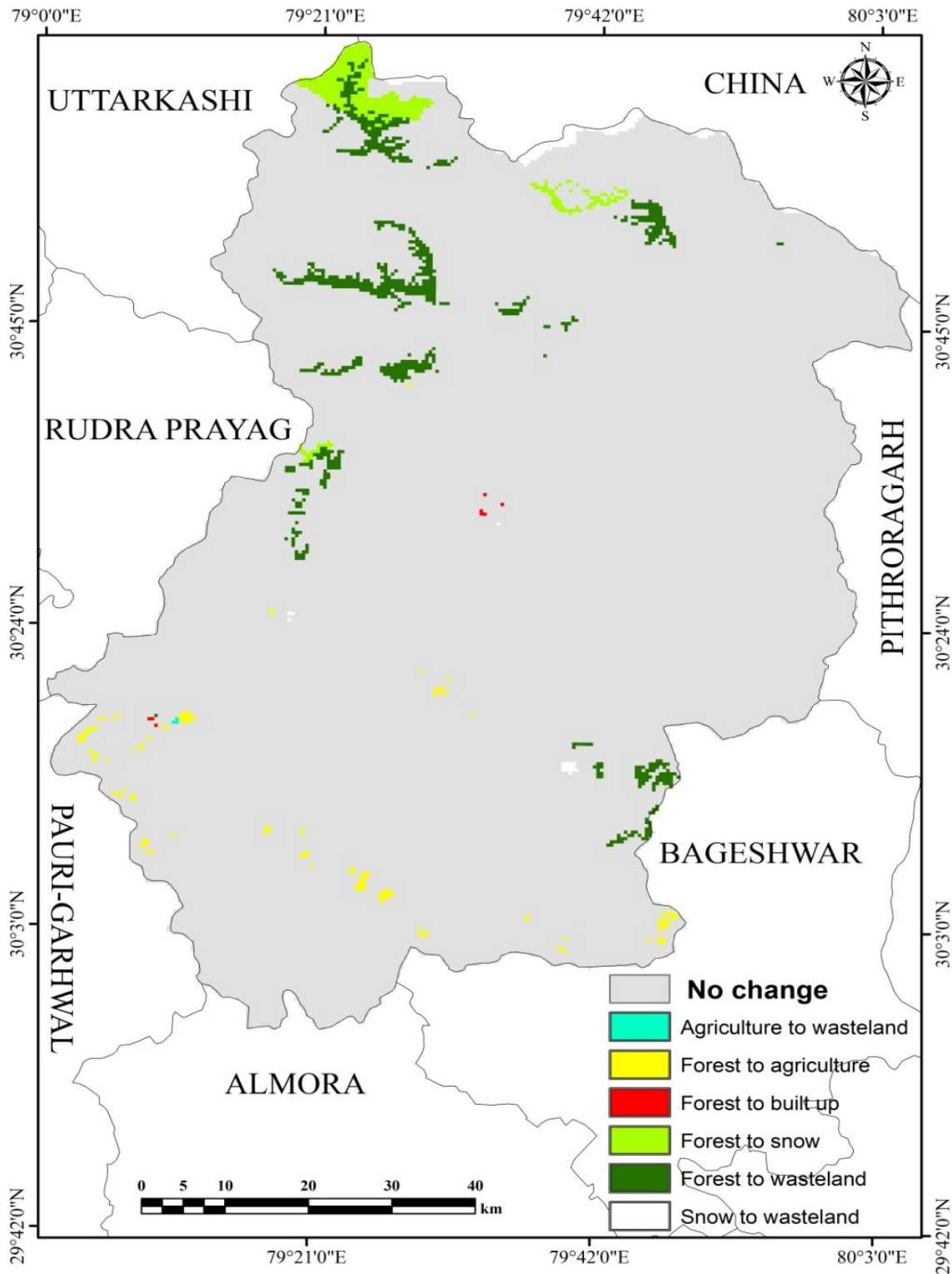


Figure 9: Vegetation types and land use change map from 1976 to 2006.

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