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Climate Change Impact on Land and Natural Resource in Chamba Tehsil of Himachal Pradesh State, India

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Abstract:
Climate change is one of most important issues facing the world today. Satellite based remote sensing data has providing key improvements to understand the climate changes impact on land and natural resource, by quantitative methods and spatio-temporal statuses of the land. Climatic change factors like temperature, evaporation, solar radiation, air impurities and precipitation are directly (due to changes in atmospheric carbon dioxide / climate) and indirectly (through complex interfaces in ecosystems) affect the land and natural resource. Output of this paper has approaching that climate change is not only an issue of the worldwide, but it is now a local problem in Himachal Pradesh / India. Due to climate change, temperature of the Chamba tehsil from Period-1 (1990-2001) to Period-2 (2002-2013) has increased form 19.28 ^{o}C to 19.79 ^{o}C (+0.52 ^{o}C), while precipitation has reduced from 1037.93 mm to 683.97 mm (- 353.97 mm), as well as agricultural land from 2001 to 2013 has reduce 41.42 Sq. Kms (-4.09%), dense forest has also reduce with 112 Sq. Kms. Soil erosion for the same period has increased approx. 76.50% (24.42 tons/ha/yr.).

***Key words**: Climate Change, Land Use, Natural Resource, Remote Sensing, & GIS*

1. Introduction

Climate change has been recognised as one of the most important challenges affecting the mankind today. It is an extremely broad locality that includes alterations in the physical and chemical climate, the affiliated impacts on agriculture and nourishment security, and feedbacks. The expected impacts of climate change have become a foremost anxiety globally in recent years, whereas perhaps less so in many developing countries, which face a plethora of development challenges that have been advised to have only restricted connections to weather change. This has started to change, with many developing countries, such as the India, evolving more worried about the possible impacts of climate change and the need to address adopting adaptation and mitigation schemes. In a country such as the India, with a mostly country population, considerable reliance on agriculture, and significant forestry assets, the need to consider the likely impacts of climate change on land use has been identified, but so has the difficulty of dividing these impacts from those driven by other factors, such as population development and economic development. This study aspires to recognise potential alterations in climate, crop suitability, land use, and natural resource that may result from climate change, as well as to identify some of the current and future impacts on land use resulting from other drivers.

2. Justification

Land use change and the physical modification of nature is one of the direct drivers of ecosystems change (Millennium Assessment Report, 2005). Demonstrations of land use change with powerful likely impacts on biodiversity, soil degradation and the earth's proficiency to support human desires are deforestation and subsequent transformations of agricultural lands in the tropics (Lambin et al., 2003). Further, land use change is an important component in the climate change cycle, and the relationship between the two is symbiotic where changes in land use affect climate and climatic change influences future land-uses (Berglund, 2003; Jong & Lageras, 2011).

Land use has therefore been utilised in diverse ways to characterize the state of the natural environment and integrated forest management. In other ways, it is advised as a substitute for some wider environmental pressure, such as the conversion of land to cultivation and the implications this might have on erosion or other similar processes. Farther, it has been used as a sign to gauge the effectiveness of a particular principle. Because of these, "land use is examined as one of the core concepts used that can comprise sustainable development issues and to assess advancement in the direction of this significant goal" (Potschin, 2009).

The interest in the study of land use is thus expanding inside and beyond academia. Topics discovered are varied, from the nature of land use and land cover, to their alterations over space and time, and to investigating the social, economic, cultural, political, conclusion, ecological and ecological processes that produce these patterns and alterations (Aspinall, 2006). With the acknowledgement that land use schemes are illustrations of socio-ecological (or connected natural and human) schemes, their study requires the association and integration of natural science and social science approaches (Aspinall & Hill, 2011); and as glimpsed in numerous investigations, such an integration of disciplines puts to good use the data capture, management, modelling, analysis, and visualization capabilities of geographic data systems and remote sensing.

3. Description of the Study Area

The Chamba tehsil is located between North latitude 32°19'22"N and 32°42'36"N and East longitude 75°59'24"E and 76°25'54"E, with an approximated area of 1012.82 Kms^2 and is enclosed on all sides by lofty hill ranges (Fig. 1). The territory is wholly mountainous with average elevation of 1,006 metres. The Chamba town is situated on the banks of the Ravi river (a major tributary of the Trans-Himalayan Indus river), at its confluence with the Sal river, built on successive flat terraces, the town is enclosed topographically by the Dhauladhar and Zanskar ranges, south of the inner Himalayas.

According to Census of India, Chamba tehsil has a population of 159,399 in 2001 and 179,253 in 2011. The tehsil has a population density (2011) of 177 people / Kms^2. Its population growth rate over the decade 2001 - 2011 was only 12.45%. Chamba has a sex ratio of 989 females for every 1000 males, and a literacy rate of 73.19%. The study area falls in Survey of India (1:50,000) toposheets No.: I43W/02, I43W/03, I43W/06, and I43W/07.

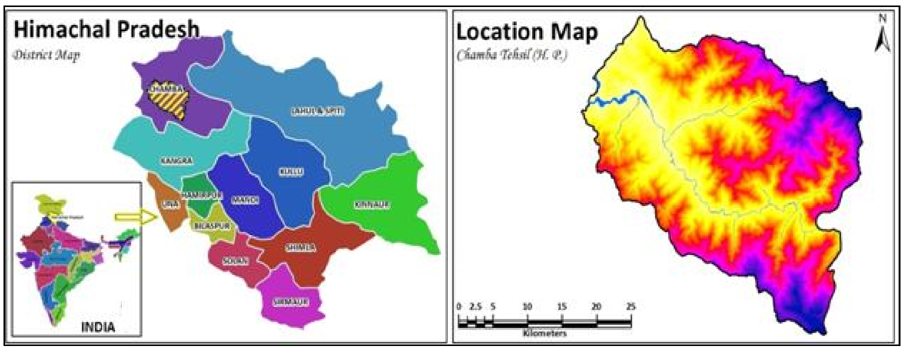

Figure 1: Location Map of the Study Area

4. Data Used and Sources

S. No.	Data Layer / Maps	Source
1.	Topographical Map	• Topographical Map, Survey of India (1:50,000) • I43W/02, I43W/03, I43W/06, and I43W/07
2.	Remote Sensing Data	• IRS ResourceSAT-2 LISS-III satellite imagery with 23.5 m spatial resolution for 2013 • IRS-P6 ResourceSAT-1 LISS-III imagery with 23.5 m spatial resolution for 2001 • LandSAT-5 TM satellite imagery with 30.0 m spatial resolution for 1990
3.	Geological Map	• Chamba District Geological Map will collect from GSI and has been updated through ResourceSAT-2 LISS-III satellite remote sensing data with limited field check
4.	Geomorphological Map	• Landforms & Geomorphological map have been prepared by using satellite remote sensing data with limited field check
5.	Hydrological Map	• Drainage network has been generated in GIS environment using ASTER (DEM) data, CartoSAT-1 (DEM) data and ArcHydro Tool in ESRI ArcGIS-10.2 software
6.	Hydro-Geomorphological & Lineament Map	• These maps have been prepared by using Geological map, DEM, and satellite remote sensing data with limited field check
7.	Land Use / Land Cover Map	• Land use and land cover maps have been prepare by using ResourceSAT-2 LISS-III satellite imagery (2013), ResourceSAT-1 LISS-III satellite imagery (2001), LandSAT-5 TM satellite imagery (1990) and have verify through limited field check
8.	Soil Map	• Soil map of Chamba district has been collected from National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) and updated through satellite data
9.	Climatic Data	• Climatic Data i.e. Rainfall, Temperature, Relative humidity & Wind Speed has been collected from Indian Meteorological Department (IMD) from 1990 to 2013
10.	Demographic Map	• Census of India, 2001, 2011

Table 1: Data Used and Source

5. Methodology

Have been carried out systematic investigation involving interdisciplinary approach to suggest a suitable programmed for climate change impact on land and natural resource in Chamba tehsil of Himachal Pradesh, India. Based on the data created through

ResourceSAT-2 LISS-III, ResourceSAT-1 LISS-III, Landsat-5 TM, CartoSAT-1 DEM, topographical maps, secondary sources thematic maps i.e. geology, geomorphology, soil, ground water, demography, rainfall, and data has been obtained from the field survey, the following methodology has been adopted for the present study.

- Preparation of base map of the study area using SoI toposheets, and satellite imageries.
- The soil map layer has been generated in a GIS environment using soil maps have obtained from National Bureau of Soil Survey and Land Use Planning (NBSS&LUP).
- A general lithological map has been prepared with the help of ResourceSAT-2 LISS-III satellite imagery and Chamba district geological map (Geology Survey of India).
- Climatic Data (1990-2013) i.e. rainfall, temperature, relative humidity & wind speed have been collected from Indian Meteorological Department (IMD). Analysis of meteorological data has been done for preparation of necessary graphs & maps.
- Land use and land cover maps have been prepared by using ResourceSAT-2 LISS-III satellite imagery (2013), ResourceSAT-1 LISS-III satellite imagery (2001), and LANDSAT-5 TM satellite imagery (1990) and have verified through limited field check.
- NDVI analysis has been done by using ResourceSAT-2 (2013) & ResourceSAT-1 LISS-III Satellite Imagery (2001), LANDSAT-5 TM satellite imagery (1900) and Spatial Analyst tool in ArcGIS-10.2 software through the basic equation of NDVI calculation: {NDVI=(NIR-R)/(NIR+R)}.
- Forest legal status and vegetation type maps have been prepared by using ResourceSAT-2 LISS-III satellite imagery (2013), ResourceSAT-1 LISS-III satellite imagery (2001).
- Preparation of geomorphological map and study of landforms features of the Chamba tehsil using geological map, DEM, and remote sensing data. Hydro-geomorphological and lineament maps have been prepared and interpreted using remote sensing techniques.
- Soil erosion modelling has been done by using Universal Soil Loss Equation (USLE) model with required thematic GIS layers.

6. Result and Discussion

6.1. Climate

The climate of the study area can be classified as Warm Sub humid (to humid with inclusion of per humid). It is characterized by semi-tropical to semi-arctic as climatic region. There are two seasons one from December to March associated with the passage of western disturbances and the other mid-June to mid-September due to south-west monsoon. The south-west monsoon is a predominant feature is this region; the average annual rainfall (24 years mean) is 860.95 mm (Table 2). Snowfall is also conventional in the higher reaches. The average temperatures in summer season ranging from 38 °C to 15 °C and in winter 15 °C to 0 °C. Meteorological Plot (rainfall and temperature) of Chamba station is shown in Fig. 2.

	Monthly Average Temperature (^{o}C)				Monthly Average Rainfall (mm)		
Period	**1990-2001(P-1)**	**2002-2013(P-2)**	**Increased**		**1990-2001(P-1)**	**2002-2013(P-2)**	**Difference**
Jan	8.23	8.72	+ 0.49		122.33	33.20	- 89.13
Feb	11.30	11.35	+ 0.05		118.20	61.63	- 56.57
Mar	15.28	16.07	+ 0.80		77.50	70.77	- 6.73
Apr	21.10	21.84	+ 0.75		40.50	17.00	- 23.50
May	25.14	26.28	+ 1.14		43.90	41.03	- 2.87
Jun	27.76	27.89	+ 0.13		74.47	52.33	- 22.13
Jul	26.69	27.44	+ 0.75		226.40	128.00	- 98.40
Aug	25.97	26.18	+ 0.21		182.80	146.07	- 36.73
Sep	24.63	24.80	+ 0.18		74.60	88.07	+ 13.47
Oct	20.28	21.09	+ 0.81		46.90	2.80	- 44.10
Nov	14.70	15.34	+ 0.64		14.90	23.67	+ 8.77
Dec	10.26	10.52	+ 0.26		15.43	19.40	+ 3.97
Mean	19.28	19.79	+ 0.52	Annual	1,037.93	683.97	- 353.97

Table 2: Meteorological Data of Chamba Station
Source: Indian Meteorological Department (IMD)

6.2. *Climate Change Scenarios*

Some of the most important responsible factors for climate change are continental drift, volcanoes, ocean currents, the earth's tilt, comets & meteorites, large-scale use of fossil fuels for industrial activities, urbanization, land use / land cover change, natural resources extensively used for construction, industries, transport, and consumption. According to the Intergovernmental Panel on Climate Change (IPCC) 2007, climate change can be defined as an identifiable change in the state of the climate by change in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer.

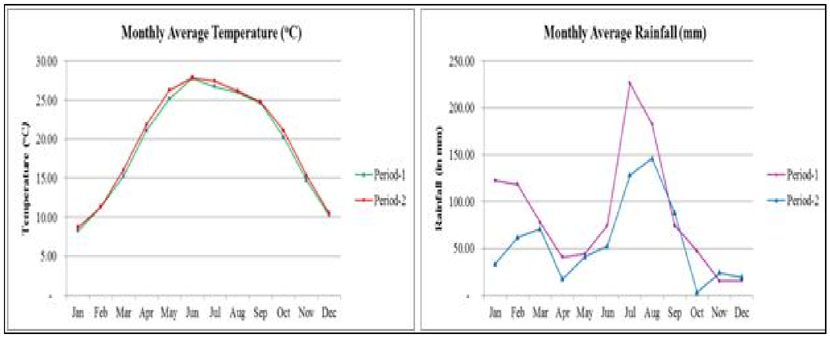

Figure 2: Meteorological Plot of Chamba Station

Trends from 1990 to 2013 have been observed in precipitation / temperature and have seen a decrease in precipitation and increase of temperature in the Chamba tehsil, have also seen contours increased of temperature from January to December, un-usual rain, and decrease in number of days of rain throughout the year. Month wise data of the temperature (Table 2) shows that the temperature of the Chamba tehsil has increased form 19.28 ^{o}C to 19.79 ^{o}C (increased +0.52 ^{o}C). Precipitation of the study area from Period-1 (1990-2001) to Period-2 (2002-2013) has reduced from 1037.93 mm to 683.97 mm (decreased - 353.97 mm).

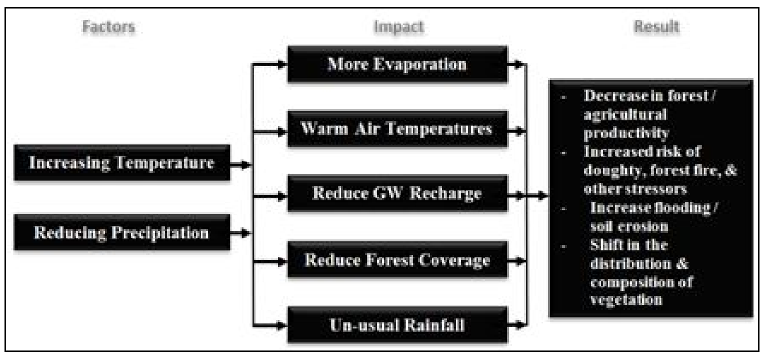

Figure 3: Climate Change Impact on Natural Resources

6.3. General Geology
A general geological map has been prepared by using geological map collected from GSI, and multi-spectral satellite imageries i.e. ResourceSAT, LandSAT to understand the geological aspect of the study area (Fig. 4). Several geologists have contributed to study the geological aspects of the study area, these are Gilbert (1877), Davis (1902), Tomlinson (1925), De Terra (1939), Krishnan et al. (1940), Wadia et al. (1964), Babu (1972), Woodroffe (1980), Bukbank (1983), and Boison et al. (1985) etc. They have recorded the primary rock formations namely (i) Jutogh - Vaikrita Group, Chamba Formation - Chail; (ii) Chail - Dalhousie - Kullu Bnudal Granite; (iii) Tipcal - Manzir - Blaini Formation; (iv) Kalhel Limestone; (v) Basic Metavolcanics; (vi) Pukhri Slates; (vii) Mandi - Dula, Waniloran Volcanic; and (viii) Kuling - Salloni Formation.

6.4. Hydrology
Hydrological analysis is important for climate change impact on land and natural resource studies. Basically hydrology is depends on the climatic factors, landforms, slopes and stage of geomorphic cycle, lithology and its permeability etc. in an area. Drainage textures and patterns depend, among others, on the lithological character of underlying rocks and their structural disposition. A hydrological map of the study area has been prepared by using ResourceSAT satellite imageries, DEM, and SoI topographical maps. Hydrological map has also been classified in stream order system according to the Strahler (1952) and present in Fig. 4.

6.5. Hydro-Geology
The study area is stimulated by hard rock formation with the age range from Lower Palaeozoic to Triassic. Joint, fractures, cracks, fault, eroded surface, and geological structure features i.e. schistose hydroplanes are grosses place for ground water movements. Ground water has also drive in terrace deposits along the major rivers-tributaries, pore spaces between sand-gravel, and tallus material. Due to steep rising hills with intervening dissected valleys together with the consolidated nature and disposition of rock disposition of rock formation leads to conclusion that no ground water reservoir of any appreciable magnitude with in the hill region exists (CGWB; 2008). Whatever quantity of water this mountainous terrain receives through rainfall and snow.

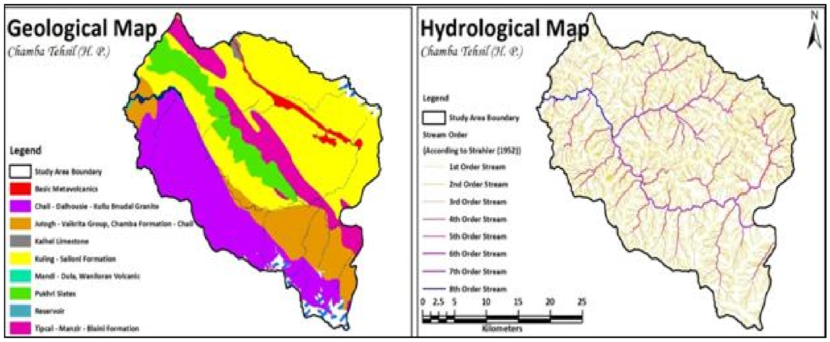

Figure 4: Geological and Hydrological Map

6.6. Geomorphology

Mapping through multi-spectral satellite imagery for geomorphological studies has established direct association with geology, soils, vegetation / land use, physiography, & hydrology. Landform and lineament mapping from satellite imagery/DEM have easily done as of its synoptic capability. Geomorphological and lineament map has been prepared by using multi-spectral satellite imageries, DEM, and with the help of geological map (structural and lithological) (Fig. 5). The study is presents a multifaceted mosaic of mountain ranges, hills and valleys. Physiographically the area forms part of middle Himalayas with high peaks ranging in height from 725 m to 4751 m amsl. The topography of the area is rugged with high mountains and deep dissected by river Ravi and its tributaries. The major geomorphic unit and its description are shown in Table 3.

Map Symbol	Geomorphic Units	Description / Characteristics
VF	Valley Fills	Low relief ranging from 728m to 842m. A level or gently sloping tract or a slightly undulating land surface produced by deposition of alluvium.
SH (MS)	Structural Hill (Meta Sedimentary)	Very high relief ranging from 1901m to 3062m, steep sided hills, steeply sloping (30 to 50 %), severe erosion to moderate erosion, thin soil covered erosional surface developed over meta-sedimentary rocks, composed mainly canglomarate, quartzite, limestone, dimictite shale, slate, sandstone, limestone under Blaini formation.
RH (S)	Residual Hills (Stale)	High relief ranging from 772m to 3052m, steeply sloping (30 to 50 %), high erosion to very high erosion, glowing drained, coarse-silty particle, Generally barren and rocky, partly buried by debris, composed mainly Pukhri slates.
DNH (Q)	Denudational Hills (Quartzite)	High relief ranging from 728m to 4751m, very steeply sloping (more than 50 %), severe erosion and strong stoniness, well drained, covered with dense natural vegetation, composed mainly limestone, shale, and quartzite under Kuling - Salloni formation.
DNH (V)	Denudational Hills (Volcanic)	Very high relief ranging from 1347m to 3923m, steep sided hills, composed mainly of basic volcanic rocks.
SH (G)	Structural Hill (Granite)	High relief ranging from 725m to 4559m, very steeply sloping (more than 50 %) showing definite trend lines, Covered with natural vegetation, composed mainly bnudal granite.
SH (Q)	Structural Hill (Quartzite)	High relief ranging from 734m to 4266m, steep sloping, excessively drained to well drained, covered with natural vegetation, composed mainly Shale, phyllite, quartzite, sandstone, gneiss, and carbonaceous shale subordinate quartzite under Chamba formation.

Table 3: List of Geomorphic Units with Characteristics

6.7. Hydro-Geomorphology

A combined analysis of landforms (geomorphology), rocks as well as structures (geology) such as faults, folds, fractures etc. in relation to groundwater occurrence aspects with the help of remote sensing of ground truth is considered very useful in preparing integrated hydro-geomorphological maps for targeting groundwater. Hydro-geomorphological maps of the Chamba tehsil was prepared using ResourceSAT, LandSAT satellite imageries, ASTER / CartoSAT - DEMs, geological map, hydrological map, hydro-geological map, lineaments map, and geomorphological map (Fig. 5). Groundwater prospects and other characteristics of the hydro-geomorphic units of the study area are summarized in Table 4. As the study area is fall under high relief, there has superlative option for ground water development. The area is full of continuing springs. They vary significantly in their discharges. By and large these springs are used for domestic, livestock and irrigation purpose.

Map Symbol	Geomorphic Units	Rock Type	Structure	Ground Water Occurrence
VF	Valley Fills	Constitutes boulders, cobbles, pebbles, gravels, sand, silt, and clay	-	Good to excellent depending upon type of lithology and thickness of the material deposited
SH (MS)	Structural Hill (Meta Sedimentary)	Conglomerate, Quartzite, Limestone, Dimictite Shale, Slate, Sandstone, Limestone	Associated with folding, faulting etc.	Poor, moderate to good along linear inner hill valleys
RH (S)	Residual Hills (Stale)	Slates	Folding	Poor
DNH (Q)	Denudational Hills (Quartzite)	Limestone, Shale, and Quartzite	Jointed and fractured	Poor to Very Poor
DNH (V)	Denudational Hills (Volcanic)	Basic Volcanic Rocks	Jointed and fractured	Moderate, good along lineaments weathered zone and depressions
SH (G)	Structural Hill (Granite)	Granite	Faulting, Jointed and Fractured	Very Poor
SH (Q)	Structural Hill (Quartzite)	Shale, phyllite, quartzite, sandstone, gneiss, quartzite	Faulting, Jointed and Fractured	Very Poor

Table 4: Important Potential Hydro-Geomorphological Units

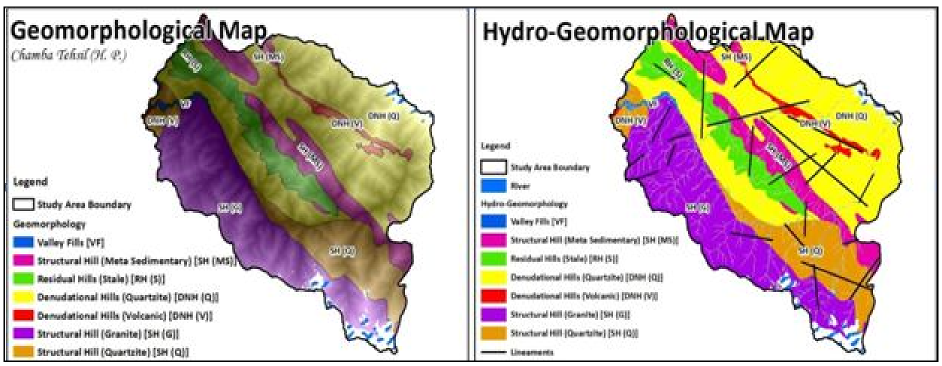

Figure 5: Geomorphological and Hydro-Geomorphological Map

6.8. Land Use / Land Cover

Land use/cover change is one of the most sensitive factors that show the interactions between human activities and the ecological environment. The LULC pattern of any region is an outcome of various physic-cultural factors and their utilization by man in time and space. Hence, it is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to be able to simulate changes (Prakasam 2010). Multi-temporal, multi-spatial, and multi-spectral satellite imageries i.e. IRS-P6 ResourceSAT-1 LISS-III and IRS ResourceSAT-2 LISS-III for year 2001, and 2013 (Fig. 6) have been used for land use and land cover mapping (Fig. 7).

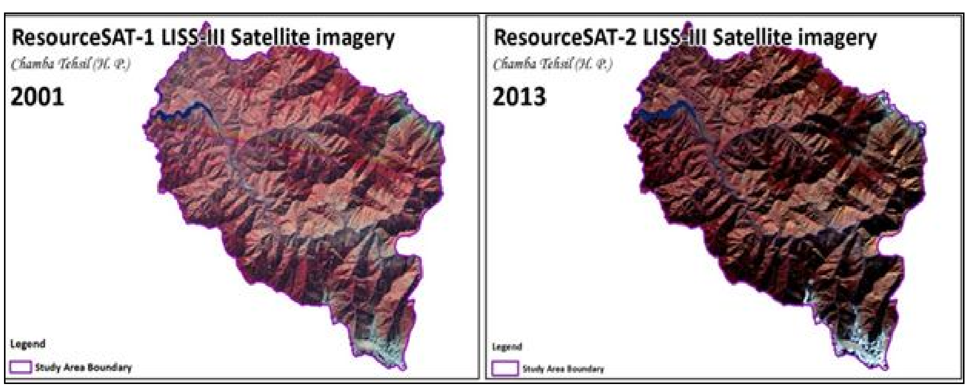

Figure 6: IRS ResourceSAT-1, and ResourceSAT-2 (LISS-III) Satellite Imageries

Image classification toolbar (iso-cluster unsupervised classification) in ArcGIS-10.2 software has used for classification with the minimum class size 4x4 pixel. Afterward classes have corrected according to actual ground condition with recoding method and selected field survey. In year 2001, LULC of the study area comprise mostly of very dense reserved forest approx. 33% and agricultural land approx. 26%, while in 2013 the area comprise mostly in very dense reserved forest approx. 27%, open protected forest approx. 19%, and agricultural land approx. 22%.

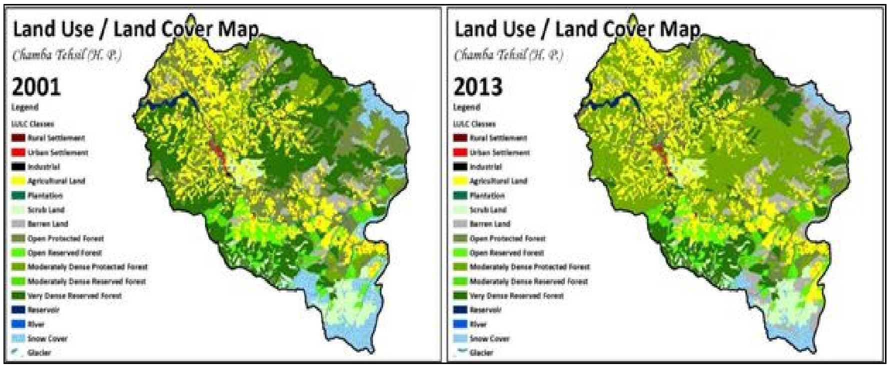

Figure 7: Land Use / Land Cover Map for Year 2001 and 2013

6.9. Land Use / Land Cover Change Analysis

Digital LULC classification approach is used in the study to detect the changes between two dates. In this approach images belonging to different dates are classified and categorised individually. Later, the classification results are compared directly and the area of changes is extracted (Singh, 1989; Jensen, 1996; Yuan et al., 1999). To find out the change categories, image analyst extension of ArcGIS-10.2 software was used. Images of two years were input and as a result the output image contained the change categories. The summery of land use land cover change pattern analysis of Chamba tehsil is shown in Table 5.

Table 5 compares the area under different classes in year 2001 and 2013. The highest amount of change is from very dense reserved forest to open protected forest (+10.11%) resulting in degradation of 102.4 Sq. Kms forest land. Other categories showing negative growth are plantation (-0.19%), open reserved forest (-0.74%), moderate dense protected forest (-2.31%), moderate dense reserved forest (-1.89%), very dense reserved forest (-585%), river (-0.23%), snow cover (-2.35%), and glacier (-0.35), while some of the other LULC categories showing positive growth, these are settlement, industrial area, barren/scrub land, open forest, and reservoir. Overall, the increased land use from the land cover has had a reason of climate change. Other significant changes in the land surface resulting from human activities include sub-tropical deforestation which changes evapotranspiration rates, desertification, which increases surface albedo, and the general effects of agriculture on soil moisture characteristics.

S.N.	Land Use / Land Cover Classes	Area (2001)		Area (2013)		Change	
		Sq. Kms	%	*Sq. Kms*	%	*Sq. Kms*	%
1	Rural Settlement	7.86	0.78	11.46	1.13	3.60	0.36
2	Urban Settlement	0.85	0.08	1.73	0.17	0.88	0.09
3	Industrial	0.03	0.003	0.39	0.04	0.36	0.04
4	Agricultural Land	259.15	25.59	217.73	21.50	-41.42	-4.09
5	Barren Land	45.72	4.51	93.37	9.22	47.65	4.70
6	Scrub Land	23.41	2.31	45.70	4.51	22.29	2.20
7	Plantation	6.58	0.65	4.70	0.46	-1.88	-0.19
8	Open Protected Forest	87.37	8.63	189.77	18.74	102.40	10.11
9	Open Reserved Forest	41.23	4.07	33.74	3.33	-7.49	-0.74
10	Moderate Dense Protected Forest	100.54	9.93	77.18	7.62	-23.36	-2.31
11	Moderate Dense Reserved Forest	38.78	3.83	19.64	1.94	-19.14	-1.89
12	Very Dense Reserved Forest	331.97	32.78	272.70	26.92	-59.27	-5.85
13	Reservoir	1.22	0.12	6.26	0.62	5.04	0.50
14	River	9.89	0.98	7.53	0.74	-2.36	-0.23
15	Snow Cover	54.65	5.40	30.89	3.05	-23.76	-2.35
16	Glacier	3.57	0.35	0.03	0.003	-3.54	0.35
	Total	1,012.82	100.00	1,012.82	100.00		

Table 5: Land Use / Land Cover Classification for Year 2001 & 2013

6.10. Vegetation

Vegetation cover is one of the most important biophysical indicators for climate change. Remote sensing based vegetation indices are widely employed for monitoring and mapping the condition of vegetation cover of a region. Vegetation indices allow for the delineation of the distribution of vegetation and soil based on the characteristic reflectance patterns of green vegetation. NDVI is one of the most widely used and efficient methods of vegetation indices, which measures the amount of green vegetation manifested in a given area. NDVI can also provide a good means to verify trends of ground observed vegetation activity. NDVI not only highlights the vegetated areas in the image but also gives an idea regarding as to how healthy the plants are. An important fact of the obtained values is that for a given NDVI image the resulting NDVI pixel value always ranges from -1 (no vegetation) to +1 (well-appointed vegetation) (Lillesand et al., 2004: Jasinski, 1990; Sader and Winne, 1992).

In order to assess the vegetation health of the study area, NDVI analysis is carried out using IRS ResourceSAT LISS-III satellite imageries for year 2001 and 2013. According to the results obtained from the NDVI analysis indicates that, the values are ranging between +0.31 to -0.83 (Fig. 8). The combination of climate and land-use change has had perceptive effects on human capacities. The geographic understanding of land use change near the settlements as well industrial areas in the area is a key aspect of this study. The temporal analysis of the spatial patterns, rates of change, and trends, has provided very insightful information on the current development activities under varying social, economic, and environmental conditions have been transforming each of the study area. The study revealed that the land use and land cover phenomena in the study area is currently experiencing a moderate transformation due to intensive anthropogenic activities for various development activities.

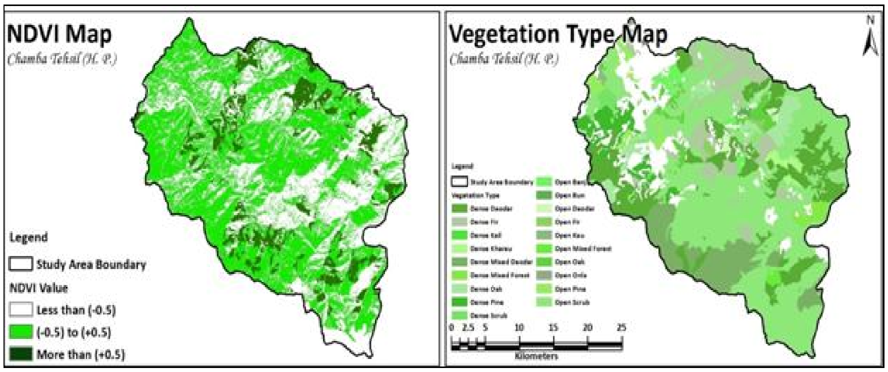

Figure 8: NDVI and Vegetation Type Map

6.11. Forest

Climate change impact on forest land use, especially in terms of change from forest land to other land cover, has been one of the most important issues in the LULC dynamics (Mayaux, Bartholome, Fritz, et al. 2004; Butler 2005; Brink and Eva 2009). Considering changes in forest cover, it is important to make projections on the potential forest cover in the present and future climate scenarios, to account for the magnitude and direction of change (Goparaju, Tripathi, and Jha 2005; Giriraj, Murthy, Beierkuhnlein, et al. 2008; Giriraj, Babar and Reddy 2008; Sharma, Lahkar, Ghosh, et al. 2008; Pareta 2012). Forest legal status and forest type map has been prepared by using ResourceSAT-2 LISS-III satellite imagery (2013), ResourceSAT-1 LISS-III satellite imagery (2001), Survey of India Topographical map at 1:50,000 Scale. Forest legal status map has been categorised in 5 classes i.e. open protected forest, open reserved forest, moderate dense protected forest, moderate dense reserved forest, & very dense reserved forest, and shown in Fig. 9. Only open protected forest has been increased approx. 10.11 (102.40 Sq. Kms) from very dense reserved forest. During the field survey as well as analysis of data, have notices that reserved forest / moderate & dense forest have been reduce due to climate change.

6.12. Soil Texture Mapping and Analysis

The soil map has been collected from National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) and was update through IRS ResourceSAT-2 LISS-III satellite imagery by using ArcGIS-10.2 software. The soil map obtained from the NBSS&LUP was geo-metrically registered to the base data to match with satellite imagery. The geo-referenced soil map was used to assist in visual classification of satellite imagery for obtaining soil categories. The final soil map was prepared and ready to spatial analysis (Fig. 10). The major soil textures of the study area are (i) Mesic, coarse-loamy soils; loamy-skeletal soils; (ii) Mesic, loamy soils; coarse-loamy soils; (iii) mesic, loamy-skeletal soils; fine-loamy soils; (iv) Rock outcrops (rocky cliffs); coarse-loamy soils; (v) Rock outcrops covered with glaciers, sandy-skeletal soils; (vi) Rock outcrops, loamy-skeletal soils; (vii) Rock outcrops, mesic, loamy-skeletal soils; (viii) thermic, coarse-loamy soils; fine-loamy soils, (ix) Thermic, loamy over sandy soils; coarse-loamy soils; (x) Thermic, loamy soils; coarse-loamy soils; (xi) Thermic, loamy soils; fine-loamy soils, and (xii) Thermic, sandy-skeletal soils; rock outcrops.

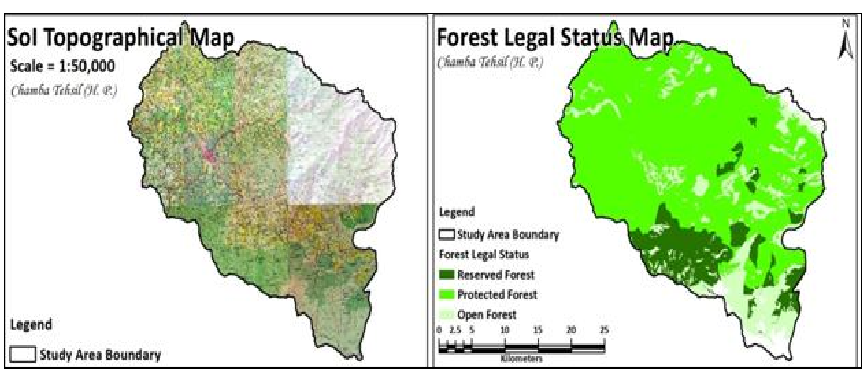

Figure 9: SoI Toposheet Map and Forest Legal Status Map

6.13.Annual Soil Loss due to Climate Change

Soil erosion and sedimentation by water involves the processes of detachment, transportation, and deposition of sediment by raindrop impact and flowing water (Foster and Meyer, 1977; Wischmeier and Smith, 1978; Julien, 1998). Soil loss is defined as the amount of soil lost in a specified time period over an area of land which has experienced net soil loss. The Universal Soil Loss Equation (USLE) was developed by Wischmeier and Smith (1978) to estimate the average annual soil loss occurring over an area. The USLE model has been used to predict annual soil loss with the equation as summarized by Wischmeier and Smith (1978), which is A= R*K*LS*C*P, where: A = Estimated average annual soil loss, R = Rain erosivity factor, K = Soil erodibility factor, L = Slope length factor, S = Slope steepness factor, C = Cover management factor, P = Support practice factor.

Annual soil loss due to climate change has been calculated by using above said model in ArcGIS-10.2 software with Spatial Analyst Tool - Map Algebra - Raster Calculator. Author has used two period data sets i.e. 2001 & 2013 for analysis. The annual soil loss in year 2001 is 31.92 tons/ha/yr and in year 2013 is 56.34 tons/ha/yr (Fig. 10). As compare to year 2001, annual soil loss has increased 24.42 tons/ha/yr in year 2013, approx. 76.50% due to climate change.

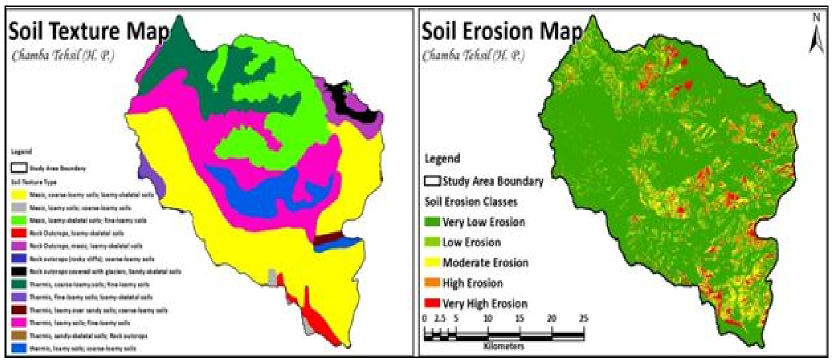

Figure 10: Soil Texture, and Soil Erosion Map

7. Conclusion

Increase in temperatures (+0.52 oC), increased evaporation, increased air temperatures and decrease in annual rainfall (- 353.97 mm) in the Chamba tehsil has affecting agriculture, forestry, biodiversity, social communities, and the reserved forest especially in the Bhandarbani, Lanot, Rambho, Bhuar, Padhri, Sana, Kulwara, Guaur, Kundi, Gauri, Khirkil, Almi, Supeka, Taili, Banjal, and Dagera reserved forest; forest cover has dry up or disappear which has affect other natural areas i.e. dense forest has change in open sparse forest, scrub land approx. 10.11 (102.40 Sq. Kms), putting pressure on native species, increased tree stress may affect growth and productivity of forests, loss of biodiversity to invasive alien species, has also change water system causing flooding and droughts. Local tree species will be less suited to local conditions as the climate changes and may migrate more slowly than climatic conditions, leading to changes to tree species distribution which have seen in the field. Extreme weather events including flash floods due to snow melt (glacier / snow cover area had reduce 2.7% in 2013 from 2001) and drought due to un-usual rainfall link with a decreased in the rainfall regime and an increase in water demand impressive pressure on water resource. Due to climate change, has increased the conflict between water users and less capacity to generate hydroelectric power at peak use times.

Population increase (approx. 20,000 person has increased in a decade) leading to uncontrolled land use patterns (agricultural land has reduce approx. 42 Sq. Kms {4.09%} in 2013 from 2001) which affect soil fertility, agriculture, and enhance desertification. Poor land use practices resulting in soil erosion (soil erosion has increased approx. 76.50% from 2001 to 2013) and loss of habitat due to partly to demographic explosion and competing for natural resources. Increase in extreme events, such as flash floods and droughts threatening food has resulting Land degradation, exacerbated by climate change and increase in population, placing more pressure on natural resources. Decreases in snow-cover / glacier and changes to freeze-up and break-up times have affected the land use and natural resource. This has also increased vulnerability of riverine settlements, flooding, landslides, soil erosion, and soil infertility. Degradation of land quality (contamination of soil, groundwater and surface waters, loss of soil fertility) due to industrialisation, urbanisation and unsustainable farming practices.

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