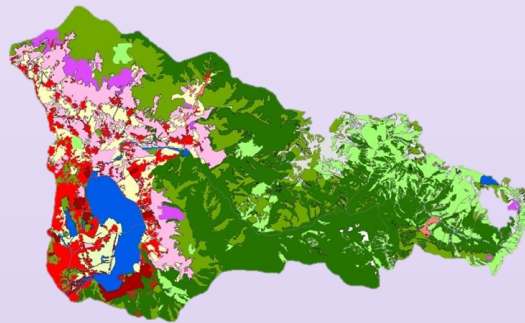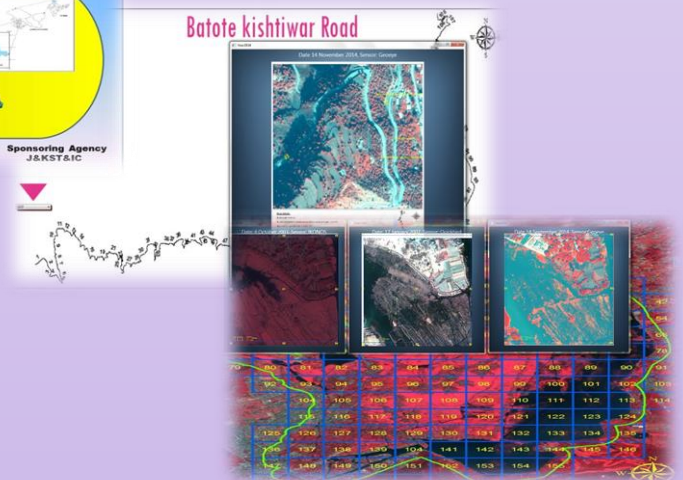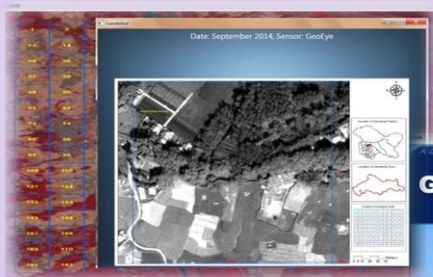# GEOSPATIAL MONITORING OF PRIORITY AREAS

Sponsoring Agency:
J&K State Science, Technology & Innovation Council
J&K Govt., Jammu/Srinagar

Government of Jammu and Kashmir
DEPARTMENT OF ENVIRONMENT AND REMOTE SENSING

SRINAGAR OFFICE: S.D.A. COLONY BEMINA SRINAGAR-190018
JAMMU OFFICE: PARYAWARAN BHAWAN, GLADNI, NARWAL, JAMMU - 180010

Preface

Om Prakash Sharma, IFS
APCCF/ Director,
Ecology, Environment & Remote Sensing,
Government of Jammu & Kashmir.

During the year 2012, the Government of Jammu & Kashmir desired to explore the possibility of geospatial monitoring of a few priority areas using the satellite technology and other geospatial tools on model basis. Accordingly, Dal and Nigeen Lake, Rakh-i-Arat, selected compartments of Neeru Forest, Wular Lake, Pahalgam, Gulmarg, Moughal Road and National Highway-Batote to Kishtwar were selected for the purpose. However, since Wular Lake is separately being monitored under the Wular Lake Conservation Project, it was latter desired to drop Wular and include Ganderbal district for the purpose. Since, Jammu & Kashmir is hilly and restricted area, procurement of very high resolution satellite images takes lot of time due to limited acquisition window owing to snow cover, cloud cover, shadow effect and procedures involved, an effort was made to seek base maps and high resolution satellite images of the areas from Mission for Geospatial Applications, Technology Information, Forecasting and Assessment Council, Department of Science & Technology, Govt. of India, New Delhi. However, this could not materialize and the J&K State Science, Technology and Innovation Council consented to sponsor the project. The project was formally initiated during 2013 and indent for procurement of necessary satellite data was made to National Remote Sensing Centre, Department of Space, Govt. of India. However, though a few scenes of moderate resolution images were received after some time, it was only in 2015 that the very high resolution satellite images were received from NRSC, Department of Space, GoI, Hyderabad.

In the present report, detailed land-use/ land cover mapping of the priority areas has been discussed besides, giving a bird's eye view of the Geospatial Monitoring application tools that were developed for the priority areas to assist in planning. The application tools have been provided on DVD's attached with the report which may be used by the concerned executing agencies for achieving efficiency in planning and monitoring of the priority areas in future. Besides, a special study has also been undertaken on Dal and Nigeen Lake and also Rakh-i-Arat area which is being issued separately.

I thank the J&KS,T&I Council for their support to carry out this project.

Om Prakash Sharma, IFS

Muhammad Afzal, IAS
Commissioner/Secretary to Govt.,
Forest, Environment & Ecology
Government of Jammu & Kashmir.

Foreword

The Geospatial technology has emerged as a powerful tool to collect accurate and near real time geo-information which when integrated with other secondary data in GIS domain works wonders to answer various problems relating to Natural Resources, Planning and Monitoring, besides Management of amenities. In Jammu & Kashmir, the inaccessibility of these resources due to hilly terrain, population scatter across inaccessible barriers and climatic variance pose a challenge to conservationists and administrators alike who often need to survey these areas for formulating development and conservation plans. Since, remote sensing technology comes handy in solving the problems of collection of near real time information about any natural phenomenon because of its synoptic and repetitive coverage at a very economical cost, the technology in conjunction with GIS tools needs to be harnessed for developing efficient decision support systems for achieving good governance in the State. With the empowerment of local institutions of self-governance, the planners as well as the public representatives need to be fully equipped with geospatial information so that judicious development and conservation plans are evolved at the grass root level which ultimately lead to good governance, social empowerment and economic growth.

In the present report the Department of Ecology, Environment & Remote Sensing has tried to explore the possibility of geospatial monitoring of natural landscape of some important priority areas identified by the J&K Govt. The study has highlighted the capability of the Geospatial technique in mapping and monitoring important areas of the state which are under intensive management practices.

I hope the concerned executing agencies will find the report useful in planning and development of the various priority areas dealt with in the report.

Mohammad Afzal, IAS

CHAPTER-1

1.0 Introduction:

The Geospatial technology has emerged as a powerful tool to collect accurate and near real time geo-information which when integrated with other secondary data in GIS domain works wonders to answer various problems relating to Natural Resources, Planning and Monitoring, besides Management of amenities. In Jammu & Kashmir, the inaccessibility of these resources due to hilly terrain, population scatter across inaccessible barriers and climatic variance pose a challenge to conservationists and administrators alike who often need to survey these areas for formulating development and conservation plans. Since, remote sensing technology comes handy in solving the problems of collection of near real time information about any natural phenomenon because of its synoptic and repetitive coverage at a very economical cost, the technology in conjunction with GIS tools needs to be harnessed for developing efficient decision support systems for achieving good governance in the State. With the empowerment of local institutions of self-governance, the planners as well as the public representatives need to be fully equipped with geospatial information so that judicious development and conservation plans are evolved at the grass root level which ultimately lead to good governance, social empowerment and economic growth.

In order to make use of this technology, the Govt. of Jammu & Kashmir identified a few areas where planning, development and monitoring could be improved through use of geospatial technology.

1.1 Objective:

The objective was to explore the application of Geospatial Tools in monitoring few priority areas on model basis for use in decision making.

1.2 Priority Areas

The various sectors that had been prioritized by the J&K Govt. for geospatial monitoring included:

1.2.1 Dal and Nigeen Lake:

The Dal and Nigeen Lake ecosystem, located at 34^0 04' North to 34^0 09' North and 74^0 49' East to 74^0 53' East, is identified with Kashmiri culture and civilization. These are urban lakes and a large population is dependent on these for drinking water supply, employment, vegetables, recreation and tourism related activities. In view of extremely high anthropogenic

pressures, the lake body is threatened for existence. Pollution from raw sewage, solid wastes and fertilizers coming from its catchment has deteriorated the water quality of this fragile aquatic ecosystem.
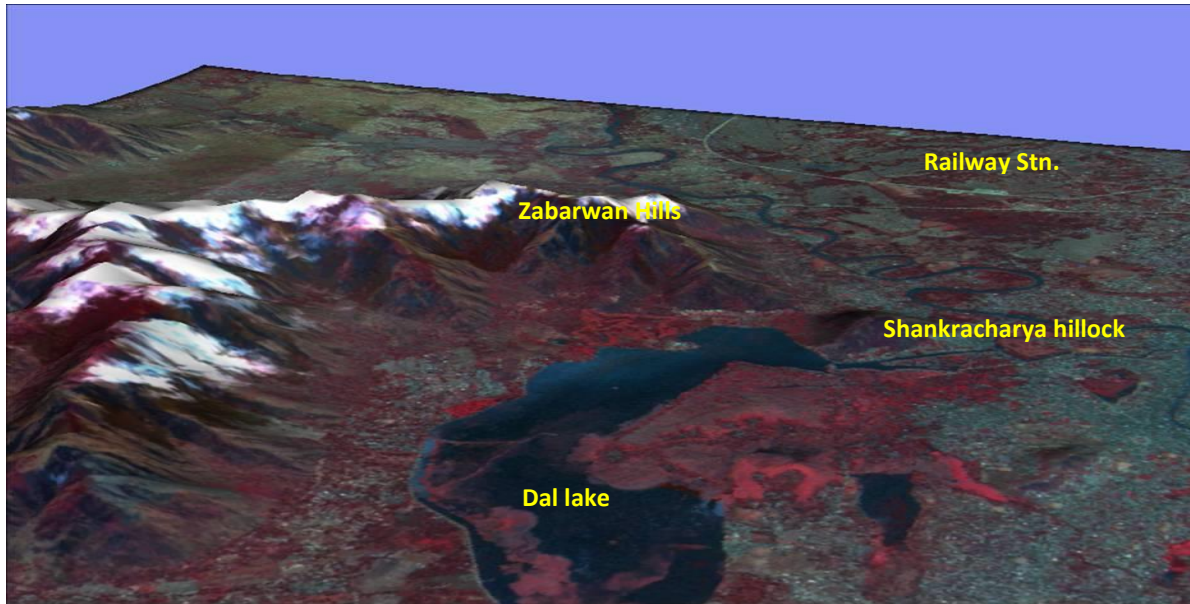

Fig 1: 3D View of Srinagar depicting Dal and Nigeen Lakes (Satellite image draped over SRTM).
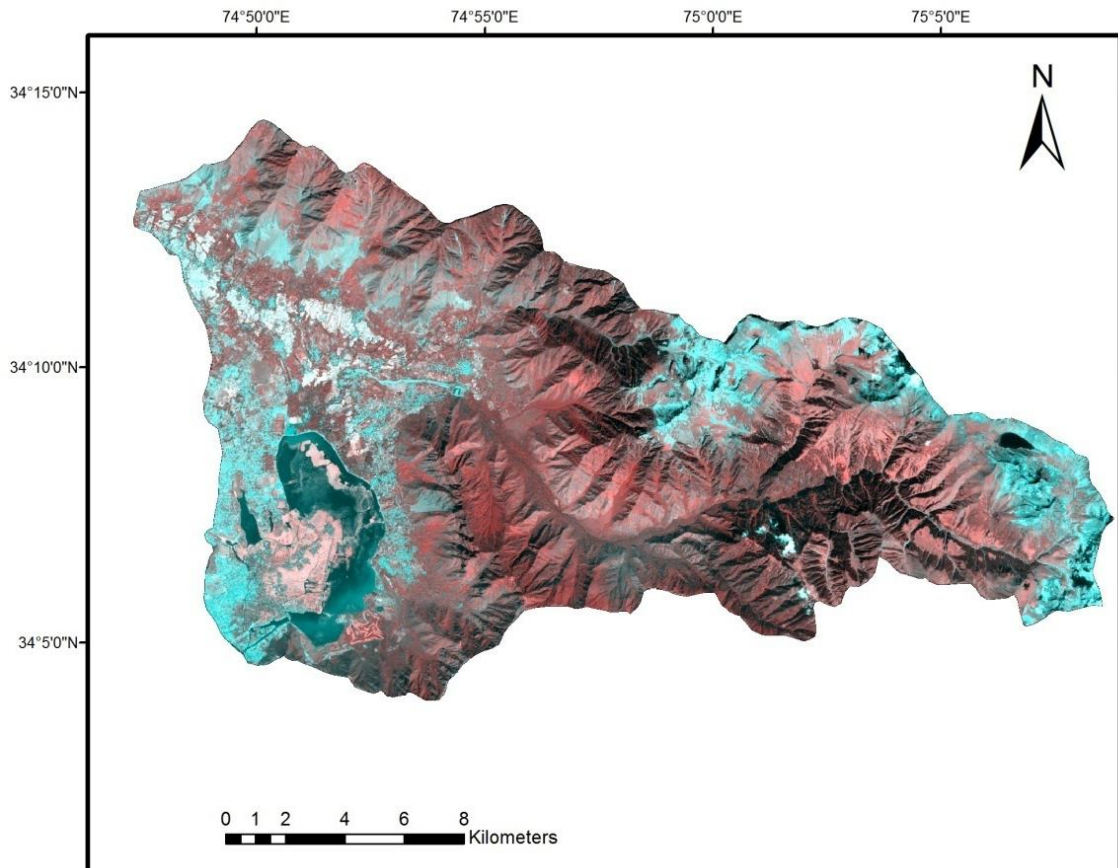

Fig 2: ETM plus image showing Dal, Nigeen Lake and its catchment area.

1.2.2 Rakh-i-Arath

The Survey of India topographical map sheet No. 43J/12 on 1:50,000 scale depicts Rakh-i-Arath as a marshy area lying towards the North-West of Hokersar wetland. However, analysis of the recent satellite images indicates that the area stands already reclaimed for cultivation by the locals. In the recent past, planners have freely used the name of Rakh-i-Arath for a marshy area lying to the south of Hokersar on the other side of the Hajibagh-Soibug link road. The area lies to the East of Srinagar city between 34° 04' 3" N to 34° 04' 58" N latitude and 74° 42' 39" to 74° 45' 03" E longitude. The area falls in the flood plain of river Jhelum and is being developed for rehabilitating the Dal Lake dwellers. The area has been earth filled and it has been desired that the progress of work needs to be monitored using geospatial technology.
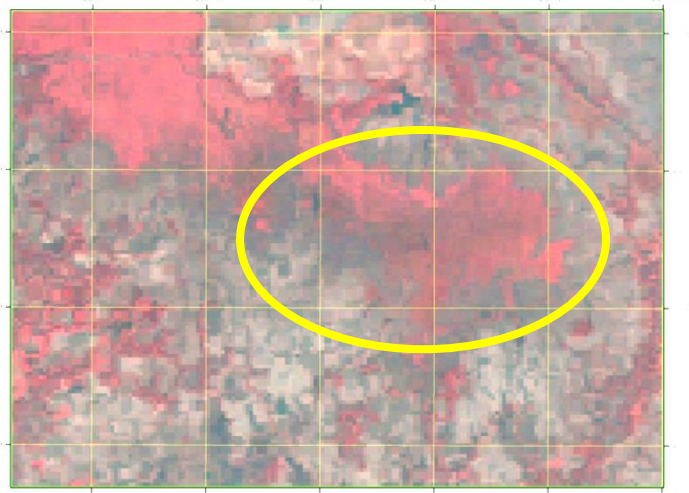

Fig 3: LISS-III image of 2004 showing southern extension of Hokersar now named Rakh-i-Arath area highlighted
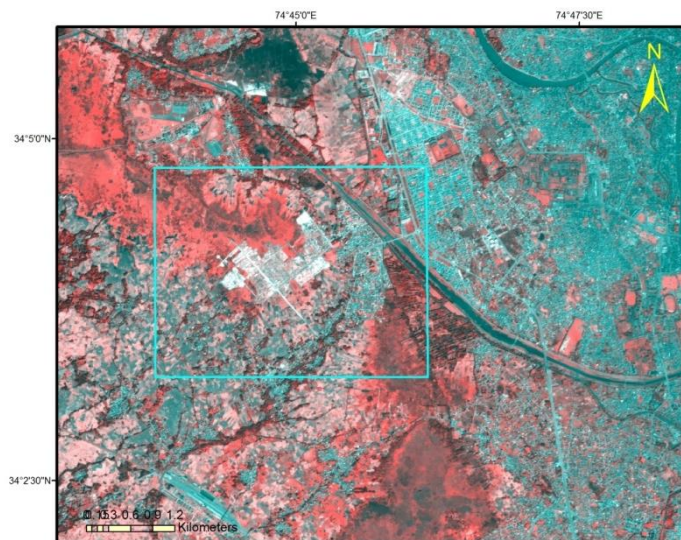
Fig 4: LISS IV Image of August 2014 showing landuse change in Rakh-i-Arath

1.2.3 Mughal Road:

In view of heavy pressure on the National Highway 1A, the government has rejuvenated this historical road which connects the valley of Kashmir with rest of the country via Poonch-Rajouri-Sunderbani-Jammu tract. The Govt. has prioritized its monitoring by using geospatial technology. The 30- 40.5 km and 24 - 43.6 km has been prioritized by the Govt. for monitoring using the geospatial technology.
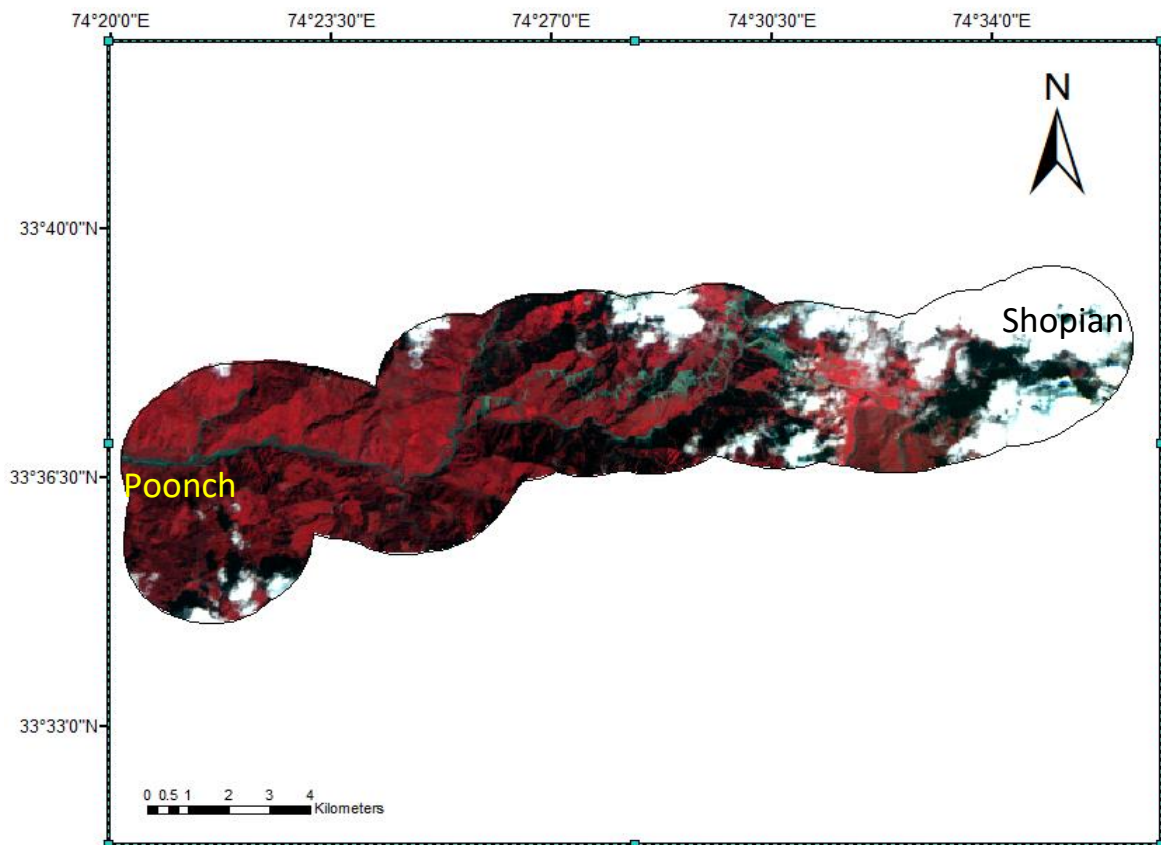
Fig 5: LISS-IV image showing Mughal road alignment in Shopian – Poonch belt 2km buffer on either side of the Highway

1.2.4 National Highway 1B (Batote –Kishtwar):

National Highway 1B is an alternate route from Anantnag to Jammu via Simthan Top, Kishtawar, Batote, Doda etc. This route has a road length of 274 Km. Out of these 274 Km some of the road patches are considered as Priority areas to check for accidents and slide prone areas. The Batote-Kishtwar National High 1B has also been prioritized for belts from km 5-20, km 44-55 and km 80-100. The road is aligned along the flow of river Chenab and this area has been prone to accidents.
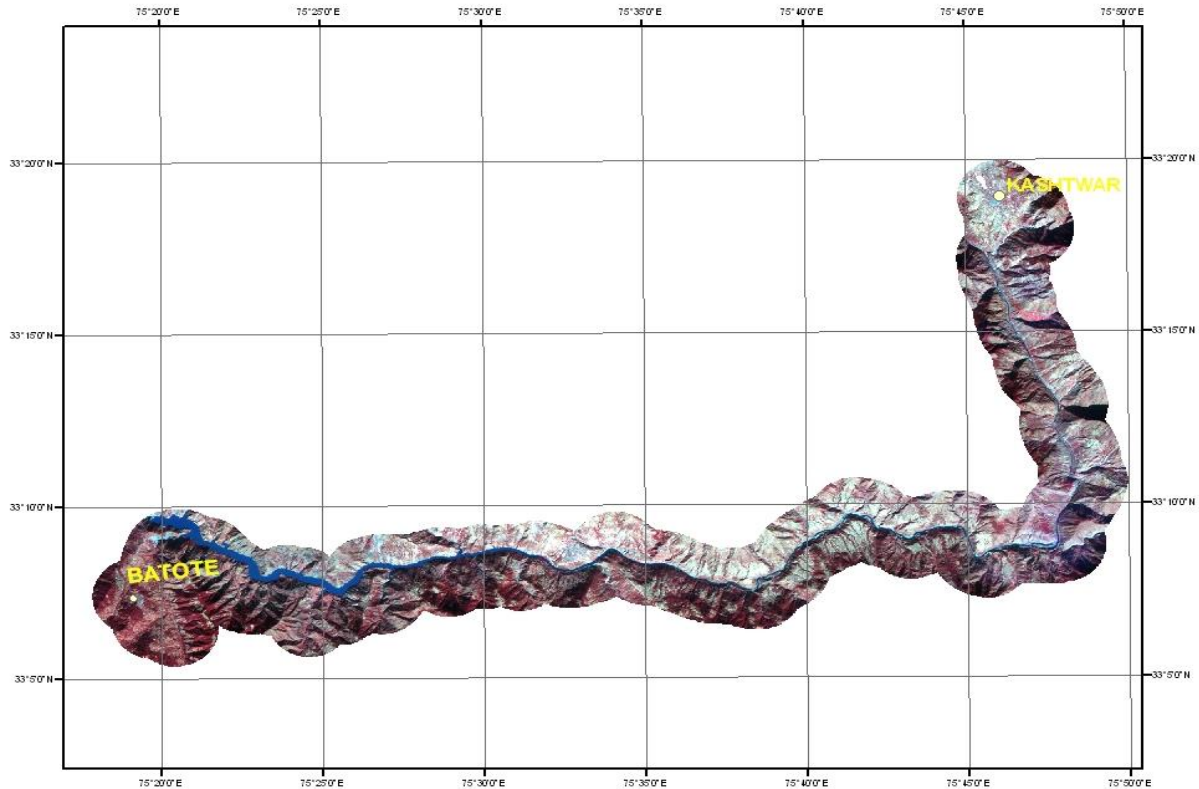
Fig 6: The NH1B Batote-Kishtwar Highway alignment with 2km buffer on either side of the Highway

1.2.5 Neeru Forest Range:

The Neeru Forest Range is located in the Baderwah Forest Division between 32°45' to 33° 45' N Latitude and 75° 30' to 75° 55' E longitude. Three areas in the Range have been prioritized for geospatial monitoring. In one of the areas, timber is being extracted by the Forest Department and in another area, the timber is being extracted by the State Forest Corporation and in the third area, a road is being widened.

As per information provided by the local forest officials, the following works are going on in the Range in various compartments:

Baderwah-Bani-Basoli Road

The timber extraction works carried out by the State Forest Corporation are being carried out in compartment Nos. 29, 30b, 33b, 34b, 36, 37 and 38. The compartments lie within the geographical coordinates of 32° 52' 00" N to 32° 57' 10" N Lat. and 75°42' 00" E to 75° 46" 45" E long.

Departmental Extraction and SFC general marking

The departmental extraction is being carried out in compt. Nos. 36, 58b and 59 while as the general marking is being carried out by the SFC in compt. No. 63. The compartments lie between the geographical coordinates of 32° 58' 00" N to 33° 00' 00" N Lat. and 75° 38" 00" E to 75° 42' 00" E long. In case of departmental extraction while as the compartment 63 lies between 32° 58' 00" N to 32° 59' 00" N lat. and 75° 37' 00" E to 75° 38' 00" E long.

Baderwah-Chamba Road

The timber extraction works carried out by the State Forest Corporation are being carried out in compartment Nos. 25, 26,27,30,31,32,33,34 and 35 and the compartments fall within the geographical coordinates of 32° 53' N to 32 57'N lat. and 75° 42' E to 75° 49' E long.
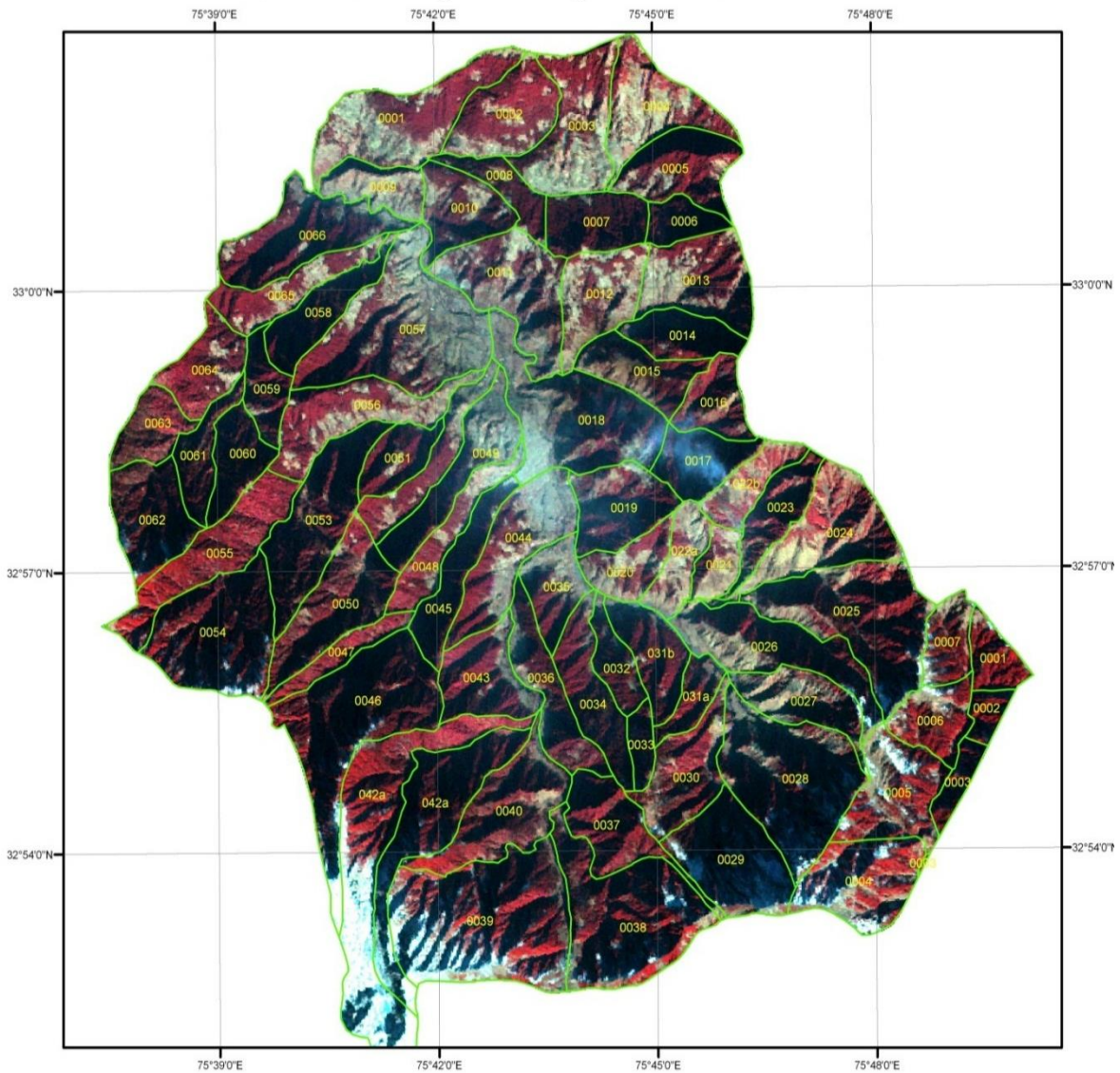

Fig 7: The LISS-III image depicting the Neeru Forest Range

1.2.6 Pahalgam:

Pahalgam is one of the prime health resorts of the state of Jammu & Kashmir, which is renowned world over. It is situated between 33° 45'to 34° 15' N Latitude and 75° 05' to 75° 35' E longitude. The area has experienced tremendous anthropogenic pressures owing to heavy tourist and pilgrim activity.
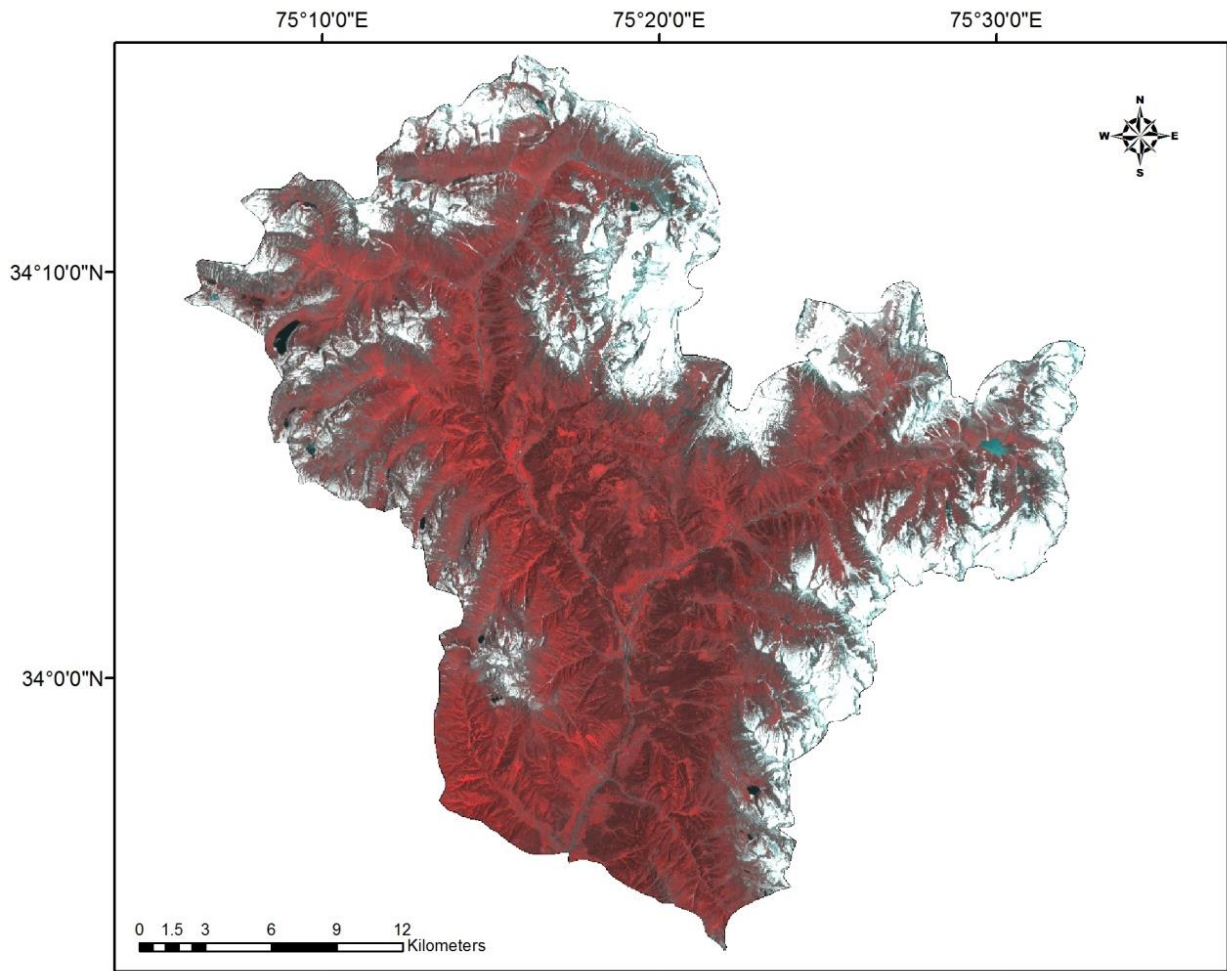

Fig 8: The LISS-III image depicting the Lidder catchment/Pahalgam area.

1.2.7 Gulmarg Tourist Resort:

Gulmarg is an important health resort of the State of Jammu & Kashmir and is situated between 34° 02' to 34° 05' N Latitude and 74° 20' to 74° 25' E longitude. The area has experienced tremendous anthropogenic pressures owing to heavy tourist activity.
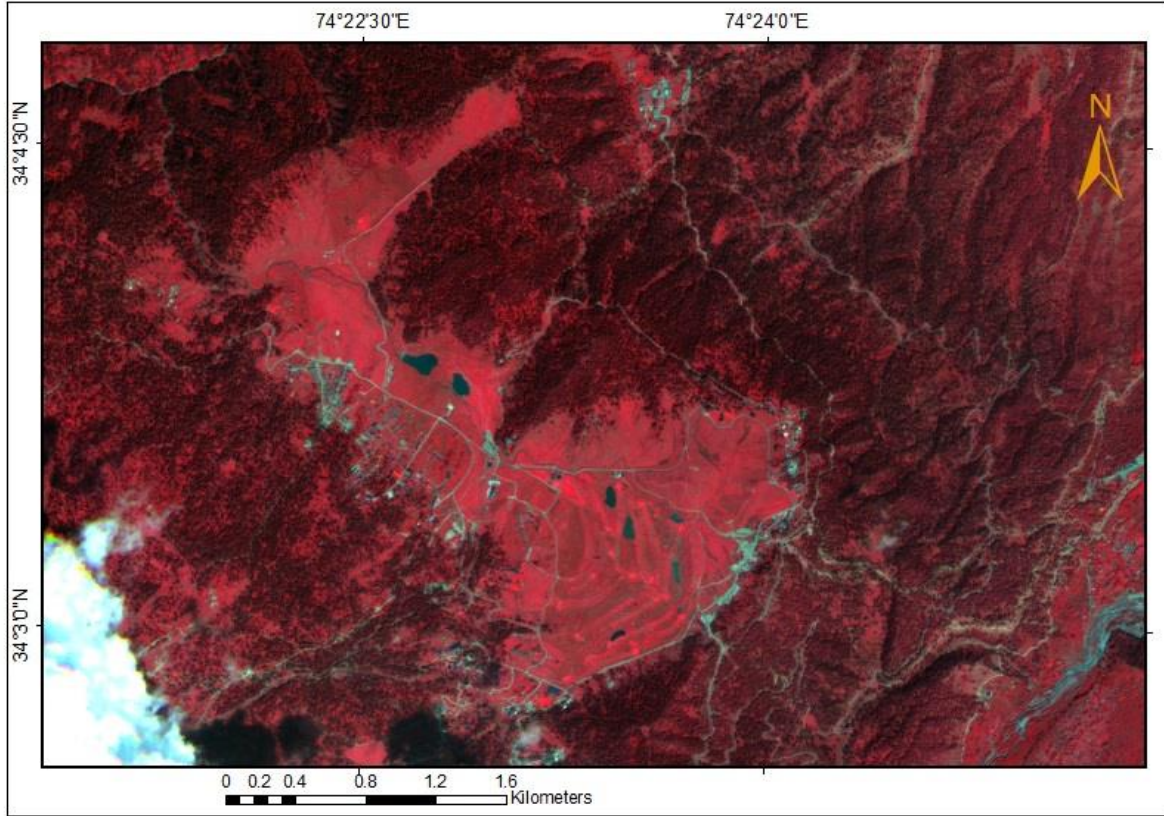
Fig 9: LISS IV image of 2014 showing Gulmarg Tourist Resort
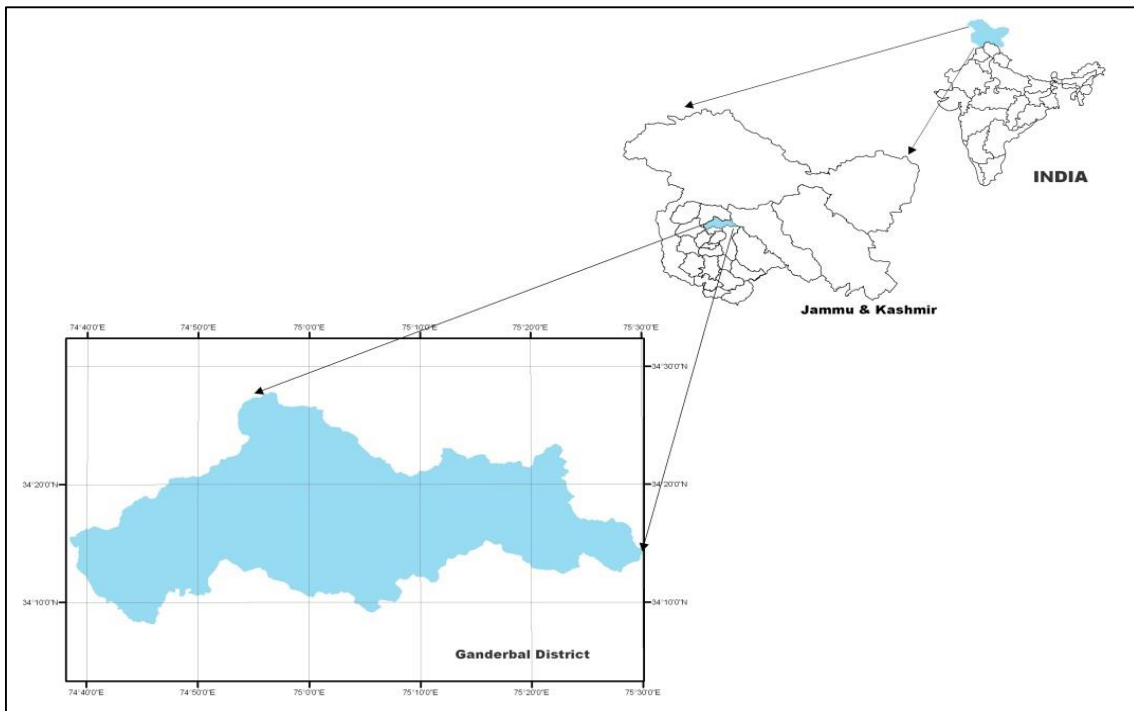
1.2.8 Ganderbal District:

Fig 10: Location of Ganderbal district

The District Ganderbal was carved out of Srinagar District and lies between geographical coordinates of 74°-30' E to 75°-30' E and 34°-05' N to 34°-30'. It lies in East-West direction with an average length of approx. 125km and average width of approx. 10-20 km. 70% of the District is having a hilly terrain with some areas remaining inaccessible for quite some time during winters. Estimated Population of the District for 2008 is 255631 of which only 10% live in municipal areas.

The reported area of the district is 1045 Km2. However, the area as per Geographical Information System (GIS) is 1374 km2. The district comprises of three tehsils namely Ganderbal, Kangan, and Lar. There are four Medical Blocks viz. Ganderbal, Kangan, Lar and Wakura. The district comprises of 136 villages. There is one CHC, two SDHs, sixteen PHCs and 53 Sub-Centers in the District.

1.2.9 Capacity building for geo-tagging of Health Institutions:

The Department has successfully accomplished a project on 'Measuring Physical Accessibility to Health Institutions and population coverage Modelling using Geo-informatics' in the state. Under this project, the health institutions were plotted for the entire Jammu and Kashmir except Ladakh Division. Under the project, the location of a medical facility existing in a small village across inaccessible terrain of the State was taken at the Centre of the village. However under GSMoPA project it was proposed that necessary capacity building of the local field staff would be provided using ICT so that the actual ground coordinates of the health institutions would be recorded by local field staff of the concerned Line Departments themselves so that the database is generated by the concerned user departments themselves economically for improving efficiency in planning process at the grass root level.

CHAPTER-2

2.0 Methodology:

The methodology employed for this work involved use of remote sensing data in a GIS environment combined with field data collection. Satellite data from the Indian Remote Sensing Centre was received for the seasons of summer and autumn. The Sensor used was LISS IV of Resourcesat-2 for conducting mapping exercise of the priority areas. Besides, very high resolution satellite images were procured from overseas through National Remote Sensing Centre, Hyderabad for development of applications. Also, in view of the importance of Dal and Nigeen Lake, a special study was carried out using multi-date Google images for growth monitoring of settlements. Besides, change analysis was also carried within 200m buffer of the lake body using very high resolution satellite images of 2007 and 2014. The following processes were carried out:-

2.1 Image selection & Data procurement

The requisite images were browsed using online web portals of the data generating agencies. As per the procedures, orders were placed through the National Remote Sensing Centre and through the requisition and funds were placed to the National Data Centre in time, yet due to sensitive nature of the state, the high resolution images were received only during 2015.

For carrying out the study, IRS LISS IV satellite data of 2013-2014 having spatial resolution of 5.2 m was procured for all the identified priority areas from National Remote Sensing Centre (NRSC) Hyderabad. Besides High Resolution Geo-eye satellite data having spatial resolution 0.5m was also procured for the year of 2014 from Digital Globe.

In view of the importance of Dal and Nigeen Lake system, a special study was carried out in the Lake body including 200m buffer of Dal and Nigeen Lake using very High Resolution Satellite data sets of Quickbird (2007) and Geoeye (2014).
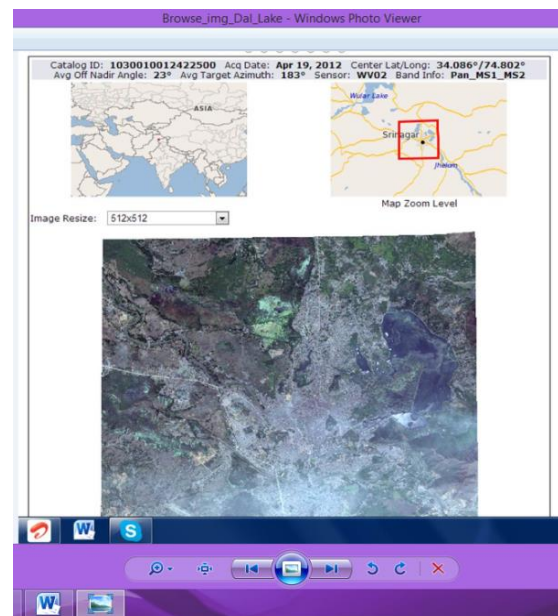
2.2 *Geo-referencing*

The remotely sensed data was distorted by the earth's curvature, relief displacement, and acquisition geometry of satellites (variation in altitude, aspect, velocity, panoramic distortion). The intent of geometric correction is to compensate for the distortions introduce by these factors so that the corrected image will have the geometric integrity of a map. The rectification is the process of projecting the data on to a plane and making it confirm to a map projection system.

2.3 *Rectification*

Digital comparison of the multi-sensor data requires further adjustment as the observations are made in sensor specified discrete spectral bands. The amount of energy received at the sensor from a particular earth feature is a function of received energy, reflectance, atmospheric propagation, sensor sensitivity and spectral band width. If we consider a homogeneous land surface and similar atmospheric condition the amount of received energy is a function of band width of spectral channel. In present study the satellite data was already radiometric corrected.

2.4 *Preliminary interpretation*

Digitization is an art/ technique using specific software like Arc GIS, ERDAS IMAGINE, etc., to delineate the spatial extent of a feature under investigation. For the current study Arc GIS software was used for the digitization of Land-use/Land cover of the priority areas delineated. LISS IV image has a spatial resolution of 5m, which is a good resolution for digitization of land-use/land-cover at district level. It will serve as a base map for the analysis of land-use/land cover changes in ten priority areas in future. Topographic maps of the corresponding areas were also used for geo-referencing.

2.5 *Classification*

Classification involved delineation of the spatial extent of various features under investigation. The delineation of Land-use/Land cover was carried out at a scale of 1:10,000 using the Reseourcesat-2 images. This database is expected to serve as base information for future land-use/ land cover monitoring of the area. The following classification system was used for land use / land cover mapping:

Table 1: Classification Scheme for Land use/ Land cover mapping

Class	Sub-class	Definition
Agriculture		These are the lands primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It includes land crops (irrigated and

		irrigated, fallow, plantations etc.)
Built-up		Built-up areas are characterized by substitution of the original (semi-) natural cover or water surface with an artificial, often impervious, cover. This artificial cover is usually characterized by long cover duration. (FAD, 2005). Basically they are the area of human habitation that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands. It consists of four level-2 classes namely - Urban built-up, Rural, Industrial and Mining/Quarry.
	Urban	Urban areas are non-linear built up areas covered by impervious structures adjacent to or connected by streets. This cover is related to centers of population. This class usually occurs in combination with, vegetated areas that are connected to buildings that show a regular pattern, such as vegetated areas, gardens etc. and industrial and/or other areas. (FAD, 2005). Hence, all places with a municipality, corporation or cantonment or which are notified town areas and all other places which satisfy the criteria of a minimum population of 5000, at least 75% of whose male working population is non-agricultural and having a density of population of at least 400 Km^2 are placed under this category. This also includes Permanent residential, industrial, transportation, power, communications and isolated areas such as mills, shopping centers, parks, playgrounds, open spaces, institutions etc. It also includes temporary hutments like slums, hostels etc. It comprises of three Level-3 classes as discussed below.
	Rural	These are the lands used for human settlement of size comparatively less than the urban settlements of which more than 80% of the people are involved in the primary activity of agriculture. All the agriculture villages covering 5 hectares area and more are included in this category.
	Scattered	It includes scattered blocks of residential flats, hamlets, small villages where numerous interstitial spaces(gardens and lawns etc.) can be distinguished; urban residential layout marked for the construction of residential houses, transport networks, cemeteries etc.
	Commercial	These are areas where commercial activities are predominant
	Recreational	These are areas with recreational facilities like parks, gardens, golf courses etc.
Forest		These are the areas bearing an association predominantly of tree and other vegetation types (within the notified forest boundaries) capable of producing timber and other

		forest produce.
Mixed Plantation/ Orchard		These areas are separable from cropland, especially with the data acquired during Rabi/Zaid season. Plantation appear in dark-red to red tone of different sizes with regular and sharp edges indicating the presence of a fence around it. Depending on the location, they are exhibit a dispersed or contiguous pattern. Use of multi-season data will enable their separation in a better way. These areas also include the horticultural plantations.
Scrub land		These are the forest areas where the crown density is less than 10% of the canopy cover, generally seen at the fringes of dense forest cover and settlements, where there is biotic and a biotic interference. They appears in light red to dark brown depending on the canopy cover and soil background. Their size will vary from small to big, irregular to discontinuous in shape, contiguous to non-contiguous in appearance. Most of these are located on hill/mountain slopes within notified forest areas, at times closer to habitations. Forest Blank are the opening amidst forest areas, devoid of trees cover, observed as opening of assorted size and shapes as manifested on the imagery. They appear in light yellow to light brown in tone, generally small in size. They possess regular to irregular shape, scattered in the forested areas. Most of these areas seen along hill/slopes midst forest areas.
Grazing/ pastures		These areas are described as the natural potential (climax) plant cover as being composed of principally native grasses, Forbes and shrubs. This category includes grassland, shrub and brush land and mixed Rangeland (USGS). In other terms the land where the potential vegetation is predominantly grasses, grass like plants, forbs or shrubs and is capable of being grazed. Located in plains, uplands, and hill-slopes or close to rivers/ streams, they are associated with agricultural lands, dry lands fenced from cultivation, riverbeds and forested areas in high altitudes.
Wasteland	*Barren rocky*	These are rock exposures of varying lithology often barren and devoid of soil and vegetation cover. They occur amidst hill-forests as openings of as isolated exposures on plateau and plains. Such lands can be easily discriminated from other categories of wastelands because of their characteristic spectral response. They appear in greenish blue to yellow to brownish in color depending on the rock type. They vary in size with irregular to discontinuous shape with a linear to contiguous or dispersed pattern. They are located in steep isolated hillocks/hill slopes, crests, plateau and eroded plains

		associated with barren and exposed rocky/stony wastes, lateritic out-crops, mining and quarrying sites.
	Vacant land	Vacant lands are those which are not currently put to any use due to financial or other natural constraints
Water body	*Floating garden*	Floating gardens are the areas within the water body which are used for agriculture purposes especially vegetables.
	Marshy/ wetland	All submerged or water-saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or dynamic, vegetated or non-vegetated, which necessarily have a land-water interface, are defined as wetlands.
	Lake/ Reservoir	These are accumulation of water in a depression of various sizes either natural or saline. Reservoir is an artificial lakes created by construction of a dam across the river specifically for Hydropower generation, irregular, and water supply for domestic/industrial needs, flood control, either singly or in combination. Tanks are small lakes of impounded water ways constructed on land surface for irrigation. They appear in light blue to dark blue depending on the depth from small to large sizes. They possess regular to irregular shape dispersed to linear, occupying lowlands, plains. They are associated with croplands, low lands and reservoirs surrounded by hills with or without vegetation
	River/stream/ canal	Rivers/streams are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards a sea in most cases or a lake or an inland basin in desert areas or a marsh or another river. Depending upon the nature of availability of water, river is sub-divided into perennial or seasonal. They appear in light to dark blue in color, long narrow to wide depending on the size of the river. They appear in contiguous, at times nonlinear pattern and associated with drainage pattern on hill slopes, flood plains or uplands, at times with vegetation along the banks. Canal and drains are artificial water course constructed for irrigation, navigation or to drain out excess water from agricultural lands.
Other	*Snow/glacier*	These are the areas under perpetual snow cover confined to the Himalayan region. They appear in bright white to white in color depending on the moisture and thickness of the snow spread in large areas. They possess irregular shape with a contiguous pattern, located in mountain peaks and slopes and high relief areas.
	Cloud cover	Area on the image covered by cloud formations

2.6 *Scale of Mapping*

The mapping was carried out at 1:10,000 scale for all the priority areas. However, for analysis of changes in the Dal and Nigeen Lake and within its 200m buffer, mapping was carried out on a scale of 1:1500 using very high resolution satellite images.

2.7 *Ground Truthing*

The preliminary interpreted maps were subjected to limited Ground Truthing and important field details were collected and incorporated in the maps.

2.8 *Final Mapping*

After incorporating necessary corrections, the maps were finalized and area statistics and layouts was generated.

CHAPTER-3

3.0 Results and discussion:

3.1 Dal and Nigeen Lake

The Landuse /Landcover of Dal and Nigeen catchment (Fig 26) was generated from LISS IV data of the year 2014 at 1:10000 Scale using on-screen digitization technique. A total of 15 land use / land cover classes were identified. Forest is the dominant class with an area of 10926.67 ha followed by Scrubland at 6643.29 ha. Floating Gardens covers an area of 533 ha and Macrophytes within water bodies spreads over 283.34 ha area. Built-up area of the catchment (both urban and rural) is estimated at 2582.78 ha. The Recreational area is spread over an area of 428.59 ha. The full statistics is given in Table 2. The detailed study carried out on Dal and Nigeen Lake is discussed in the Geospatial Atlas of Dal, Nigeen and Rakh-i-Arath forming Annexure to this report.

3.2 Batote -Kishtawar Road

Land use/ Land cover map of the Batote-Kishtwar Road (Fig 27) was generated for within 200 meter buffer on either sides of the road using LISS IV image of 2014. The Statistics of the land use Land cover map is given in Table 3. Agriculture is the dominant land-use of the area having an area of 7823.53 ha. The forest cover of the area is 3493.35 ha, while Built-up (urban and rural) is spread over an area of 947.42 ha. Wasteland having very steep slopes and prone to landslide and shooting stones is spread over an area of 3343.54 ha.

3.3 Mughal Road

Land-use /Land-cover map of Mughal road (Fig 28) was generated for 200 meter buffer on both sides of the road stretch, using LISS-IV data of 2014. The road passes through the picturesque Pir Panjal mountain range with lush green forest and alpine meadows. The Statistics of the land use land cover map is given in Table 4. Forest is the dominant land cover class with an area of 6001.47 ha, followed by Alpine Pastures with an aerial extent of 1860 ha. Built-up is scattered over an area of 225.03 ha and Agriculture land over 1386.86 ha area approximately.

3.4 Pahalgam

The land-use/ land-cover map of the Pahalgam area (Fig 29) was generated from LISS IV data of 2014. Snow cover is the dominant land/cover class with an area of 19784.75 ha, followed by forest cover with an area of approximately 18020.79 ha. Alpine Pastures cover

an area of 10458.01 ha while Agriculture spreads over an area of 1362.25 ha. Builtup (Commercial and Rural) spreads over an area of 204.03 ha as given in Table 5.

3.5 Neeru Forest Area

The land-use /land-cover map of Neeru forest range (Fig 30) was generated from LISS IV data of 2014 on the basis of visual image interpretation and onscreen digitization, at 1:10000 Scale. Three main classes of forest were identified viz. Forest dense, Forest open and Forest scrub, in addition to other land use/land cover classes. The statistics is given in Table 6. Forest Dense is the dominant class of the forest area with an area of 12654.21 ha while open forest covers an area of 381.11 ha. Forest scrub covers an area of 1364.24 ha and Alpine Pastures cover an area of 398.29 ha. Agriculture land spreads over an area of 3834.61 ha and Builtup covers an area of 502.37 ha. The land use/land cover map of Neeru Forest Area is given in Figure 30.

3.6 Gulmarg

The Landuse Landcover map of Gulmarg tourist resort (Fig 31) was generated from LISS-IV image of 2014. The main classes that where identified include Agriculture, Builtup-Commercial, Builtup-Rural, Forest, Grazing /Alpine Pasture, Recreational, Waterbody Lake/Reservoir, and Waterbody River/Stream. Figure 17 shows the Landuse/Landcover map of Gulmarg bowl.

The area statistics of various Landuse/Landcover classes of Gulmarg resort is given in Table 7. Forest is the dominating Landcover class with an area of 303.091 ha, followed by Grazing land/Alpine Pasture (249.283 ha). Builtup Commercial comprises of 52.949 ha while Recreational area including Golf Course covers an area of 138.389 ha. Also Builtup (Rural) cover an area of 0.413 ha. Agriculture land comprises of 12.908 ha.

Although Forest is the dominant Landcover but the area is under tremendous anthropogenic pressure.

3.7 Rakh-i-Arth

The Land use/Land cover Map of Rakh-i-Arth (Fig 32) was generated from LISS IV image of 2014. Being adjacent to famous wetland "Hokersar", Agriculture is the dominant land use with an area of 482.03 ha. The area is being landfilled and converted into residential colonies and built-up area of 217.50 ha has already been completed and the filling of 91.70 ha area has further been completed for conversion into residential colonies. Marshy land has an area of 201.09 ha and Mixed Plantation/ Orchard covers an area of 22.38 ha. The statistics of the

land use/ land is given in Table 8. The detailed study carried out on Rakh-i-Arath is discussed in the Geospatial Atlas of Dal, Nigeen and Rakh-i-Arath forming Annexure to this report.

3.8 Ganderbal District

Land use/Land cover of Ganderbal district (Fig 33) was generated from LISS IV satellite data of 2014. From the statistics of land use /land cover map given in Table 9, it is evident that Forest is the dominant land cover with an area of 34969.37 ha and followed by Scrub land with area of 34108.55 ha. The area is known for its high altitude pastures and meadows, which covers an area of 8456.61 ha. Agriculture covers an area of 11238.07 ha. The area under Snow covers an area of 4639.92 ha. Built-up residential (urban, rural and scattered) cover an area of 2004.65 ha. The district has an industrial area of 18.22 ha.

3.9 Capacity Building for mapping of Health Institutions

A two day Capacity Building Program on "Spatial Data Capturing and Applications of Geoinformatics" was organized on 18th and 19th of June 2014 at Institute of Management and Public Administration (IMPA). In the workshop representatives from various line Departments like Health, LAWDA, NRHM, SDA, SMC, Town Planning, etc. were sensitized with the applications of Geoinformatics. The representatives were given hands on training in capturing of Spatial data using GPS and Andriod mobile applications (developed in the department) from the field.

One day workshop was organized at Mini Secretariat Ganderbal district on 17th of February 2016, for providing hands on job training to representatives of various departments like CAPD, LAWDA, Health, NRHM, etc. The representatives were given training in capturing of Spatial data from the field using Android based Application developed within the department for capturing of spatial data for various line departments. The Application was provided on spot to the representatives for using it in the field. The representatives were also given training for submission of captured data to the department for formation of a Geodatabase. The representatives were also sensitized about the applications of Geospatial technology to achieve Good Governance.

CHAPTER-4

4.0 Application development

For monitoring process Geospatial Monitoring Applications were developed for all the Priority areas. The Applications. Provides a grid based index image of the individual priority area. The grids are numbered. The user clicks the year of satellite image and clicks on the particular grid to get an enlarged image of that grid for better understanding of the ground features.
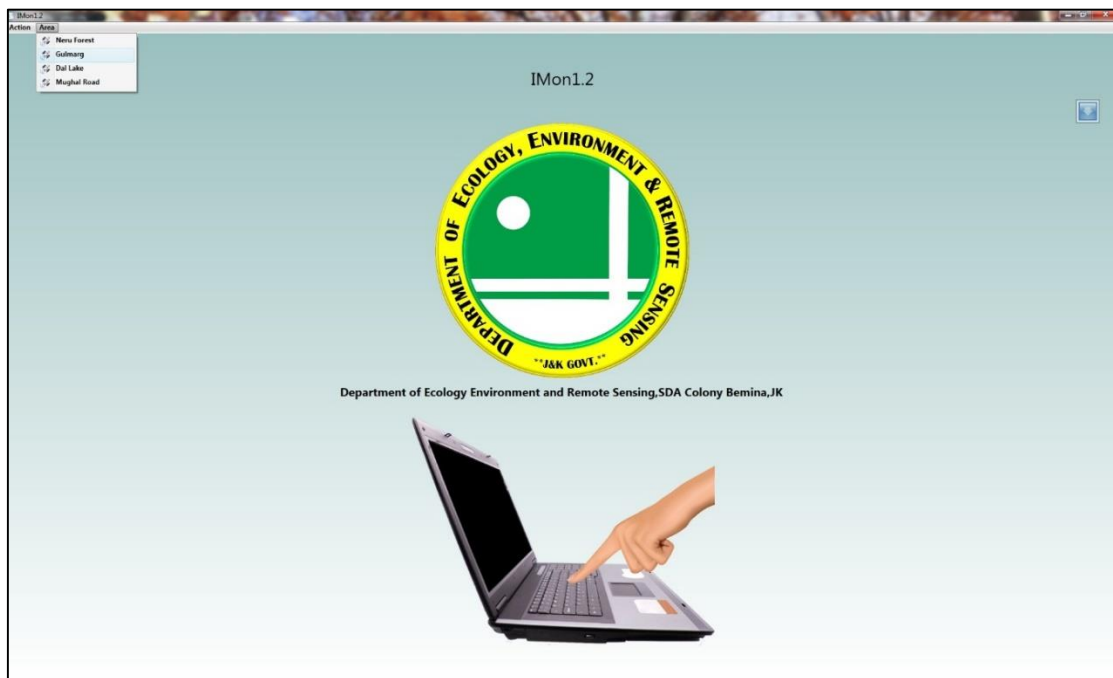
Fig. 11: Home page of the Application development on Priority Areas

Figure 11 shows the home page of the Monitoring Application. The home page has Area tab from where the user can select the area for which he intends to see the value added High Resolution Imagery. After selecting the area (Gulmarg Fig. 12 and Dal lake Fig 14, Mughal Road Fig 16, Neeru Forest Fig 18, Pahalgam Fig 20, Batote-Kishtwar Road Fig 22), the home Page of the Priority area will get displayed, were the User has to Select the year of data that is available for that particular area. After selecting the year a satellite image with inserted grids and unique grid numbers will get displayed. The user can then view the value added high resolution images of any grid one by one and if available can also compare it with the previous year Satellite images (Fig: 13 Gulmarg, Fig: 15 Dal Lake, Fig 17 Mughal Road, Fig 19 Neeru Forest, Fig 21 Pahalgam, Fig 23 Batote-Kishtwar Road).
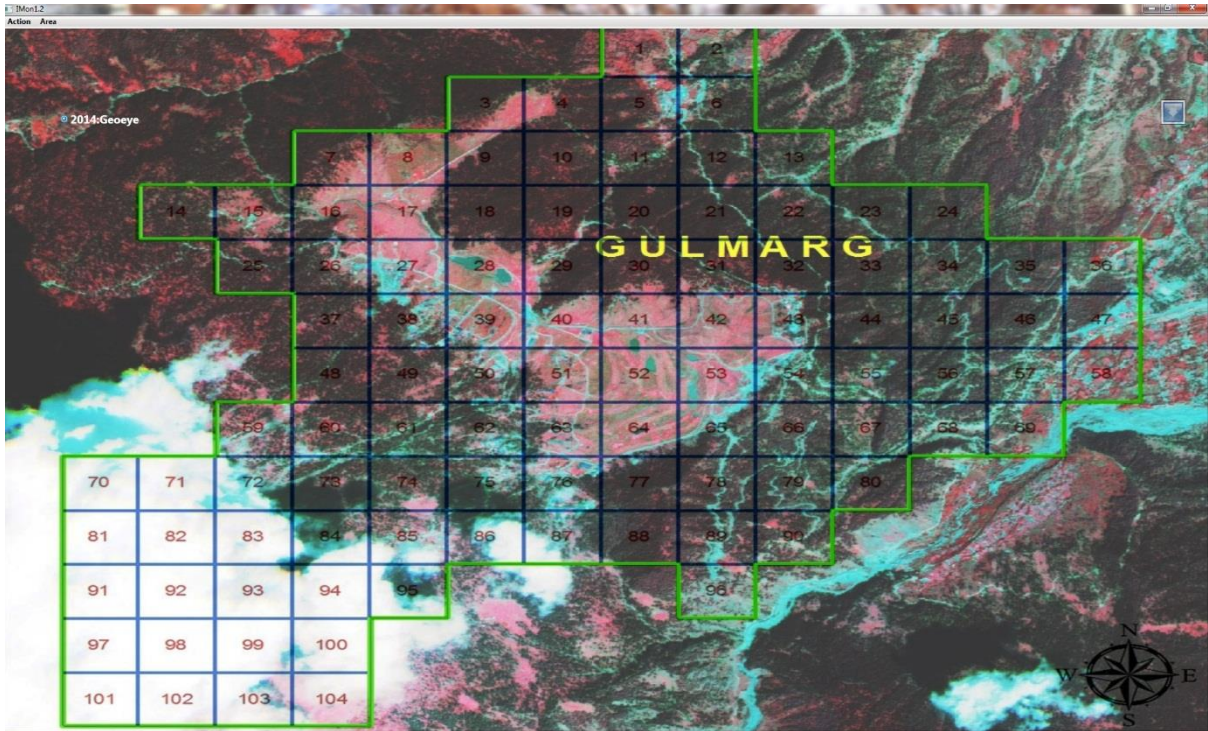
Fig. 12: Home page of Gulmarg Area on the Application
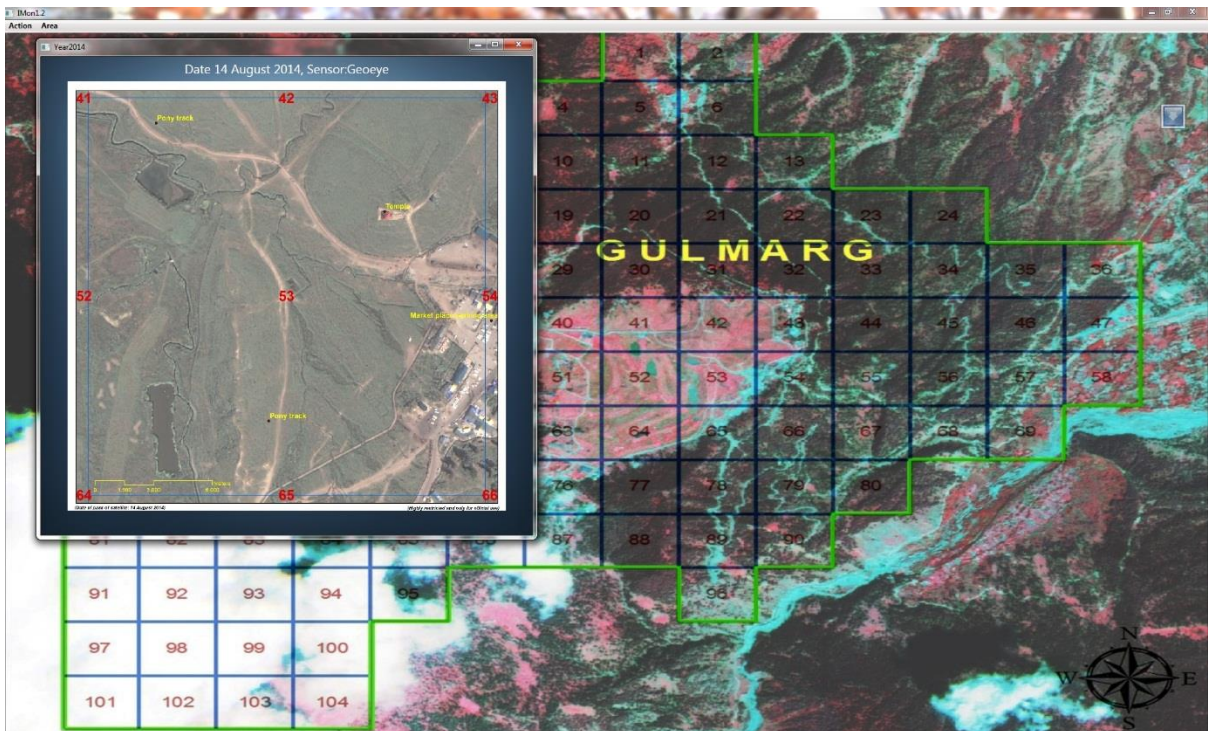
Fig. 13: View of value added Satellite image after selecting a particular grid.
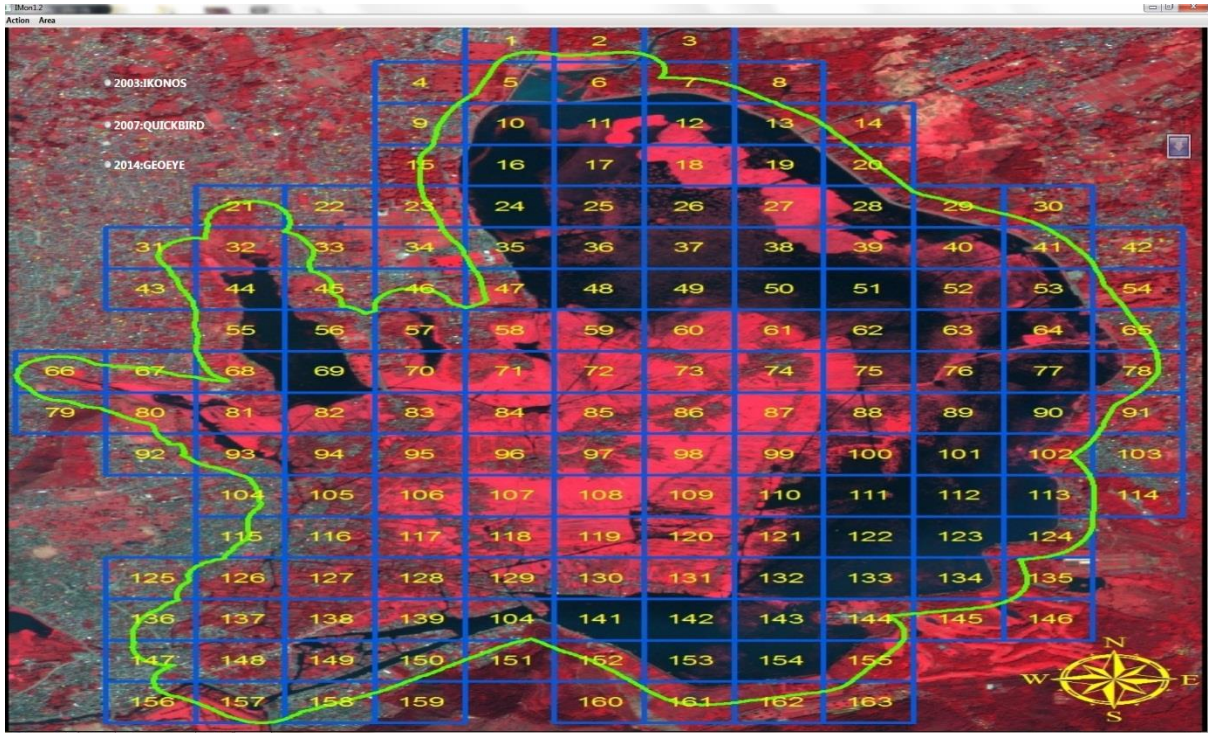
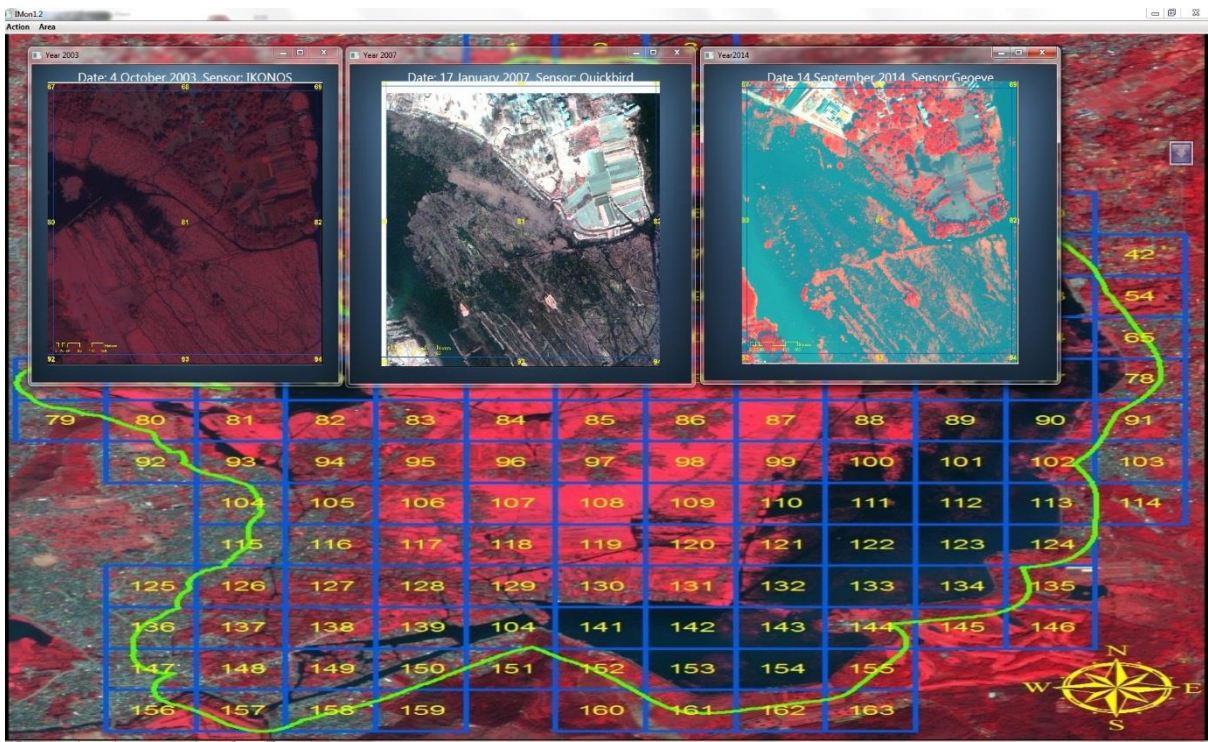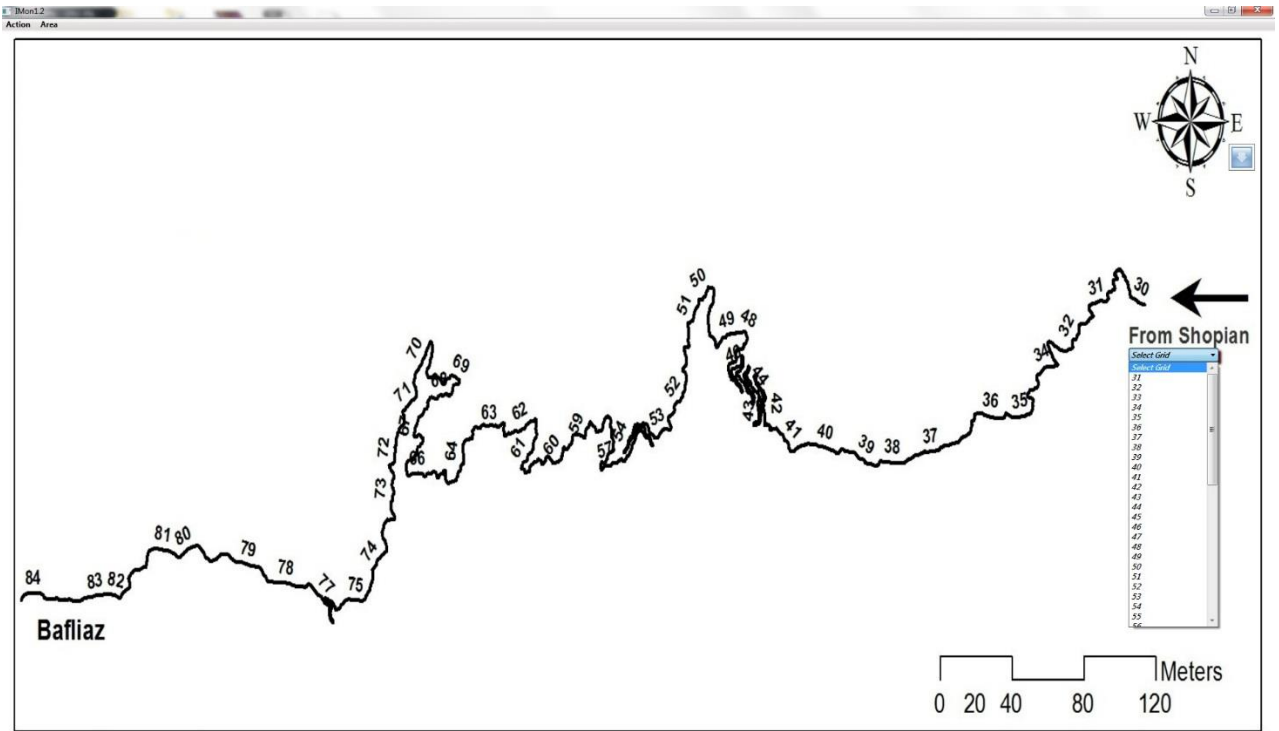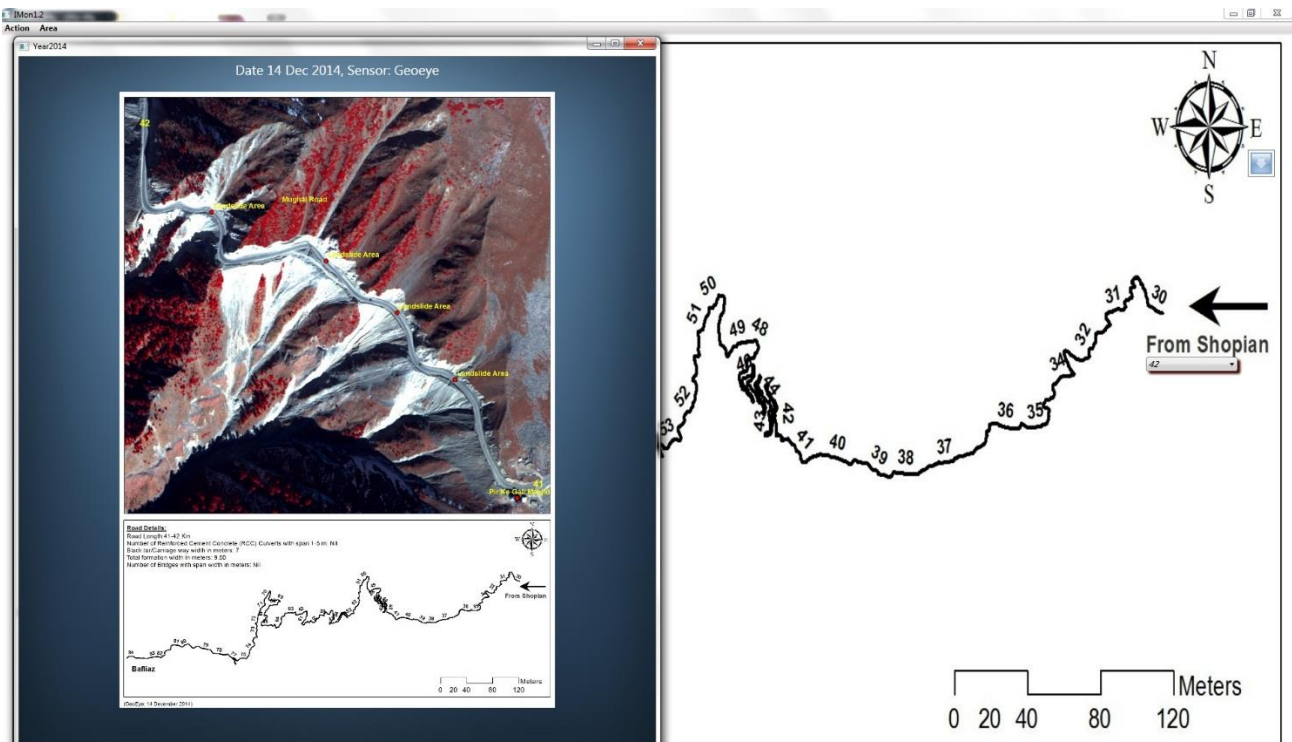**Fig 14: Homepage of Dal Lake on the Application**

Fig 15: View of Satellite Data of different years on selecting a particular grid

(GeoEye: 14 December 2014)

Fig 16: Home Page for Monitoring Application of Mughal Road

(GeoEye: 14 December 2014)
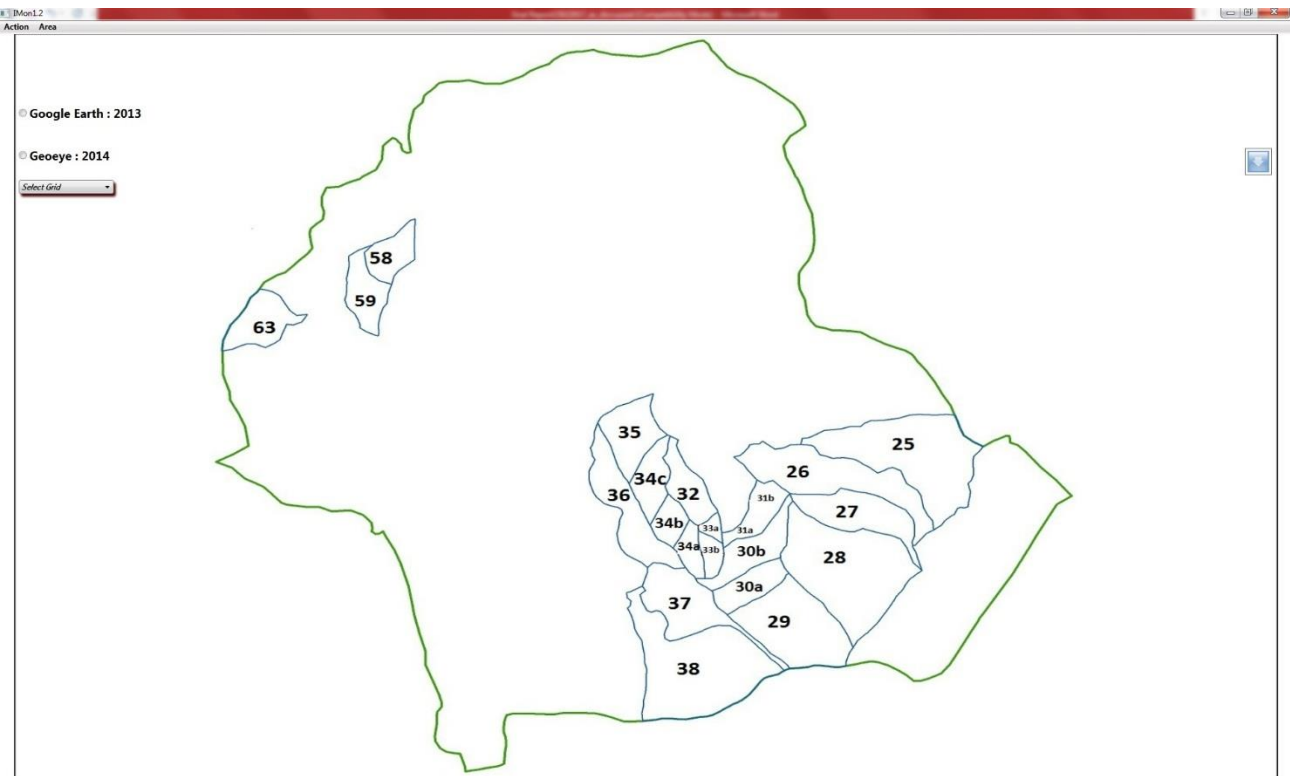
Fig 17: View of value added satellite Image for one Kilometer of road

Fig 18: Home Page for Monitoring Application of Neeru Forest identified priority compartments

Fig 19: view of satellite Image of various compartments of Neeru Forest
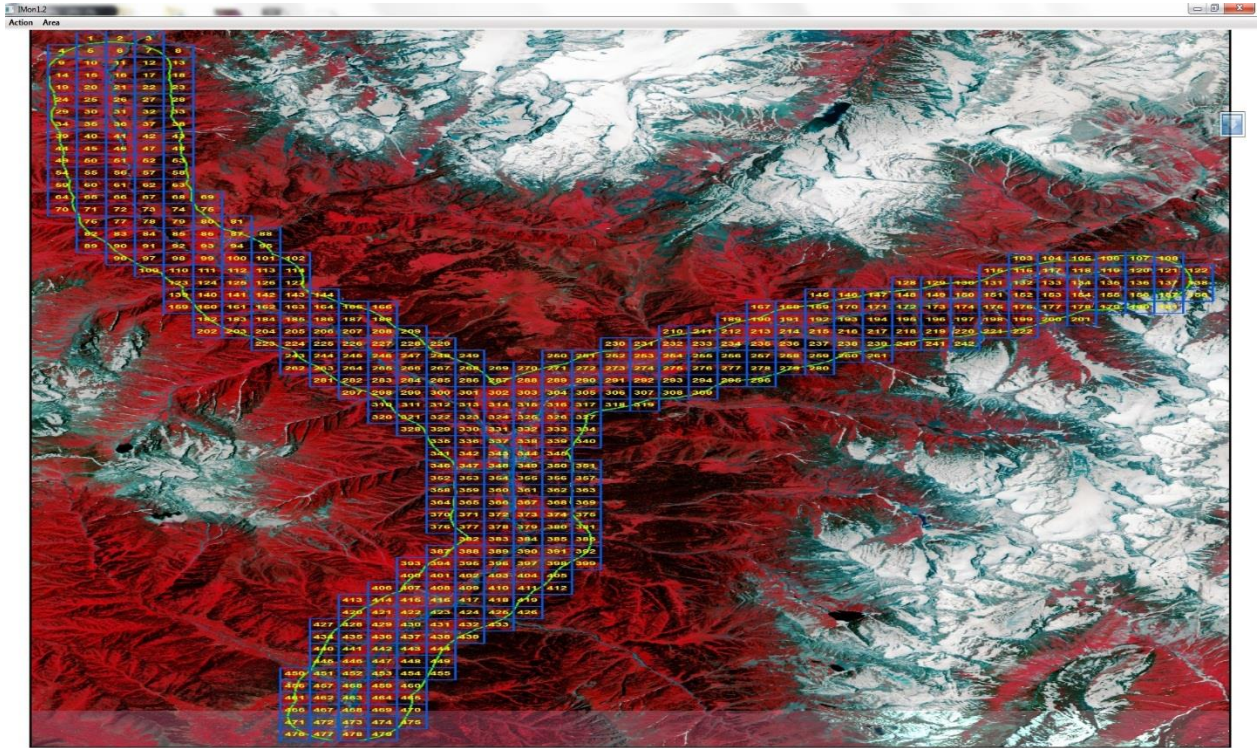
Fig 20: Homepage of Pahalgam on the Application
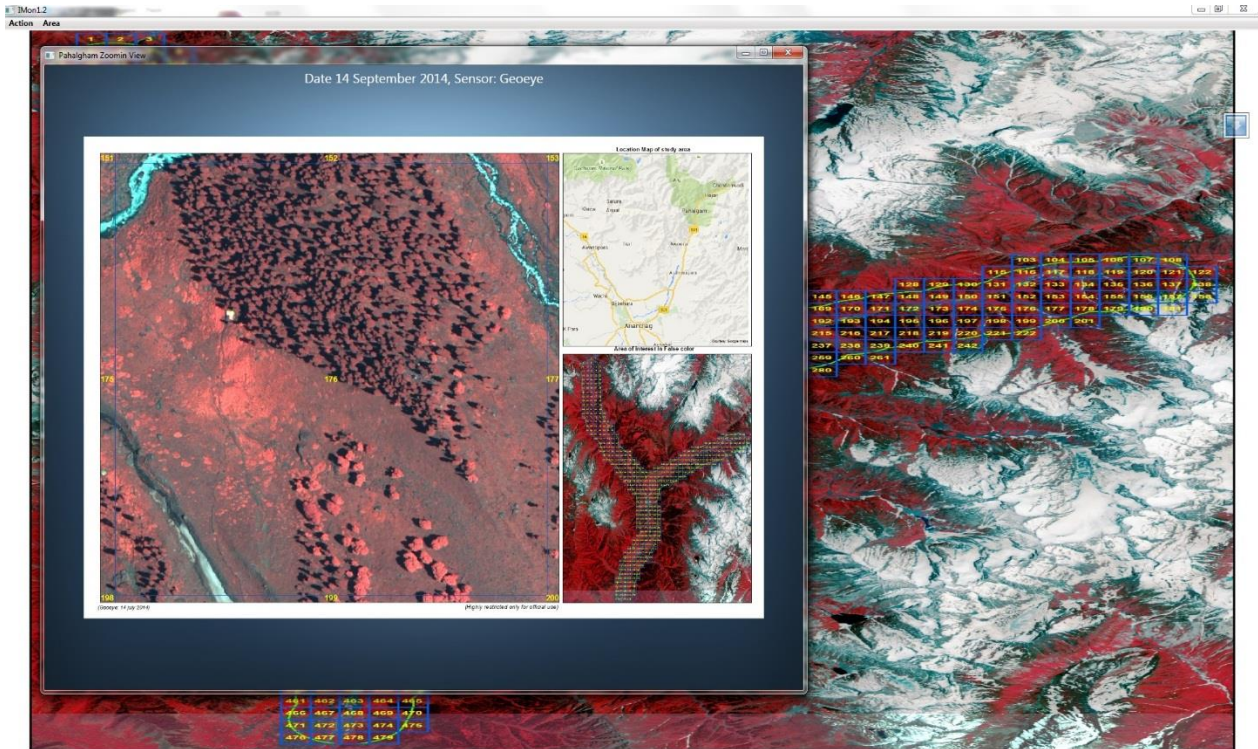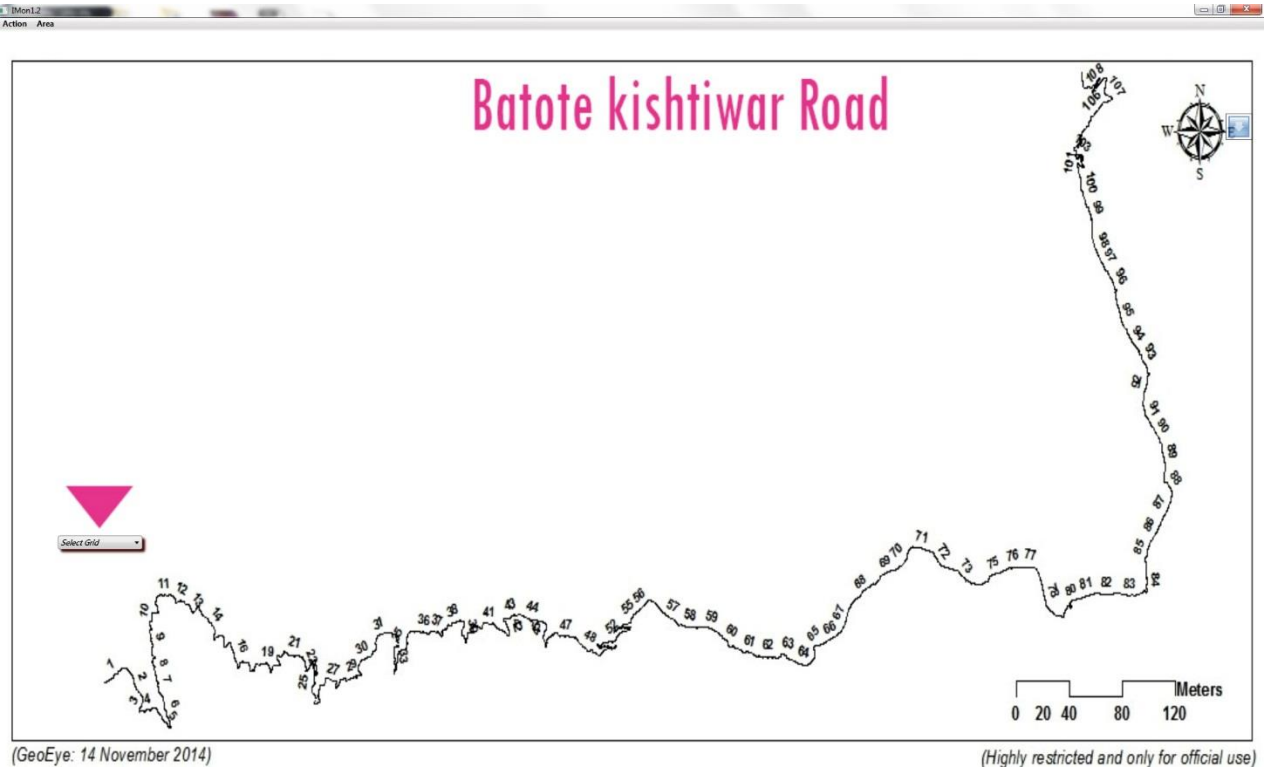

Fig 21: View of Satellite image on selecting a particular grid

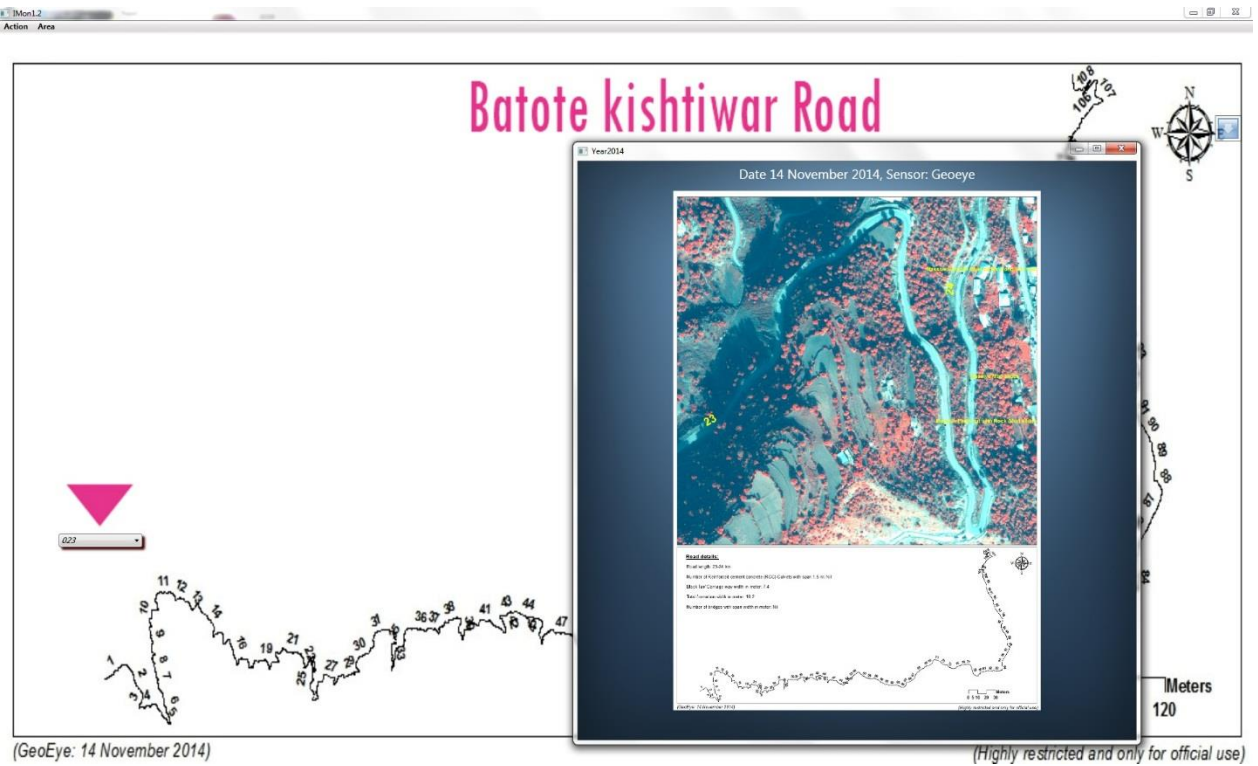**Fig 22: Home Page for Monitoring Application of Batote- Kishtiwar Road**

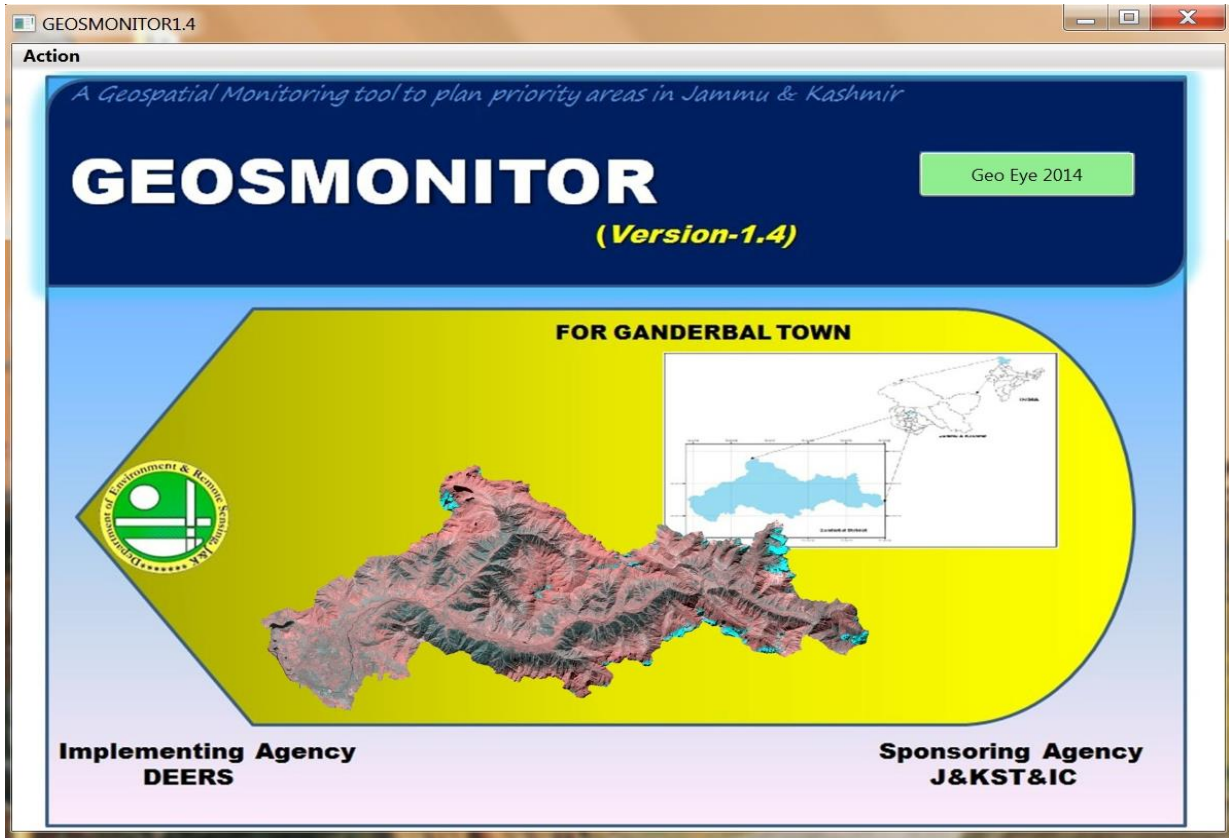**Fig 23: View of value added satellite Image for one Kilometer of Batote- Kishtiwar road**

Fig 24: Homepage of Ganderbal on the Application
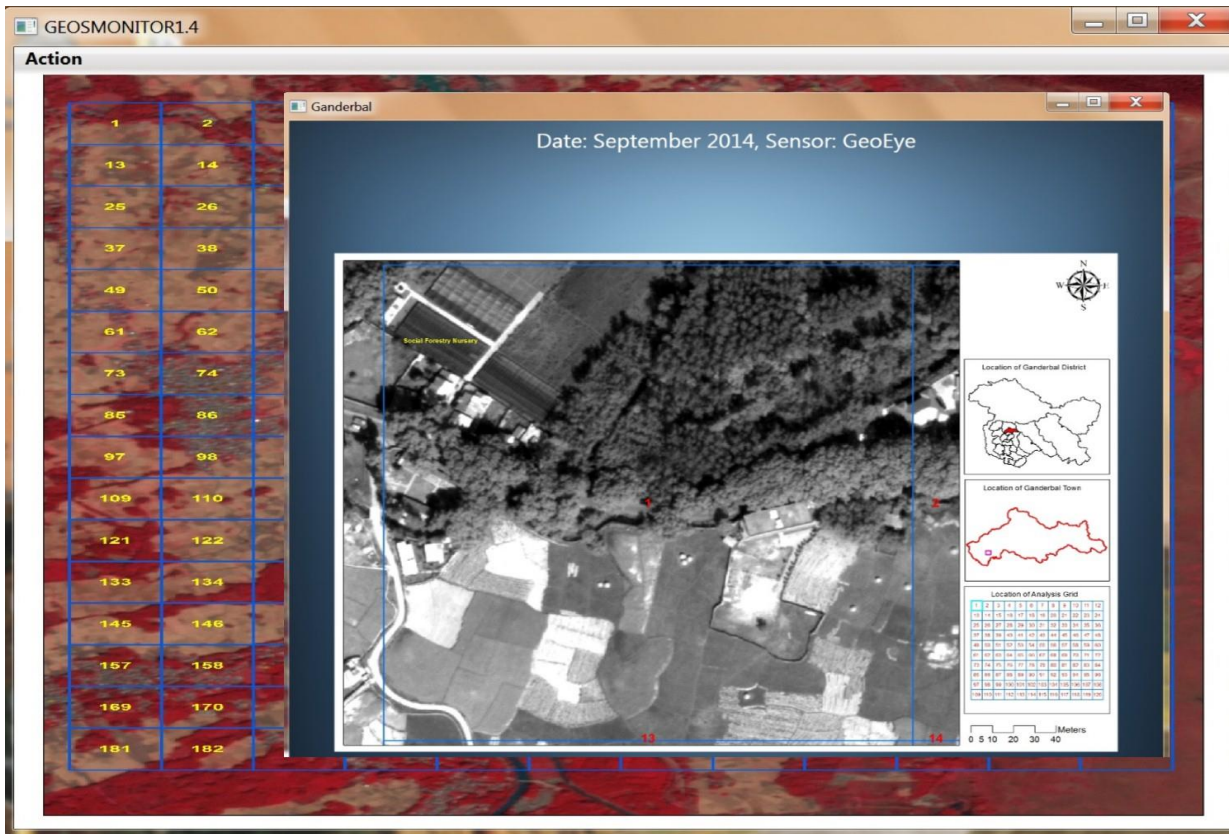

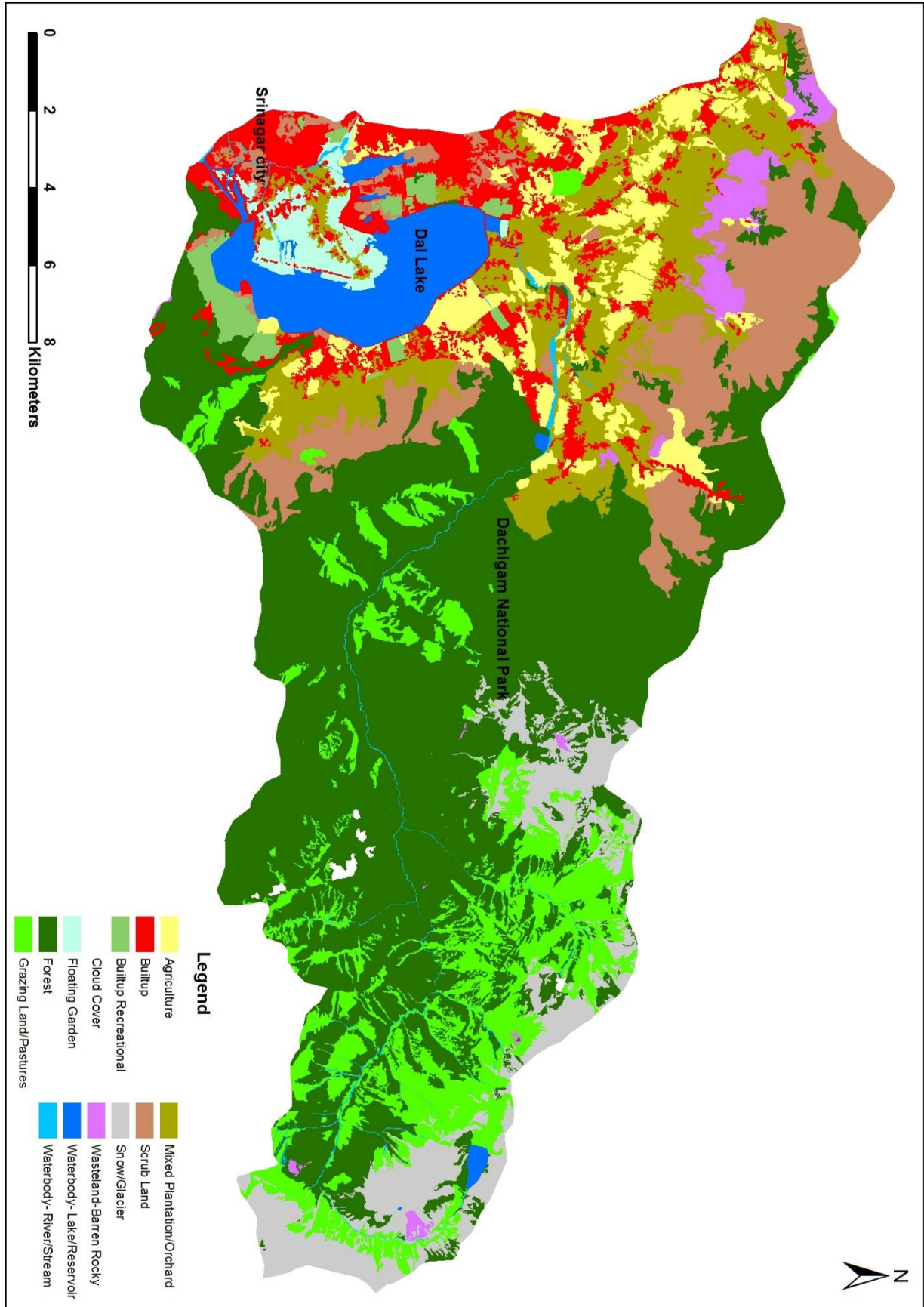**Fig 25: View of Satellite image on selecting a particular grid**

Maps

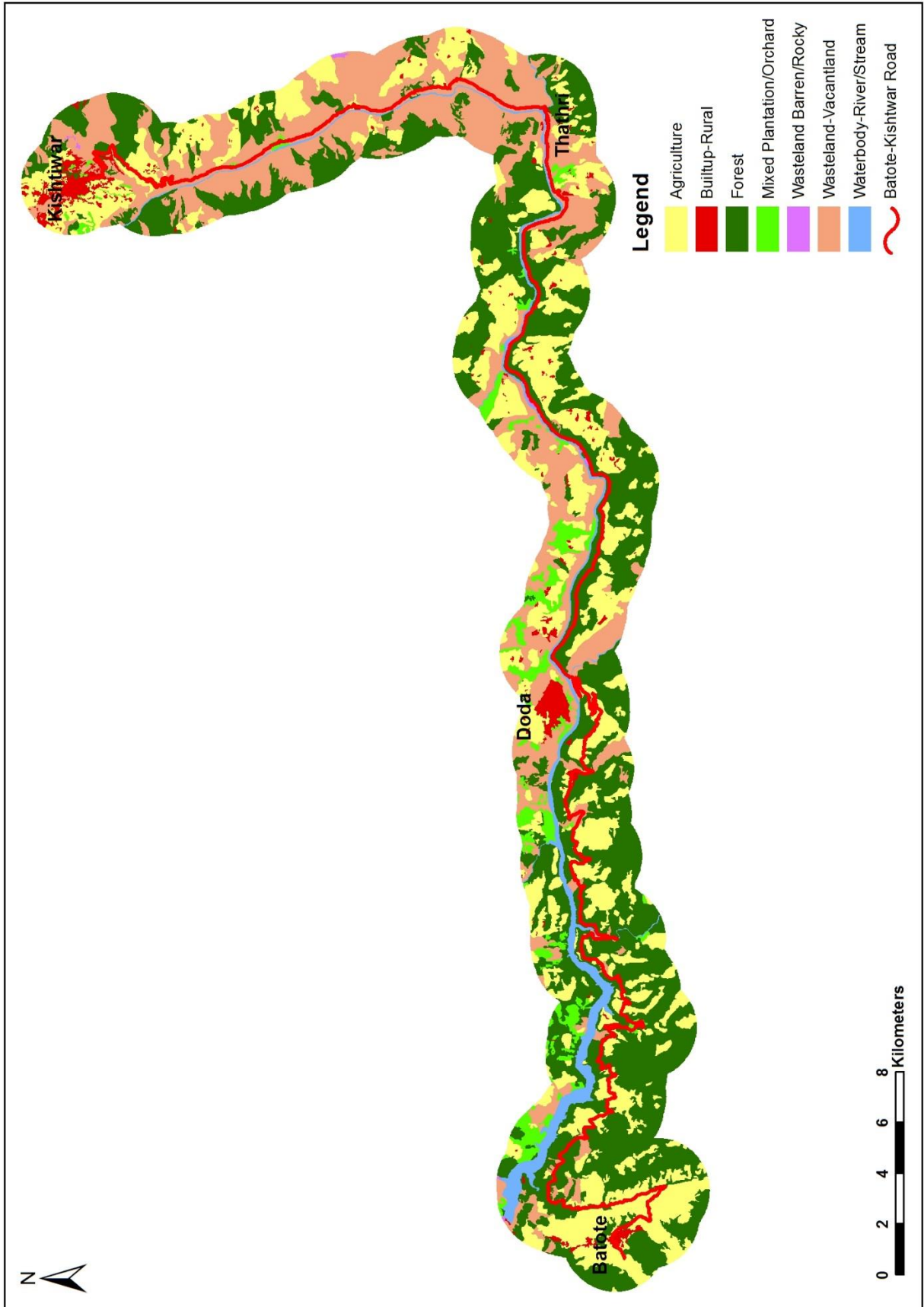**Fig 26: Land use/ land cover of Dal Lake and its Catchment**

Fig. 27: Land use / land cover on either side of Batote-Kishtawar Road

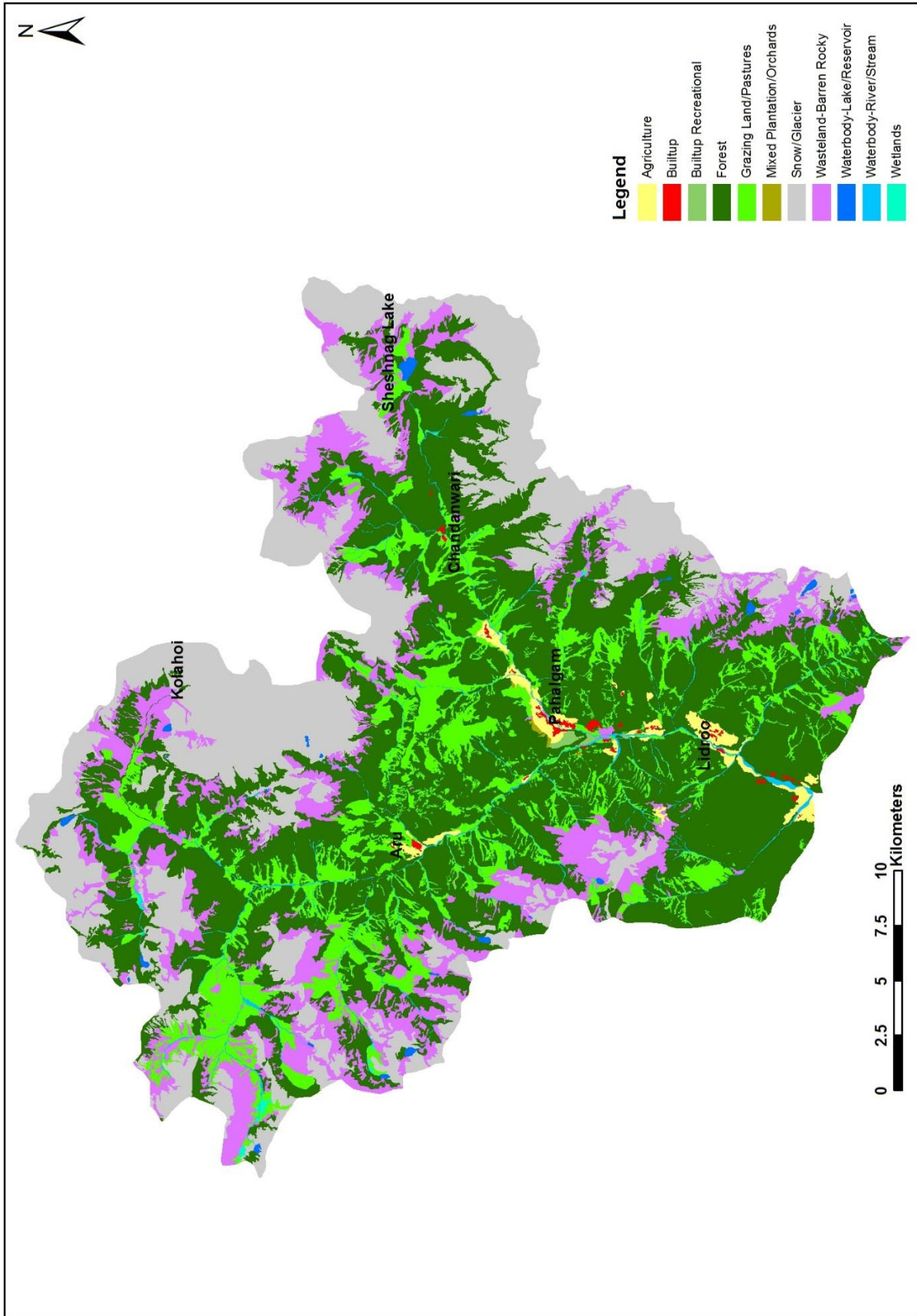**Fig. 28: Land use / land cover on either side of Mughal Road**

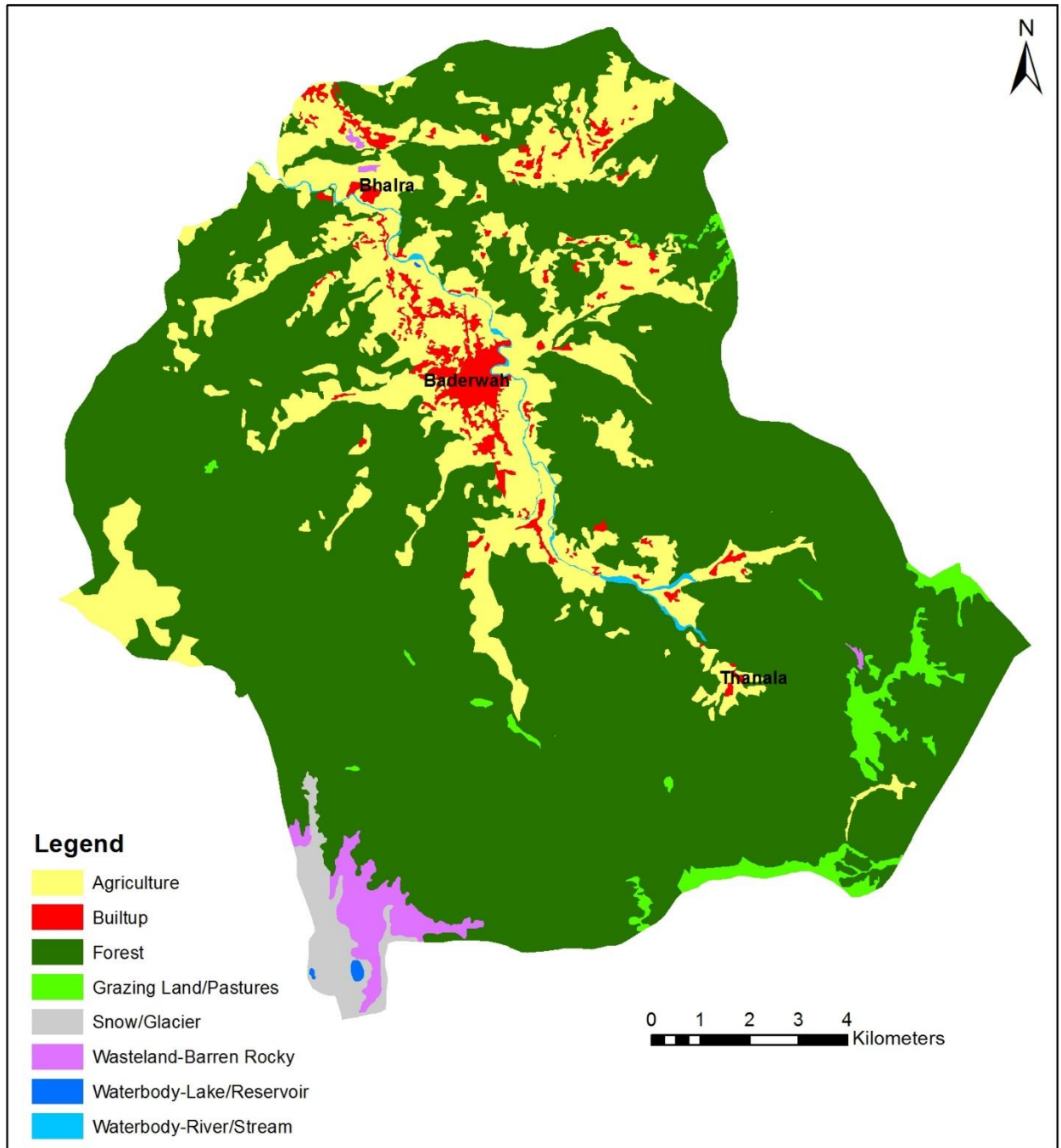**Fig. 29: Land use / land cover map of Pahalgam Catchment**

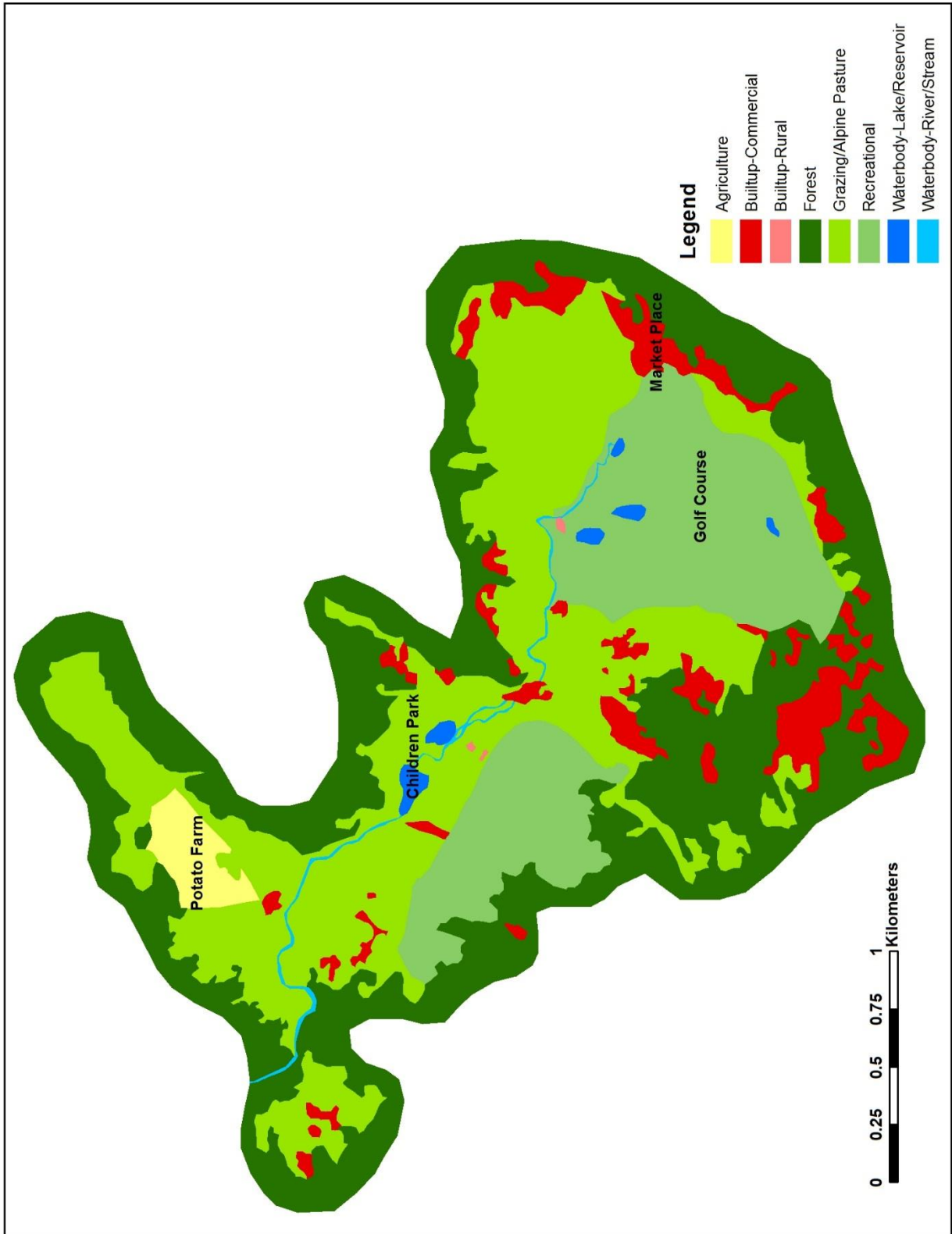**Fig. 30: Land use / land cover map of Neeru Forest Area**

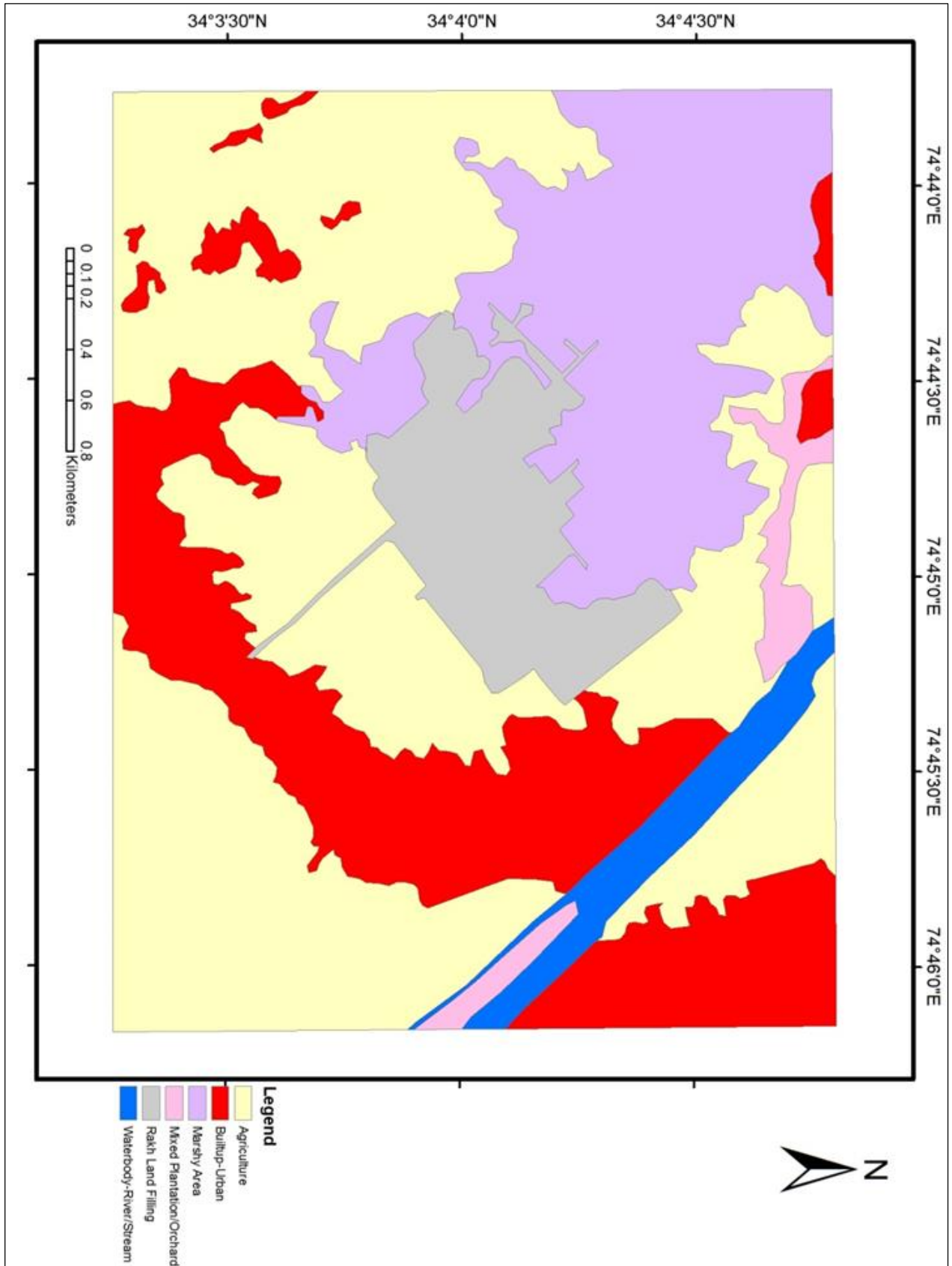**Fig 31: Land use / land cover map of Gulmarg area**

Fig 32: Land use / land cover map of Rakh-i-Arath
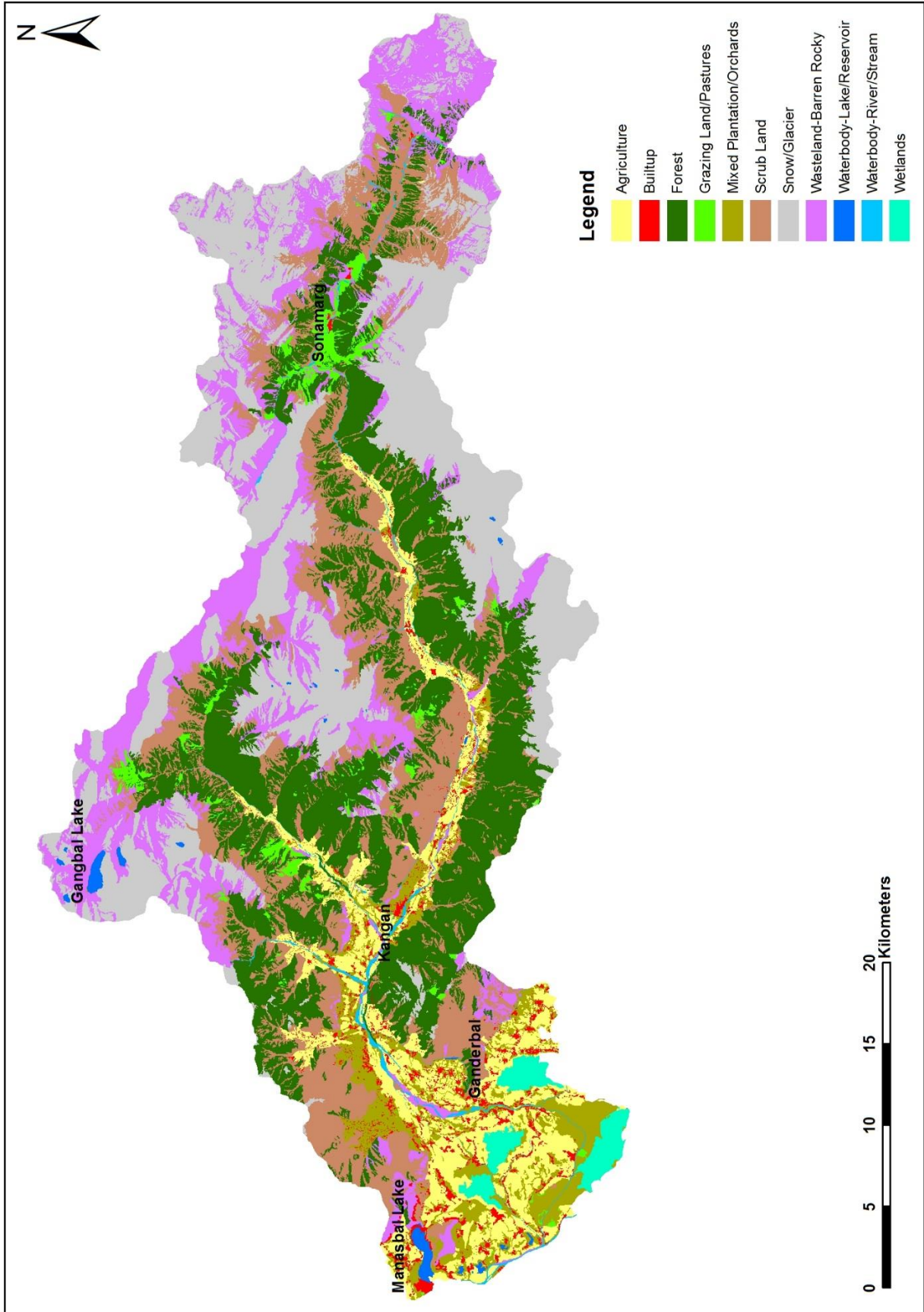
Fig. 33: Land use / land cover map of Ganderbal District

Tables

Table 2: Areal extent of land use/ land cover classes of Dal Lake including catchment area

Land use / Land cover	Area (ha)
Agriculture	1916.62
Built-up	2407.26
Built-up Recreational	428.59
Cloud Cover	55.66
Floating Garden	518.48
Forest	14184.11
Grazing Land/Pastures	3911.24
Mixed Plantation/Orchard	3496.21
Scrub Land	3509.22
Snow/Glacier	2185.63
Wasteland-Barren Rocky	568.13
Waterbody- Lake/Reservoir	1470.62
Waterbody- River/Stream	194.59
Grand Total	**34846.36**

Table 3. Areal extent of land use/ land cover categories within 200m buffer on either side of Batote-Kishtwar road

Land use / Land cover	Area (ha)
Agriculture	8791.22
Built-up-Rural	829.28
Forest	12723.00
Mixed Plantation/Orchard	1180.00
Wasteland Barren/Rocky	33.06
Wasteland-Vacant land	8052.92
Waterbody-River/Stream	1101.41
Grand Total	**32710.89**

Table 4: Areal extent of land use/ land cover categories within 200m buffer on either side of Mughal Road

Land use / Land cover	Area (ha)
Agriculture	1271.90
Built-up	14.90
Forest	8001.45
Grazing Land/Pastures	1040.62
Mixed Plantation/Orchard	18.18
Scrubland	1733.92
Wasteland-Barren/Rocky	775.71
Waterbody-River/Stream	144.90
Grand Total	**13001.57**

Table 5: Area under various land use/ land cover classes in Pahalgam Catchment

Land use / Land cover	Area (ha)
Agriculture	896.13
Builtup	184.22
Builtup Recreational	76.96
Forest	36340.40
Grazing Land/Pastures	10472.17
Mixed Plantation/Orchards	32.18
Snow/Glacier	19696.59
Wasteland-Barren Rocky	10864.03
Waterbody-Lake/Reservoir	260.97
Waterbody-River/Stream	950.12
Wetlands	64.05
Grand Total	**79837.83**

Table 6: Area under various land use/ land cover classes in Neeru forest range

Land use / Land cover	Area (ha)
Agriculture	3882.20
Builtup	502.37
Forest	18044.90
Grazing Land/Pastures	459.76
Snow/Glacier	328.93
Wasteland-Barren Rocky	315.19
Waterbody-Lake/Reservoir	12.39
Waterbody-River/Stream	70.52
Grand Total	**23616.26**

Table 7: Area under various land use/ land cover classes in Gulmarg area

Land use / Land cover	Area (ha)
Agriculture	12.908
Builtup-Commercial	52.949
Builtup-Rural	0.413
Forest	303.091
Grazing/Alpine Pasture	249.283
Recreational	138.389
Waterbody-Lake/Reservoir	4.734
Waterbody-River/Stream	3.969
Grand Total	**765.736**

Table 8: Areal extent of land use/ land cover classes in Rakh-i-Arth at Bemina

Land use / Land cover	Area (ha)
Agriculture	482.03
Builtup-Urban	217.50
Marshy Area	201.09
Mixed Plantation/Orchard	22.38
Rakh Land Filling	91.70
Waterbody-River/Stream	33.15
Grand Total	**1047.84**

Table 9: Area under various land use/ land cover classes in Ganderbal district

Land use / Land cover	Area (ha)
Agriculture	11734.35
Builtup	2551.58
Forest	32803.82
Grazing Land/Pastures	2551.37
Mixed Plantation/Orchards	7190.36
Scrub Land	25282.08
Snow/Glacier	31717.78
Wasteland-Barren Rocky	20057.65
Waterbody-Lake/Reservoir	593.61
Waterbody-River/Stream	975.66
Wetlands	1916.99
Grand Total	**137375.25**

Photographs

Fig.34: Two day capacity building programme organized at IMPA, Srinagar

Fig.35: Training of the representatives of two day workshop at Institute of Management and Public Administration (IMPA), Srinagar for capturing field data using GPS

Fig.36: Officials of line Departments getting trained in the use of GPS

Fig.37: Proceedings of one day workshop organized at Mini-Secretariat Ganderbal

Fig.38: Demonstration and capturing of field data using Android based Mobile Application developed by the Department

Fig.39: Dy. Commissioner, Ganderbal district inaugurating the training programme for the employees of CAPD, Health Services Dept. and Lakes Authority in the use of PointGIS developed by the Department

Fig.40: Batote-Kishtiwar Road blocked due to landslide

Fig.41: Project staff collecting field data

Fig.42: Landslide clearing work on Batote-Kishtiwar road

Fig..43: Demolition works in Gagribal Basin of Dal Lake

Fig.44: Deweeding works going on in Dal Lake

Fig.45: Landslide clearing work in Mughal Road

Fig.46: Highly Landslide prone area in Mughal Road

Fig.47: Camping site at Gulmarg

Fig.48: View of Gulmarg tourist resort from Afarwat

Fig.49:Potato farm Gulmarg

Fig.50: Site for proposed residential colony at Rakh-i-Arath

Fig.51: Construction works in Rakh-i-Arath

Fig.52: Landfilling works going on in Rakh-i-Arath