A Village Level Climate Change Vulnerability Analysis and Indicative Adaptation Plan Framework

Bees River Basin

District Kullu

Himachal Pradesh

Department of Environment, Science & Technology
Government of Himachal Pradesh

Department of Science & Technology
Ministry of Science & Technology
Government of India
NMSHE

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Addl. Chief Secretary (Env.,S&T) to the Government of Himachal Pradesh

Manisha Nanda, IAS

MESSAGE

In today's global scenario, climate change is inescapable reality which is both a challenge and opportunity for the sustainable development which poses significant threat in Himalayan region which is vulnerable due to its fragile ecology and stress due to disastrous prone topography.

The impact of the warming world has impacted every facet of social and economic progress. Developing countries' vulnerability is higher and critical due to variation in various society and eco-system. Our Himalayan region being fragile and precarious require multi-pronged and comprehensive scientific approach to tackle this.

During the last three decades most weather stations in Himachal Pradesh have reported increasing trend of temperature and as a result the rainfall as well as snowfall are becoming erratic. The snowfall days particularly in Shimla are showing the decreasing trend. The glaciers in Himalayan regions are direct indicator of climate change. The rate of retreat of glaciers especially in two Basins have been fast since 1962 and the area in snow cover has also changed between October and June.

Earlier occurrence of spring seasonal events and later occurrence of autumn seasonal events in plants and animals; lengthening of breeding seasons; northwards and uphill movement of many plant and animal species, but the migration rate of many species is insufficient to keep pace with the speed of climate change; establishment of warm-adapted alien plant species; many habitats of our hill species are potentially threatened by climate change over their natural range in Himalayas.

We need to prepare comprehensively to tackle the impacts of climate change. An exercise carried out by the Department of Environment, Science and Technology (DEST) during year 2011 has highlighted the vulnerability of the state due to climate change at block level. This further insisted upon for making actions on the ground to analyse and adopt more scientific, empirical approach with micro watershed level assessments.

The Vulnerability Assessment is a first step in a scientific, systematic process of preparing for the adaptation planning and accordingly implementation of the actions. I am very happy to learn that A Village Level Climate Change Vulnerability Analysis and Indicative Adaptation Plan Framework Beas River Basin – District Kullu Himachal Pradesh has been prepared.

This report is presented as a part of Beas River basin and will guide the field level functionary through a simplified understanding of climate risks, vulnerability to climate change and actions to cope with the impact of climate change by connecting adaptation, mitigation and sustainable development, regional climate change strategies, climate change adaptation and disaster risk reduction, climate financing, sustainability. It includes an analysis of observed and projected climate change over Kullu region at *Panchayat* level, and the socio-economic impacts of extreme weather events in Beas Basin. I am sure that this will facilitate the planning process in forestry, terrestrial ecosystems and biodiversity, water resources sectors, settlements, human health, energy.

I am proud to be part of **"Team Environment"** headed by our **Illustrious Chief Minister** who has been practically associated with rural agrarian economy and the speed with which as a **policy maker** need to **adopt and adapt** the required steps to achieve the balanced sustainable development.

I sincerely acknowledge and complement the members of the DEST for their efforts in preparing this report.

(Manisha Nanda)

Director-cum-Special
Secretary (Env.,S&T)
Himachal Pradesh

D.C. Rana, HAS

FOREWORD

The severity of climate change impacts is observable and devastating at the local level, especially among the poor and ethnic people settled in the marginal and ecologically fragile areas, because of their least adaptive capacities and resilience. Thus, it is crucial to understand the local climatic risks, vulnerabilities and adaptive capacities to develop appropriate coping and adaptation strategies. However, the reliable climate data and information are not available at local level because of few meteorological stations. It is very difficult to assess and analyze the climate vulnerabilities and impacts, needs and priorities of the communities at micro level.

Himalayan region is quite vulnerable regions to climate change amongst all regions. Located in Indian Himalayan Region, State of Himachal Pradesh is in particular very sensitive to climate change and its environment health, is important to maintain water cycles and various ecosystem services for more than 200 million people down the line. But due to the impacts of climate change on this mountain landscape, these services are under tremendous threat. A comprehensive State Strategy and Action Plan on Climate Change have been prepared for Himachal Pradesh.

Climate Change Vulnerability is generally explained by the characteristics and contexts of the system or community that are susceptible to the risks and hazards based on the socio-economic, physical and environmental conditions. It has been widely discussed, debated and negotiated in the national, regional and international levels, but few concrete and realistic actions are taking place at the ground to respond to the negative consequences faced by the communities.

Micro watershed approach is useful in assessing various impacts and develop mitigation plans effectively. There are five river basins in the State contributing to Indus & Ganges river basins. These five river basins are *Beas, Satluj, Yamuna, Ravi & Chenab*. Small Watershed to river basin scale using Hydrological modelling to simulate the quality & quantity of surface and ground water, to predict the environmental impact of land use management practices & climate change could be effective tool in asserting the impact and develop the adaptation plans at local level.

I am really pleased to say that an attempt has been made to analyse the climate change vulnerability at very micro level- at village level as represented by this report, and I am hopeful that it shall herald a beginning in micro level planning. We hope that this vulnerability assessment through hydrological modelling process would lead to institutionalization of climate change adaptation planning process in Himachal Pradesh at micro level – *Panchayat* level and would meet the challenges of future climate impacts effectively.

(D. C. Rana)

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Introduction

1. Introduction

Located in North India, Himachal Pradesh (HP) is a small mountainous state bordering Punjab, Haryana, Uttarakhand, and Jammu and Kashmir. With a geographical area of 55,673 sq. kms. and population of 6.6 million, HP accounts for 1.6 percent of the national geographical area and about 0.6 percent of India's population. It is one of India's leading states in terms of human development, and, in recent years, HP has achieved higher growth rates than the rest of the country – powered by rapid expansion of the secondary and tertiary sectors. HP is a unique state because of the success it has achieved over the past three decades, despite severe structural disadvantages of relative remoteness, environmental fragility, and a difficult hill terrain which raises the costs of service delivery – all characteristic of Himalayan states in India. At the same time, the state is rich in natural resources with abundant water, minerals, forests, biodiversity, and fertile soils, and judicious and sustainable exploitation of these resources could present opportunities for further development.

1. 1 Project Details

There are five river basins in the State contributing to Indus & Ganges river basins. These five river basins are Beas, Satluj, Yamuna, Ravi & Chenab. The major activity under this knowledge cell is to map and analyse small watershed of river basin scale using Hydrological modelling to simulate the quality & quantity of surface and ground water, to predict the environmental impact of land use management practices & climate change. The climate change vulnerability assessment using Micro watershed approach is useful in assessing soil erosion prevention and control in regional management of watershed. Based upon the assessment of climate change vulnerability the micro watershed based climate change adaptation plan framework at village/panchayat level is to be formulated and developed which will be further useful for formulating all developmental plans at regional level.

This activity is an accomplishment of the objective of undertaking climate change vulnerability analysis of all the river basins of the State of Himachal Pradesh. The major tasks to be undertaken through the present assignment as follows:

Activity 1 Micro Watershed, Hydrological modelling based vulnerability analysis of the Beas river basin

Activity 2 Preparation of District wise indicative Adaptation Plan Framework.

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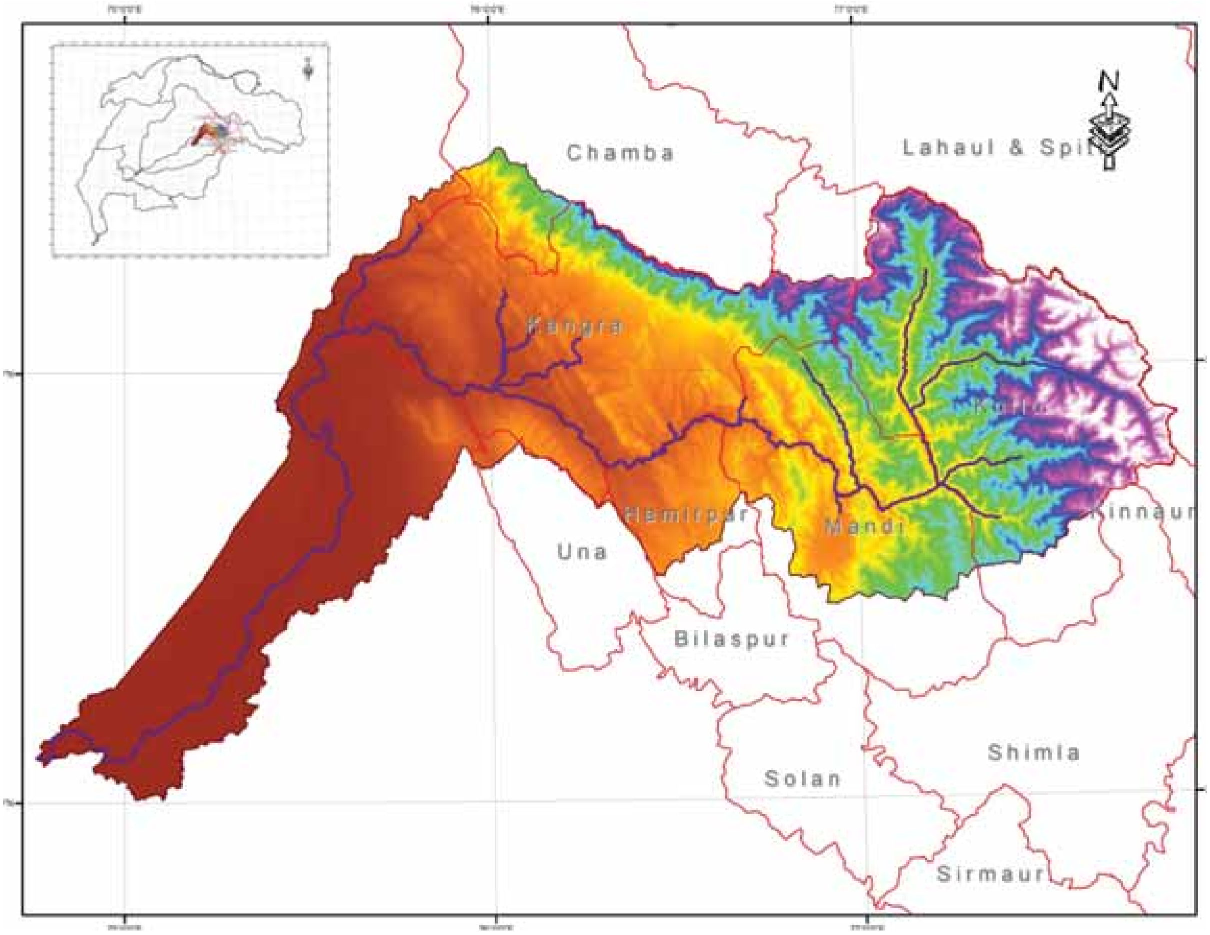
Beas River Basin: District Kullu

2. Beas River Basin: District Kullu

2.1 Beas River Basin - Profile

The Beas River is one of the five major rivers of Himachal Himalayas, flowing for approximately 470 km before joining the Sutlej River. Soils in the catchment are young and relatively thin, with their thickness increasing in the valleys and areas with gentle slopes (Pandey, 2002).

The major land cover classes include forest, snow and bare rock, with about 65% of the area covered with snow during winter (Singh and Bengtsson, 2003). The Beas catchment is under the influence of western disturbances that bring snowfall to the upper sub-catchment during winter (December-April), whilst the monsoon provides around 70% of the annual rainfall during June - September.



Map 2.1 Beas River Basin

The catchment is characterised by moderate – low temperatures with mean minimum and mean maximum winter temperatures of -1.6°C and 7.7°C, respectively (Singh and Ganju, 2008).

The river rises 4,361 metres (14,308 ft.) above sea-level on the southern face of Rohtang Pass in Kullu at Beas Kund. It traverses through Mandi, Hamirpur Districts and enters the Kangra District at Sandhol, 590 metres (1,940 ft) above sea-level.

During its lower course the River Beas is crossed by numerous ferries, many of which consist of inflated skins (darais). Near Reh in Kangra District it divides into three channels, which reunite after passing Mirthal, 300 metres (980 ft) above sea-level. On meeting the Shivalik Hills in Hoshiarpur, the river sweeps sharply northward, forming the boundary with Kangra District.

Then bending round the base of the Shivalik Hills, it takes the southerly direction, separating the districts of Gurdaspur and Hoshiapur. After touching the Jalandhar district for a short distance, the river forms the boundary between Amritsar and Kapurthala.

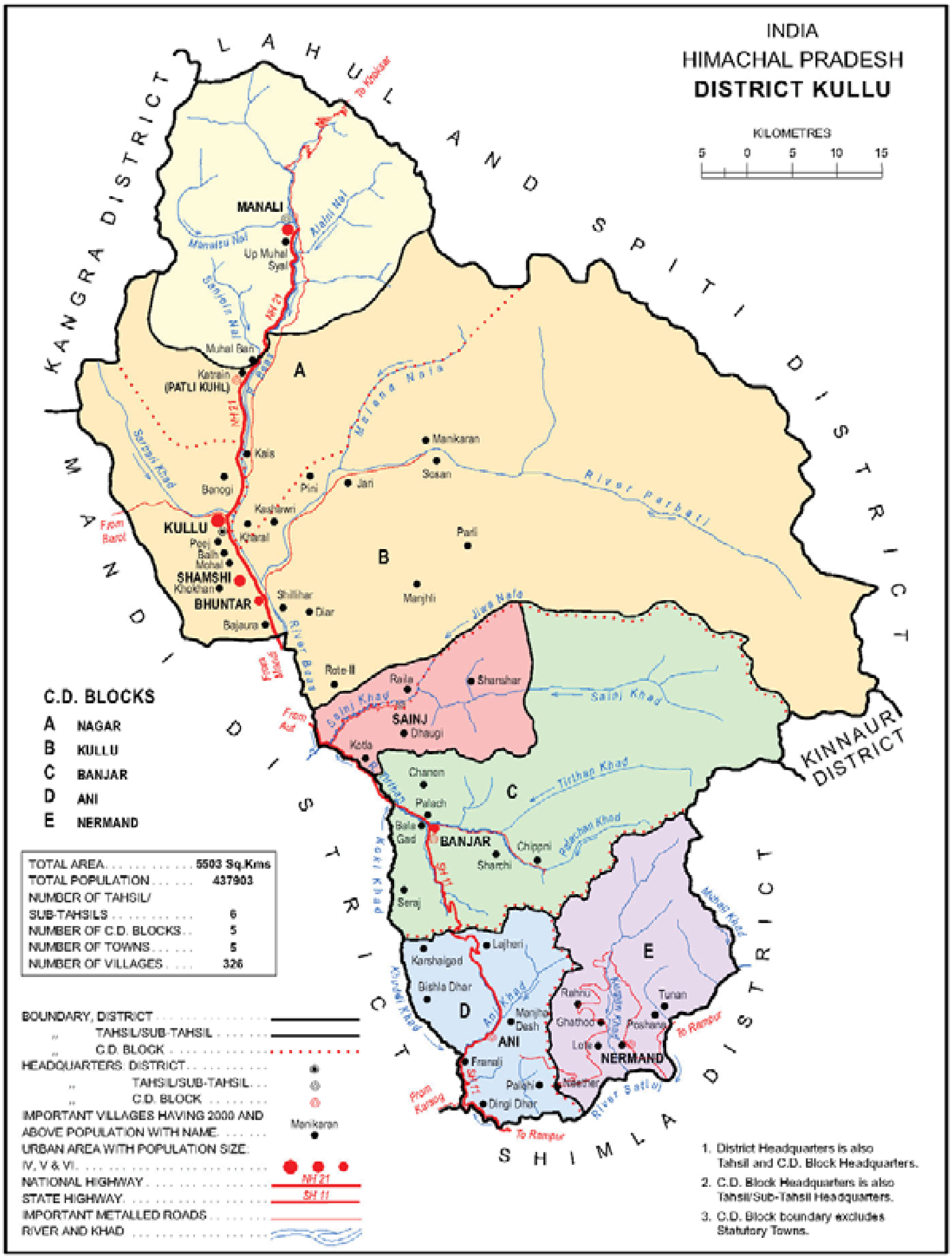
Finally the River Beas joins the river Sutlej at the south-western boundary of Kapurthala district of Punjab after a total course of 470 kilometres (290 miles). The chief tributaries are Bain, Banganga, Luni and Uhal. The Sutlej continues into Pakistani Punjab and joins the Chenab River at Uch near Bahawalpur to form the Panjnad River; the latter in turn joins the Indus River at Mithankot.

The total catchment area of the Beas River Basin is about 20,303 km^2. However, the catchment area, upstream of the Pong reservoir, is around 12,560 km^2. The catchment areas of the river covers 4 districts i.e. Kullu, Mandi, Hamirpur & Kangra.

The climate change vulnerability assessment study will cover district Kullu out of four districts:

2.2 Kullu District: At a Glance

Total Area	**5503 Sq. Kms.**
Altitude (height from MSL in mts)	1500 to 4800
Total Assembly Constituency	4- Kullu, Banjar, Anni, Manali
Climate	Alpine, Cold temperate and Warm Temperature
Major River	River Beas
Population (2011 census)	4,37,424 Persons
Administrative Units	4 Sub Divisions, 4 Tehsils, 2 Sub-Tehsils, 5 Blocks 5 Towns , 300 Villages
Literacy (2011 Census)	3,10,487 Persons (Male 1,76,548; Female 1,33,935; Others 4)
Panchayati Raj	204 Panchayats 71 Backward Panchayats
Agriculture **Ago-Climatic Zones** **Agricultural Land** **Net Shown Area** **Irrigated Area**	 Mid- Hill, High Hill 65,186 Hectares 36,342 Hectares 2,878 Hectares
Forest **Total Forest area** **Total Forest Cover**	 4,952 Sq. Kms. 1,958 Sq. Kms.
Industries **Large & Medium Scale Units** **Small Scale Units**	 2 Units 1,962 Units



Name of Development Block.		Number of Panchayats
1.	Kullu	70
2.	Ani	32
3.	Banjar	36
4.	Nirmand	26
5.	Naggar	40
	Total Panchayats:	**204**

2.3 Socio-economic and Physical Aspect of Kullu District

Kullu was probably the most ancient state next to Kashmir and Kangra. The Chinese pilgrim, Hiuen Tsiang (AD 629-645) described the country of Kiu-lu-to (Kullu) situated at 117 miles to the north-east of Jalandhar which exactly corresponds with the position of Kulata. According to known history, it was founded in the first century of Christian era by one Behangamani Pal whose forefatheres origianlly came from Tripura and had migrated from there Allahabad and then to Mayapuri near Hardwar. Many legends are associated with the name of Behangamani Pal. It appears that the people of the higher valley of Kullu at that time were suffering under the repressive regime of the Thakurs of Spiti and a keen desire to overthrow the Thakurs was smoldering in their hearts. Behangamani Pal organised what may be rightly called the upper valley first revolution sparked off at Jagatsukh. A renowned astrologer of village Paljhot is believed to have helped him allot and his endeavors duly blessed by the powerful Goddess Hadimba, were crowned with success. This goddess is up to now is respected as the 'grandmother and the patron-deity' by the Rajas of Kullu. Pal dynasty was thus established. It's original capital was established at Jagatsukh and nearly ten generations ruled from there, till it was shifted to Naggar which remained as the seat of the Government for many as 1400 years till it was finally mover to Kullu.

Their rule continued till about 1,450 when reference is available of Raja Kelas Pal. After this, there was long break of about 50 years. It appears the Thakurs and the Ranas might have captured power during this period, forcing the Pal Rajas to flee from the valley. It was again in the fifteenth century that the name of the Sidh Singh appears as the Raja of Kullu. There is almost identical legend about Sidh Singh as marked the name of Behangamani Pal. He too rallied the people against the Thakurs and established the old Pal dynasty, duly pleased by the goddess Hadimba.

Reference may be made to Raja Jagat Singh (1637-1672) who conquered the fort the Madankot which belonged to Jihna Rana, above Manali and also the of Baragarh opposit to Naggar, where Rana Bhosal held his sway. It was during his regime that the famous idol of Raghunathji was brought from Ayudhya and installed at the temple of Raghunathji at Sultanpur (Kullu). This of course a historic turn of events, in-as-much as the Rajas who had till then Shaiv and Shktik, adopted Vaishnava Dharma. Not only this, the Raja gave away the whole kingdom to Raghunathji by placing the image on the 'gaddi' (throne) and himself became the vice-regent of Raghunathji. Since hten, the Rajas of Kullu ruled the state in the name of Raghunathji.

Kullu remained a tehsil of district Kangra for a long time after independence. It was made full fledged district in 1963 with its headquarter at Kullu. From the administrative point of view, the entire district has been divided into six tehsils/sub tehsils viz. Kullu, Sainj, Banjar, Nirmand, Ani and Manali and five Community Development Blocks viz. Kullu, Naggar, Banjar, Ani and Nirmand.

2.4 Administrative Setup

The Kullu district comprises four tehsils namely Kullu, Manali, Banjar and Nirmand with two sub-tehsils at Ani and Sainj. Naggar, Kullu, Banjar, Ani and Nirmand are five development blocks of Kullu. There are total 300 revenue villages in Kullu district out of which 186 villages are under Naggar Block, 28 villages are under Kullu Block, 43 villages are under Banjar Block, 17 Villages are under Anni Block and 26 villages are under Nirmand Block. Kullu Manali, Bhuntar, Shamshi and Banjar are the major towns.

2.5 Geographical Profile & Location

Kullu district is located in the northern part of Himachal Pradesh. Between 31.58 degree north latitude and 77.64 degree east longitude. On the north and north east, it is bounded by Lahaul Spiti and Kangra district. On the east and south east by Kinnaur and Shimla districts and in the south by Mandi district. The total geographical area of the district is 5503 Sq. Kms. and its population as per the census of 2011 is 4,37,474 persons.

The district of Kullu forms a transitional zone between the Lesser and Greater Himalayas and presents a typical rugged mountainous terrain. The district has high mountains, rivers, rivulets and valleys. Kullu district has an average elevation of 1,278 m or 4,193 ft). It lies on the bank of Beas River. A major tributary, Sarvari, leads to the less explored and steeper Lug-valley on the west. Beyond the ridge lies Manikaran valley, along the Parvati river which joins Beas at sangam in Bhuntar. On the South of Kullu lie the town of Bhuntar, Out (leading to Anni, Banjar and Siraj Valley) and Mandi (in Mandi district). Historically Kullu was accessible from Shimla via Siraj valley or through passes on the west leading to Jogindernagar and onto Kangra. To the north lies the famous town of Manali, which through the Rohtang pass leads onto the Lahaul and Spiti Valley. Once can see an enormous change in the climate as one climbs up the windward side of the ranges to proceed to the leeward and much drier plateaus to the north of Manali.

2.6 Geology

The rock types found in the district are phyllite, slate, quartzite lime stone, schists and granites and have been classified on the basis of their physical characters and mode and period of formation. These are named either on rock types or after local names where these were first studied. These groups are central gneiss, Kullu formation, Banjar formation and tourmaline granites. Central gneiss presumably the oldest rocks made over 1,500 million years old and comprised various types of gnessic rocks within layers of quartizite, granites and pegmatites. The largi formation contains thick layers of grey dolomite and pink limestone besides slate phyllite and quartizite. The tourmaline granites are inferred to occur as intrusive and are the probable source of high radio activity in the area where many hot water springs have occurred in this area. On the basis of physiography, climate, soil cover, geology and natural vegetation, the district has been divided into 5 sub-micro regions which are given as below:

Kullu Valley: The valley mainly spreads on the both banks of Beas river and also on the lower parts of its major tributaries like Parvati and Tirthan rivers. It covers maximum parts of Manali, Kullu tahsils and Sainj sub-tahsil and a small part of Banjar tahsil. This region is surrounded by Kullu forests from almost all corners. Mandi district forms its south-western limit. This valley is mainly formed by Beas river and is narrow in the north and becomes more wider in Kullu and in the central and southern parts of Manali tahsils whereas the parts of this valley falling in Sainj sub-tahsil and Banjar tahsil are undulating. This region in the district is comparatively plain and fertile and the elevation varies from 1,089 metres and 2,980 metres above the mean sea level. Slope rises gradually as one moves away from the river banks and these slopes are densely covered with apple orchards. Most of the area of this region falls below 2,000 metres. The Beas rises in the Pir Panjal range near Rohtang pass and it enters the region near Rohla from the north. This river flows through central part of the region and flows towards southern direction upto Aut. The Tirthan river, after meeting with the Koki and Sainj khads join the Beas river from south and then the combined course flows towards west. Major tributary of the Beas river in this region is the Parvati river which also receives the water of Malana Nalla and Tos Nalla and joins then Beas on its left Bank near Bhuntar town. Other minor tributaries are Manalsu, Solang, Phojal, Debar, Sanjoin, Siriv Nalls and Sarwari Khad on the right side and Chaki, Pakhnoj, Duhangan, Aliaini and Hurla Nalls on the left side. The climate of this valley is warm during summers and cool during winters. Upper areas of this valley receives snow fall during the month of December and January. Snow clad peaks look very beautiful. The geology of this region is mainly composed of middle proterozoic formations. The northern fringe of this region contains Granites(unclassified), while south-eastern part has sholi – Deoban and Largi groups and Rampur- Banjar formations. Soil of this region are mainly covered with orthents – ochrepts (58) while in the northern extreme, it contains Udalfs (20) type of soil. Higher slopes of this region are covered with mixed vegetation mainly of Deodars. This valley in the state, with its natural charm and grandeur is famous for the scenic beauty beyond expression.

Kullu Greater Himalaya: This region comprises the crest of greater Himalaya which passes through north and eastern Kullu district. It covers eastern parts of Kullu and Manali tahsils,north-eastern tip of Sainj Sub-tahsil and northern, eastern and south-eastern parts of Banjar tahsil. This region is surrounded by Lahul & Spiti district from north to east, by Shimla district and Satluj basin from south and by Kullu forests from west. Its south-eastern boundary is formed by Kinnaur district. This region is very rugged and mountainous and also has many Dhars. Some of the important Dhars are Ali Ratni Dhar (5,269 metres), Ghodil Dhar (4,220 metres), Sirkhand Dhar (5,159 metres) and Dharing Dhar (4,183 metres). Elevation in this region varies between 4,012 metres and 6,632 metres above the mean sea level. Pin Parvati Pass (5,319 metres) is an important physical feature in this region and is situated on the boundary line between Kullu and Lahul & Spiti districts in the east. The region contains many glaciers viz. Dudhon glacier, Parvati glacier, Tichu glacier, Sara Umga glacier and Dibi ka glacier on the north and north-eastern parts. Parvati river which originates from the Parvati glacier, is the major tributary of the Beas river in this region. Another tributary Tirthan river also takes birth in the region from Sirkhand Dhar. The climate of this region is severe and dry. The main geological structure of this region is Granites (unclassified), Haimanta group and Jutogh group and central gneiss. The region is covered by udalfs (20), orthents-ochrepts(58) and glaciers and snow cap (103) types of soils. The region has no vegetation cover. This region covers a huge unmeasured and uninhabited area due to its rugged terrain and unfavourable climatic conditions.

Pir Panjal: This region is situated in the extreme northern and north western parts of the district and occupying only a small part of Manali tahsil. It makes its boundary with Kangra district in the west, Lahul & spiti district in the north and east and Kullu forests in the south while Kullu Greater Himalaya touches it from the south-east direction. The region is characterized with high snow covered mountains, glaciers and passes. The altitude of this region varies between 3,685 metres and 5,932 metres above the mean sea level. Maximum height of 5,932 metres in this region is attained by Hanuman Tibba which is situated on the boundary line between Kullu and Kangra districts in the west. Rohtang pass(3,978 metres) is situated in the northern part, is one of the major Physical feature of this region besides other passes viz., Thanod,Taintu Ka Jot (4,996 metres) and Hamta Jot(4,268 metres). This region contains many Dhars. Some of these are Beas Kunder Dhar, Shiti Dhar,Kara Dhar,Rohan Dhar and Satbehui Dhar. Western part of this region is comparatively higher in elevation than eastern part. Beas River which is the main river of Kullu district, originates in the Pir Panjal range from Beas Rishi spring near Rohtang pass and flows towards south. The geological structure of this region is mainly formed by granites (unclassified) formations and it has Udalfs (20) type of soil cover which is high base status of humid regions. The region is without vegetation cover. This region covers very small unmeasured area of the district and is un-inhabited due to its tough and rugged terrain and climatic conditions. The only motorable road is border road which connects this region as well as district with Lahul & Spiti district. Rohtang pass in this region is a place of tourist interest as the crest of this pass affords a wide spread panorama of mountain scenery.

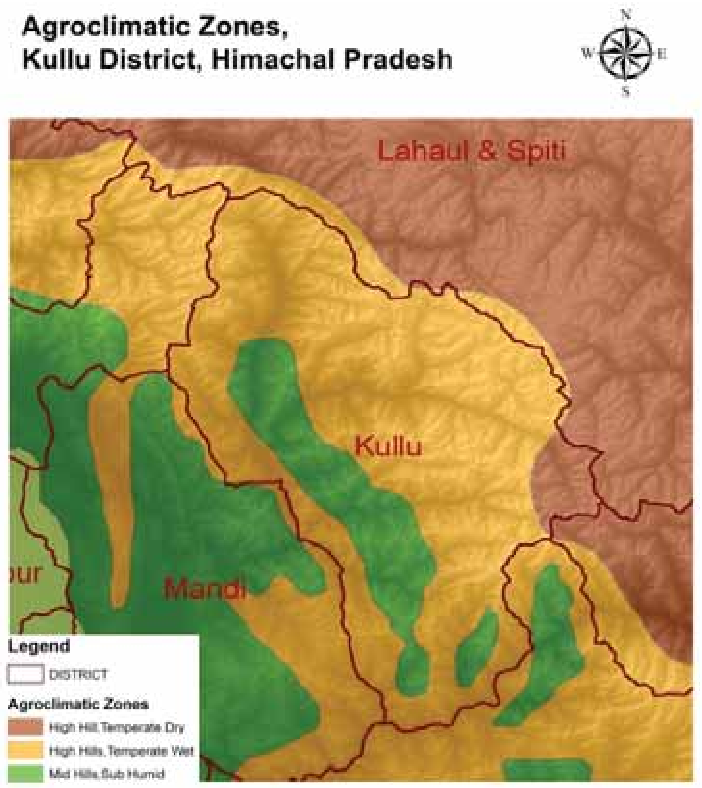
2.7 Minerals

The district does not possess minerals of commercial significance and reserve of a few minerals is found in the parts of district but their mining is not economically viable. The following minerals are found in the district which is used locally:

Minerals	Description
Beryl	White and blueish coloured crystals of beryl are found in Saraouga valley and north-east of Dando Dee Thack in the Parvati valley. Beryl is the source of beryllium and its transparent green variety emerald is a precious gem stone.
Building Stone	The area abounds in variety such as quartizite and granite. A Number of slate quarries producing roofing slate for local use which are located in the rocks of the central gneiss Kullu and Banjar formations.
Kyanite	It is a silicate of aluminium and is used for refractory bricks. The mineral occurs at a number of places in Parvati valley. It is found in the form of blue blades and associated with central genesis formations.
Copper	Occurrence of copper ore is reported from Chashikni, Jhari, Maol, Saon and Satgahr but deposit of copper ore is not in large quantity
Lime-stone	Limestone is the main raw material for cement. It occurs in the Larji formation in southern parts of Kullu valley and also in the Garsha saiji valleys. Limestone found in this district is yet to be exploited for commercial use as no cement plant has been set-up in the district or nearby area.

2.8 Agro Climatic features

The district Kullu has diverse agro-climatic features. Out of the four distinct agro-climatic zones of the state, this district comes under High Hill, Temperate Dry, High Hill, Temperate Wet and Mid Hills, Sub Humid zones. Major parts of the cultivable land falls in the Mid Hill, Sub Humid where farmers besides cereal crops (wheat, paddy, maize) are cultivating pulses, oilseeds and cash crops i.e. vegetables on large scale. High Hill, Temperate Wet zone is characterized by heavy rainfall and snow. In this zone cropping intensity is low and horticultural crops are the major crops. However, wheat, maize, barley, paddy, pulses and oilseed are also grown in large scale. Very small part of district falls under High Hills, Temperate Dry zone. In these zones vegetables are grown at such a time when it is not possible to grow them in low lying areas due to adverse climatic conditions and some of the vegetables grown are tomato, capsicum, French-bean, cucumber, summer squash, peas, cabbage and cauliflower etc. So these are exclusively off-season vegetables of the district Kullu. Weather of district is cold and dry. From January to June the temperature varies between 15.8°C to 32.8°C and from July to December between 21.1°C to 0.7°C (Average of 1985-2007). The summers are generally mild but winters are harsh due to snow clad higher reaches. The rainfall is well distributed with maximum rains in July and low rains during October- December.



Agro-climatic Zone & major agro-ecological conditions

S. No	Agro-climatic Zone	Characteristics
1.	Mid-hill sub-humid zone	The elevation of this zone varies from 651 to 1800m amsl. Soil texture varies from loam to clay loam and soils are deficient in N & P with poor water & nutrient holding capacity. Soils are acidic in reaction. The average rainfall is about 1500mm. In this zone, wheat, paddy, maize, seed potato, pulses and oilseeds are the main crops Stone and citrus fruits occupy considerable area. Forest and pastures are also important in this zone.
2.	High-hills temperate wet zone	The elevation of this zone lies above 1800m amsl. The soils are shallow in depth, acidic in reaction, silt loam to loam in texture and deficient in N & P. Terrace farming is practiced. Soil erosion, low fertility and inadequate water management are main problems of this zone. The main crops are wheat, maize, paddy, barley, pulses and oilseeds. Mostly rainfed farming is practiced. The average rainfall is about 1000mm. This zone is suitable for raising off-season vegetable and seed production of temperate vegetable, Apple, other temperate fruits and nuts are important horticultural crops.

S. No	Agro ecological condition	Characteristics
1.	Valley areas	This includes the valley areas having elevation ranging from 651 to 1300m amsl in all the five development blocks. The average annual rainfall is about 1000mm. Soils are Entisol and Inceptisol with gentle slopping topography. The net cultivated area under this AES is about 12.7 thousand ha (35.05%) with partial irrigation facilities. Main sources of irrigation are flow and lift irrigation schemes. Vegetables, cereal and fruit based cropping systems are predominant in this AES. The net cultivated area is spread over approximately 54.3, 11.8, 11.8, 11.8 and 10.3% in Kullu, Naggar, Banjar, Nirmand and Ani blocks, respectively.
2.	Mid-hill mild temperate areas	Area of this AES also spreads through the five blocks of the districts. The elevation of this AES ranges from 651 to 1300m amsl having annual rainfall of about 1540mm. The soil are Entisol, Inceptisol and Mollisol. Topography is hilly terrain. The net cultivated area is about 16.02 thousand ha (44.23%) with meager irrigation facilities. Cereal, pulse, fruits and vegetable based cropping systems are predominantly in practice in this AES. The net cultivated area is spread over approximately 19.2, 16.7, 20.6, 18.5 and 24.7% in Kullu, Naggar, Banjar, Nirmand and Ani blocks, respectively.
3.	High-hill temperate areas	Area of this AES too spreads in all the five blocks of the district with elevation ranging from 1300 to 1800 m amsl. Average rainfall is about 1078 mm and soil types are Alfisol and Inceptisol. Topography is hilly terrain having net cultivated area of approximately 6.0 thousand ha (16.58 %) with inadequate irrigation facilities. Fruits, off-season vegetables, pulses and traditional mountain crops

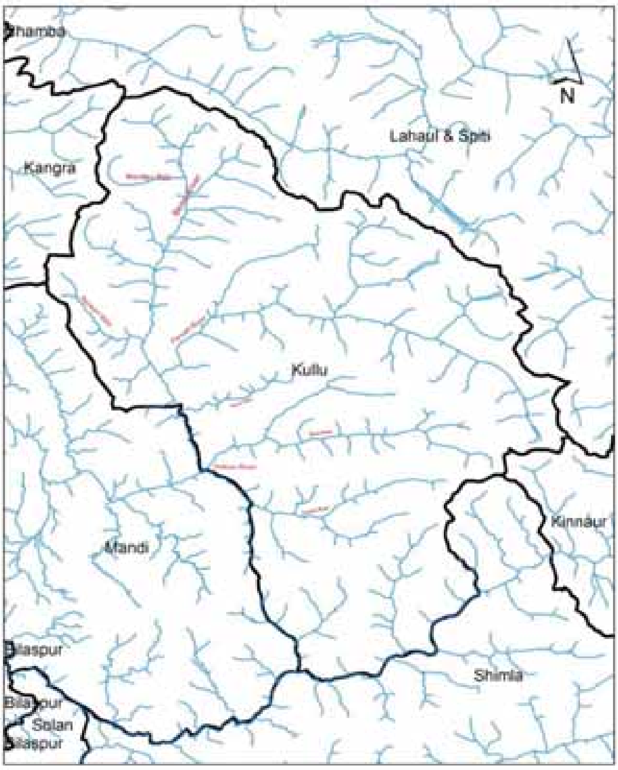
S. No	Agro ecological condition	Characteristics
		are predominant. The net cultivated area under this AES is spread over approximately 41.3, 25.0, 15.1, 13.3 and 5.3% in Kullu, Naggar, Banjar, Nirmand and Ani.
4.	High hill wet temperate areas	This AES also extends in all the five blocks with elevation above 1800 m amsl with medium shallow soil. Topography is hilly terrain with net cultivated area of approximately 1.5 thousand ha (4.14%). Heavy snowfall with one growing season is characteristic feature in some of areas in this AES. Mountain traditional crops, pulses, cereals, fruits and vegetables are grown by the peasants. The net cultivated area under this AES is spread over approximately 33.3, 21.0, 12.3 and 13.3% in Kullu, Naggar, Banjar and Nirmand blocks, respectively.

S. No	Soil type	Characteristics	Area in ha
1.	Entisols & Inceptisols (Valley Areas)	Entisolsl: Soil has no diagnostic pedogenic horizons. They may be found in virtually any climate on very recent geomorphic surfaces. Inceptisols: Soils that are usually moist with pedogenic horizons of alteration of parent materials but not of illuviation. Generally, the direction of soil development is not yet evident from the marks left by various soil- forming processes or the marks are too weak to classify in another order	12.7 thousand hectare
2.	Entisols, Inceptisols and Mollisols (Mid-hill mild temperate Areas)	Entisolsl: Soil has no diagnostic pedogenic horizons. They may be found in virtually any climate on very recent geomorphic surfaces. Inceptisols: Soils that are usually moist with pedogenic horizons of alteration of parent materials but not of illuviation. Generally, the direction of soil development is not yet evident from the marks left by various soil- forming processes or the marks are too weak to classify in another order. Mollisols: Soils with nearly black, organic – rich surface horizons and high supply of bases. They have mollic epipedons and base saturation greater than 50% in any cambic or argillic horizon.	16.4 thousand hectare
3.	Alfisols & Inceptisols (High-hill temperate areas)	Alfisols: Soil with gray to brown surface horizons, medium to high supply of bases, and B horizons of alluvial clay accumulation. These soils form mostly under forest or savanna vegetation in climates with slight to pronounced seasonal moisture deficit. Inceptisols: Soils that are usually moist	6.0 thousand hectare

S. No	Soil type	Characteristics	Area in ha
		with pedogenic horizons of alteration of parent materials but not of illuviation. Generally, the direction of soil development is not yet evident from the marks left by various soil- forming processes or the marks are too weak to classify in another order.	
4.	Medium shallow (High hill wet temperate areas)	-	1.5 thousand hectare

2.9 River System

The River Beas is the principal river flowing in and from the district. The Sutlej touches the fringes of district boundary in the Nirmand and Ani tehsils and the entire drainage of the district is received by these two rivers. The river Beas originates from the Beas Kund, a small spring of Pir Panjal Ranges at Rohtang Pass at a height of 3,900 metres approximately and flows southwards for about 120 kms. till it reaches Larjee. In this area tributaries are on the east bank spread out in the shape of a fan based on the length of the river between Bhuin and Larjee. On the right of West bank of the main affluent are the Solang, Manalsu, Fozal nullahs and the Sarwari khad at Kullu. The Parvati River also receives the water of the Malana nullah at Jari and other tributaries of the Parvati River are also on its right bank. The Parvati River after flowing in the north-westerly direction then flows in a south-westerly course before merging with Beas River. Between its basin and that of the Sainj nullah lie the Hurlagad which rises from a glaciated area. It joins the Beas River opposite Bajaura. The Sainj River originates from Supa Kuni a high peak located on the boundary of Spiti and after running through the Sainj valley, it merges with river Beas at Larjee. The Tirthan stream joins the Sainj River a little above the junction of the latter with the Beas River. The flow of river Beas and its tributaries are at its lowest during the winter months of December, January and February and highest during June, July and August. In July and August, these rivers and their tributaries are in flood and overflow their banks. The Sutlej River which forms the southern boundary of the district and separating it from Shimla district rises from Mansarover and touches the district in Nirmand Tehsil opposite to Rampur Tehsil of Shimla district. Its main tributaries from the Kullu district are Kurpan and Ani which originate from Bashleo and Jalori Peaks. These rivers and their tributaries are the life line of the district and these are useful for generation of electric power and raising fishery activities.



2.10 Climate

The climate of the district is cool and dry. There are three broad seasons viz. Cold season from October to February, hot season from March to June and rainy season from July to September. Wind characteristics depend upon season, as it is hot during the months of May and June and coldest in the months of December and January.

Snowfall generally occurs in December and January at higher hills and most of the regions are cut off from the district headquarters since the mountain passes are closed. The district receives moderate rainfall and bulk of it is received during the months of July, August, December and January. August is the wettest month throughout the district. There are three rainfall recording stations in the district. These stations are Kullu, Banjar and Tinder. During the monsoon period, the land becomes fresh and green and the small water channels in the hills begin to swell.

The climate in Kullu is predominantly cold during winter and moderately cool during summer. The temperatures range from 4 °C (39 °F) to 26 °C (79 °F) over the year. The average temperature during summer is between 10 °C (50 °F) and 26 °C (79 °F), and between −15 °C (5 °F) and 12 °C (54 °F) in the winter.

Climate data for Kullu (1971–2000)													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Record high °C	19.5	23.5	27.0	30.0	35.0	33.2	32.6	30.6	29.2	30.0	25.6	21.5	35.0
Avg. high °C (°F)	10.6	11.6	15.9	21.9	24.9	27.2	25.9	25.4	25.0	22.5	18.4	13.7	20.4
Avg. low °C (°F)	−1.6	−0.7	2.3	5.8	8.5	12.4	15.4	14.9	11.2	5.5	1.5	−0.1	6.5
Record low °C (°F)	−11.6	−11.0	−6.0	−1.0	1.0	4.4	7.4	7.0	3.0	−1.5	−5.0	−10.0	−11.6
Avg. rainfall mm	108.4	133.5	202.3	108.0	78.9	88.0	215.1	221.7	100.4	52.3	43.0	59.5	1,411.1
Average rainy days	6.6	8.2	9.3	6.2	5.7	7.3	14.7	15.0	8.5	3.4	2.8	3.5	80.1
Source: India Meteorological Department (record high and low up to 2010)													

Monthly precipitation varies between 31 mm (1.2 in) in November and 217 mm (8.5 in) in July. On average, some 45 mm (1.8 in) of precipitation is received during winter and spring months, increasing to some 115 mm (4.5 in) in summer as the monsoon approaches. The average total annual precipitation is 1,363 mm (53.7 in). Manali experiences snowfall predominantly between December and beginning of March. The month of January is when it is usually the highest.

2.11 Forest

Forests occupy a prominent place in the economy of the district. Extensive tracts of forests exist throughout the districts which are richly wooded. Forests constitute a major proportion of the total land. The forests of Kullu district are rich in various kinds of medicinal herbs like Karu, Dhoop, Muswala and Kakar Singi. Mushrooms are also available in plenty and extracted in large quantity. Deodar attains considerably dimensions in the upper Beas and Parvati valleys. All the higher ranges have dense forests, while in the valleys as one descends lower, the growth of forests is less. The Kullu forests considerably resemble those in the adjacent parts of Kangra and Mandi with the exception that in quality these are better. Cheel Pine is found best in quartizite rock and it is

available in the Parvati and Tirthan valleys. Wild olive and mulberry are found on lower levels. Extensive forests of common Himalayan oak are found largely in the Hurla valley above 2,400 metres elevation. Spruce and silver fir forests also exist.

The oak, spruce and silver fir trees attain a height of about 61 metres. Hazal, Hornbeam, Yew and Bird Cherry are also found. Birch, Moru, Ban and Rhododendron are found in greater quantity along with willows, Ash, Wild, Apple and Juniper. Tree growth is replaced by Alpine pastures ascending to the limit of vegetation and snow line. These grazing grounds are used for grazing sheep and goats during the summer and also by the ponies where the slope is not too steep. There are many shrubs and plants which provide food, medicines and dyes. Wild strawberry, raspberry and barberry are also found.

2.12 Biodiversity

The following various species of the plants and forest trees are generally found in Kullu district :

Botanical Name	Local Name
Cedrela serrata	*Duri or Dari*
Aesculusindica	*Gun or Khaner*
Acer caesimum	*Mandar*
Pistacia integorrima	*Kakrain or Kakar*
Rhus cotinus	*Tung*
Rhus wallichii	*Rikhal, Arkhal*
Dalbergia sissoo	*Tali or Shih and Shishu*
Pyrus pashia	*Kainth or Shegal*
Pyrus lanta	*Pala*
Prunus padus	*Paja*
Prunus padus	*Jaman*
Prunus armeniaca	*Shari*
Prunus persica	*Aru, Malaru*
Contoneaster bacillaris	*Reunsh*
Prinsepia utilis	*Bhekhal*
Rubus ellipticus	*Anchu, Achla*
Rubus paniculatus	*Thisri*
Pieria evalifolia	*Ailan or Arban*
Rhododendron campanulatum	*Shargar, Kashmiri Pata*
Fraxinums floribunda	*Angu*
Buxus sempervirens	*Shamshad*
Ulmus villosa	*Maran*
Morus indica	*Chun, Chimo*
Ficus rxburghii	*Trembala or Trimul*
Ficus palmate	*Phagra*
Populus ciliata	*Phalsh*
Alnus nepalensis	*Koi or Kosh*
Querous semecarpifolia	*Kreu or Kharshu*
Taxus baccata	*Phatish or Rakhal*
Cedrus deodara	*Kelon or Kelo*
Abias webbaiana	*Tos*
Picea morinda	*Rai*
Cupressus terulesa	*Dedididar*

The district provides habitation and sustenance for numerous fauna. The mountains, forests and streams, abundant food, shelter and water and large stretches of uninhabited and comparatively inaccessible area provide favourable condition for sheltering many kinds of wild life.

Brown and black bear, the spotted and white leopard, musk deer, wild cat, flying squirrel, hyaena, wild pig, jackal, fox and marton are found in the district. The climatic conditions prevailing in the district are most favourable for their regeneration game birds.. Hill pheasant and monal are found in the higher ranges. The white crested pheasant, koklas and the cheer, red jungle fowl, black and wood partridge, chukor are very common in lower hills. Snipe, wood cock and teal are also found. In winter the snow pheasant and snow partridge are also found along with the wild duck and geese. Eagles, vultures, kites and hawks inhabit the upper fastnesses and occasional specimens have been secured by bird fanciers. Due to considerable pressure on the forests and reckless felling of trees many places have been denuded resulting in the fast disappearance of wild animals and birds.

2.13 Agriculture & Horticulture

The economy of the district is primarily depends on agriculture & horticulture and more than 80 per cent of the workers are engaged in these activities. The texture of soil ranges from sandy loam to clay loam and the colour of the soil also vary from brown to dark brown. Generally the sandy soil is acidic in nature and the terrain except the valley is all hilly. Depth of the soil varies from 50 to 150 cms. But despite this all the agro climatic conditions provide a range of potentialities for growing cash crops like off season vegetables, seed potatoes, pulses and temperate fruits apart from the cereals, millets and oil seeds. Among the cereals, wheat, maize, paddy and barley are extensively grown. The holdings are small and cultivation is done by traditional techniques of farming leading to low production. The mechanization of agricultural operation is not possible due to small size and terraced fields.

Horticulture occupies an important place in the economy of the district. Agro-climatic conditions prevailing in the district offer a great scope for the production of temperate and sub-tropical fruits especially apple, peach, apricot, chestnut, almonds, persimmon (*Japani Phal*), cherries, goose berries and olive.

Block wise & fruit wise estimated/ actual production of different fruit grown (in Metric Ton) in the district during the year 2014-15 is as under:

Sr. No.	Name of Fruit	Kullu Block	Naggar Block	Banjar Block	Anni Block	Nirmand Block	Total
1.	Apple	20500.00	65000.00	10400.00	15000.00	11500.00	122400.00
2.	Plum	3200.00	1500.00	800.00	8.00	10.00	5518.00
3.	Peach	1.00	46.00	320.00	9.00	5.00	381.00
4.	Apricot	6.00	34.00	700.00	14.00	20.00	774.00
5.	Pear	2451.00	6000.00	1500.00	35.00	45.00	10031.00
6.	Cherry	1.00	14.00	0.50	1.00	0.00	16.50
7.	Kiwi	4.50	55.00	0.00	1.00	1.00	61.50
8.	Pomegranate	760.00	98.00	1.00	1.00	1.00	861.00
9.	Persimmon	28.00	395.00	32.00	12.00	5.00	472.00

Sr. No.	Name of Fruit	Kullu Block	Naggar Block	Banjar Block	Anni Block	Nirmand Block	Total
10.	Strawberry	2.50	4.50	0.00	0.00	0.00	7.00
11.	Almond	6.00	1.50	0.00	8.00	14.00	29.50
12.	Walnut	1.50	48.00	10.50	1.00	1.00	62.00
							Source: Deptt. of Horticulture

Block wise area (in hectares) brought under different fruits during the year 2013-2014 in district Kullu is as follows

Sr.No.	Name of fruit	Naggar Block	Kullu Block	Banjar Block	Anni Block	Nirmand	Total area
1.	Apple	9701.03	6397.69	4388.78	3670.44	1467.13	25625.08
2.	Plum	815.28	969.90	284.46	22.65	32.00	2124.28
3.	Peach	13.60	22.59	11.60	4.53	6.00	58.32
4.	Apricot	58.25	72.25	98.25	8.35	21.0	258.10
5.	Pear	203.90	168.90	89.90	20.02	6.40	489.12
6.	Cherry	15.35	9.35	11.35	2.00	1.21	39.26
7.	Kiwi	9.00	18.50	5.00	0.00	0.91	33.41
8.	Pomegranate	85.08	247.73	48.91	2.94	5.61	390.27
9.	Persimmon	24.00	46.00	52.00	1.00	24.5	147.5
10.	Strawberry	4.00	2.00	2.00	0.00	0.00	8.00
11.	Almond	44.60	181.00	49.00	27.5	38.00	340.10
12.	Walnut	19.09	39.08	23.09	1.00	5.00	87.26
							Source: Deptt. of Horticulture

Area under main crops in district Kullu (Hect.)

Crops	District		Tehsil-wise area (Hect.)						Total
	2008-09	2009-10	Kullu	Manali	Sainj	Banjar	Aani	Nirmand	
Edible Crops									
1.Cereal									
Wheat	24,160	19,033	8,415	221	1,905	2,246	2,403	3,843	19,033
Maize	16,683	16,394	6,920	421	1,851	2,231	2,459	2,512	16,394
Rice	1,443	1,404	511	219	65	-	225	384	1,404
Barley	3,343	3,223	1,083	377	40	533	630	560	3,223
Other grains	1,003	1,107	385	82	-	62	229	349	1,107
2. Pulses									
Gram	104	113	-	-	-	-	63	50	113
Other pulses	2,795	3,431	1,342	249	87	662	334	757	3,431
Total edible food	49,531	44,705	18,656	1,569	3,948	5,734	6,343	8,455	44,705
3. Other edible crops									
Potato	1,013	1,362	636	11	16	236	235	228	1,362
Fruits	10,456	9,022	4,929	1,032	384	617	1,340	720	9,022
Onion	71	64	53	-	-	-	-	11	64
Other vegetables	1,607	1,562	953	76	24	258	91	160	1,56273
Pepper (Mirch)	70	73	43	5	5	17	3	-	779
Garlic	296	779	149	13	9	229	379	-	23
Other spices	40	23	12	-	5	-	-	6	313
Dry fruits	320	313	261	-	-	-	-	52	13,198
Total other crops	13,873	13,198	7,036	1,137	443	1,357	2,048	1,177	13,198

Crops	District		Tehsil-wise area (Hect.)						Total
	2008-09	2009-10	Kullu	Manali	Sainj	Banjar	Aani	Nirmand	
Total edible food and other crops	63,404	57,903	25,692	2,706	4,391	7,091	8,391	9,632	57,903
Non Edible crops /Non food crops									
Edible Groundnut and Sesame seed	42	34	-	-	-	-	2	32	34
Non edible Sarson	739	529	450	38	9	12	-	20	529
Soya bean	4	11	6	-	5	-	-	-	11
Tobacco	2	-	-	-	-	-	-	-	-
Cotton & other fiber crop	-	-	-	-	-	-	-	-	-
5. Fodder Crops	65	63	63	-	-	-	-	-	63
Total non food crops	852	637	519	38	14	12	2	52	637
Total edible & non edible crops	64,256	58,540	26,211	2,744	4,405	7,103	8,393	9,684	58,540

2.14 Animal Husbandry

Livestock is an important source of income. Every household invariably keeps a few cows, buffaloes, sheep, goats etc. Besides providing a source of income, livestock also serves as a source of balanced diet for the people. Milk, meat and eggs provide protein for the human diet and manure for the fields. Bullocks are utilized for ploughing the fields as mechanisation of forming activities is not much possible due to small holdings and hilly terrain. Most of the fish habitation in Kullu district is found in the interior valleys having rivers, streams and nullahs which provide ample scope for development of aqua culture in the district. The main source of these rivers/streams and nallahs are perennial snow covered peaks of inner Himalayas. The crystal clear water of these rivers containing lot of minerals is most favourable for the growth of fisheries.

Livestock & Poultry of Kullu district as per livestock census 2007

Livestock & Poultry	District/ Tehsil/ Sub Tehsil						Total
	Kullu	Manali	Sainj	Banjaar	Aani	Nirmand	
Cattles	84,581	10,403	16,483	30,050	2,917	30,814	1,75,248
Buffalos	202	59	23	-	-	63	347
Sheep	77,298	9,461	8,554	19,841	1,112	13,576	1,29,842
Goats	44,818	1,472	7,930	10,283	556	13,037	78,096
Others	1,707	748	94	70	34	199	2,852
Total	2,08,606	22,143	33,084	60,244	4,619	57,689	3,86,385
Poultry	10,197	616	398	1,235	-	3,266	15,712
Dogs	7,713	1,056	1,050	1,811	79	1,063	12,772

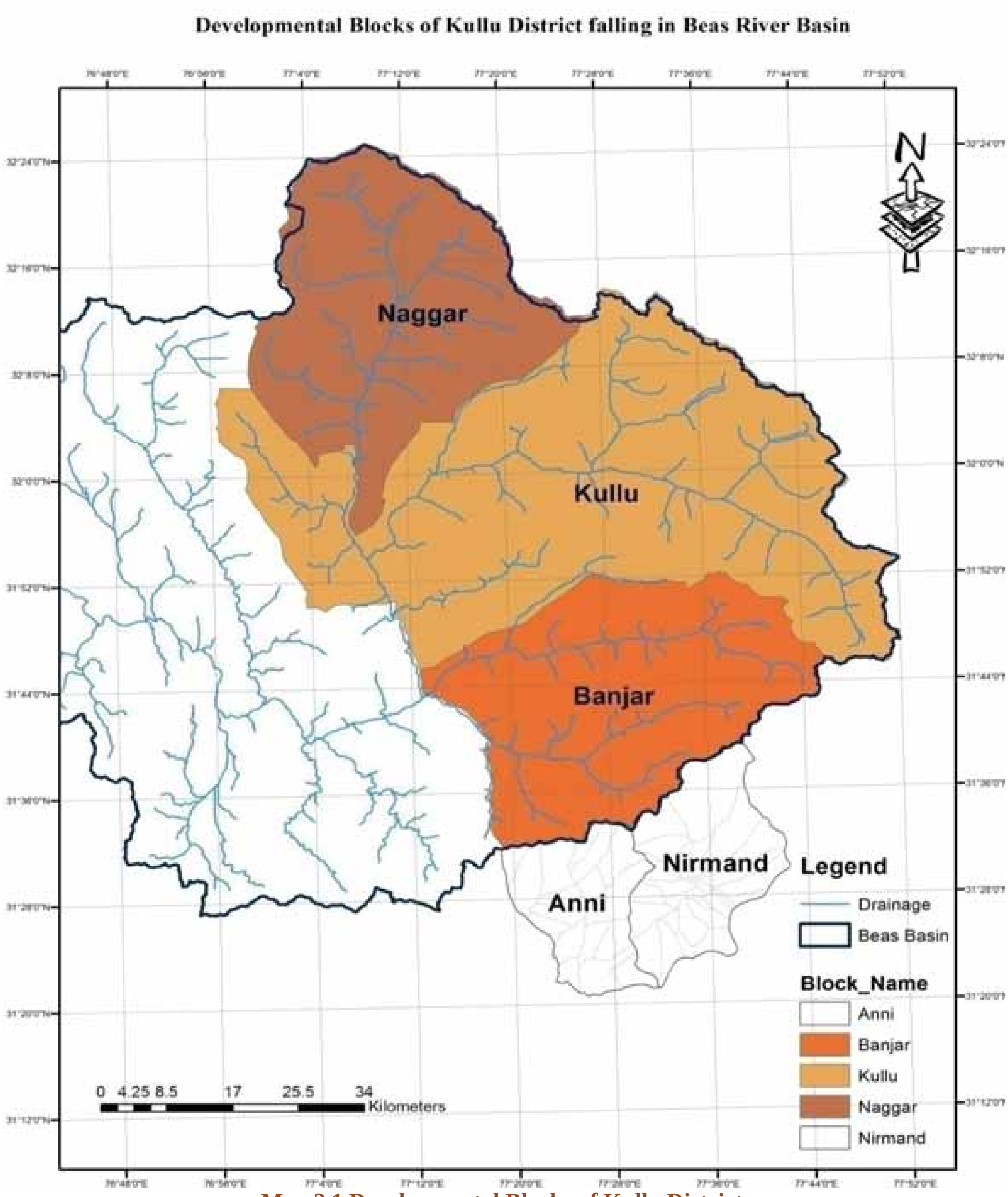
Source: Animal Husbandry Deptt., Kullu

3

Blocks Profile falling in Beas River Basin: District Kullu

3. Blocks Profile falling in Beas River Basin: District Kullu

Under this assessment study only three blocks of distric kullu i.e. Naggar, Kullu & Banjar are considered since these blocks are falling inside the area of Beas River Basin and the rest of another two blocks Ani and Nirmand are falling in Satluj River Basin. Therefore, only three blocks are being analysed under this study:

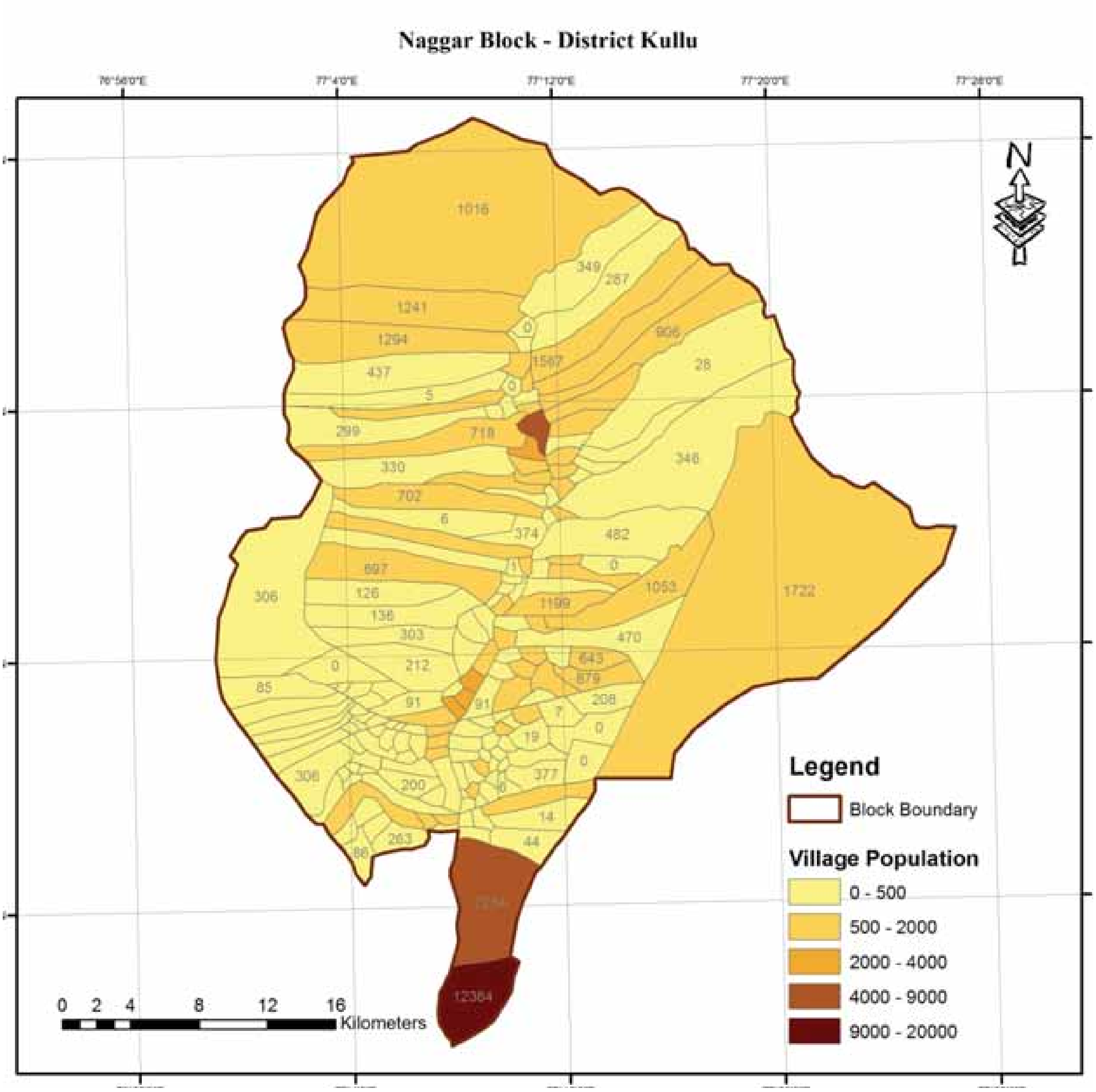


Map 3.1 Developmental Blocks of Kullu District

Developmental Blocks of District Kullu covered under Study	Panchayats
1. Naggar	40
2. Kullu	70
3. Banjar	36
Total Panchayats:	**116**

3.1 Profile: Development Block – Naggar

Naggar is a Block situated in Kullu district in Himachal Pradesh. Located in rural part of Himachal Pradesh, it is one among the 5 blocks of Kullu district. According to the administration register, the block number of Naggar is 25. The block has 186 villages and there are total 22775 houses in this Block.



Map 3.2 Village Population map of Naggar Block (Census 2011)

As per Census 2011, Naggar's population is 102270. Out of this, 52687 are males while the females count 49583 here. This block has 11462 children in the age bracket of 0-6 years. Among them 5865 are boys and 5597 are girls. Literacy ratio in Naggar block is 70%. 71821 out of total 102270 population is literate here. In males the literacy rate is 77% as 40806 males out of total 52687 are literate whereas female literacy rate is 62% as 31015 out of total 49583 females are educated in this Block. The dark side is that illiteracy rate of Naggar block is 29%. Here 30449 out of total 102270 persons are illiterate. Male illiteracy rate here is 22% as 11881 males out of total 52687 are illiterate. In females the illiteracy rate is 37% and 18568 out of total 49583 females are illiterate in this block. The count of occupied people of Naggar block is 63812 however 38458 are non-working. Out of 63812 occupied people 29285 persons are completely dependent on farming.

Population Table of Naggar Block

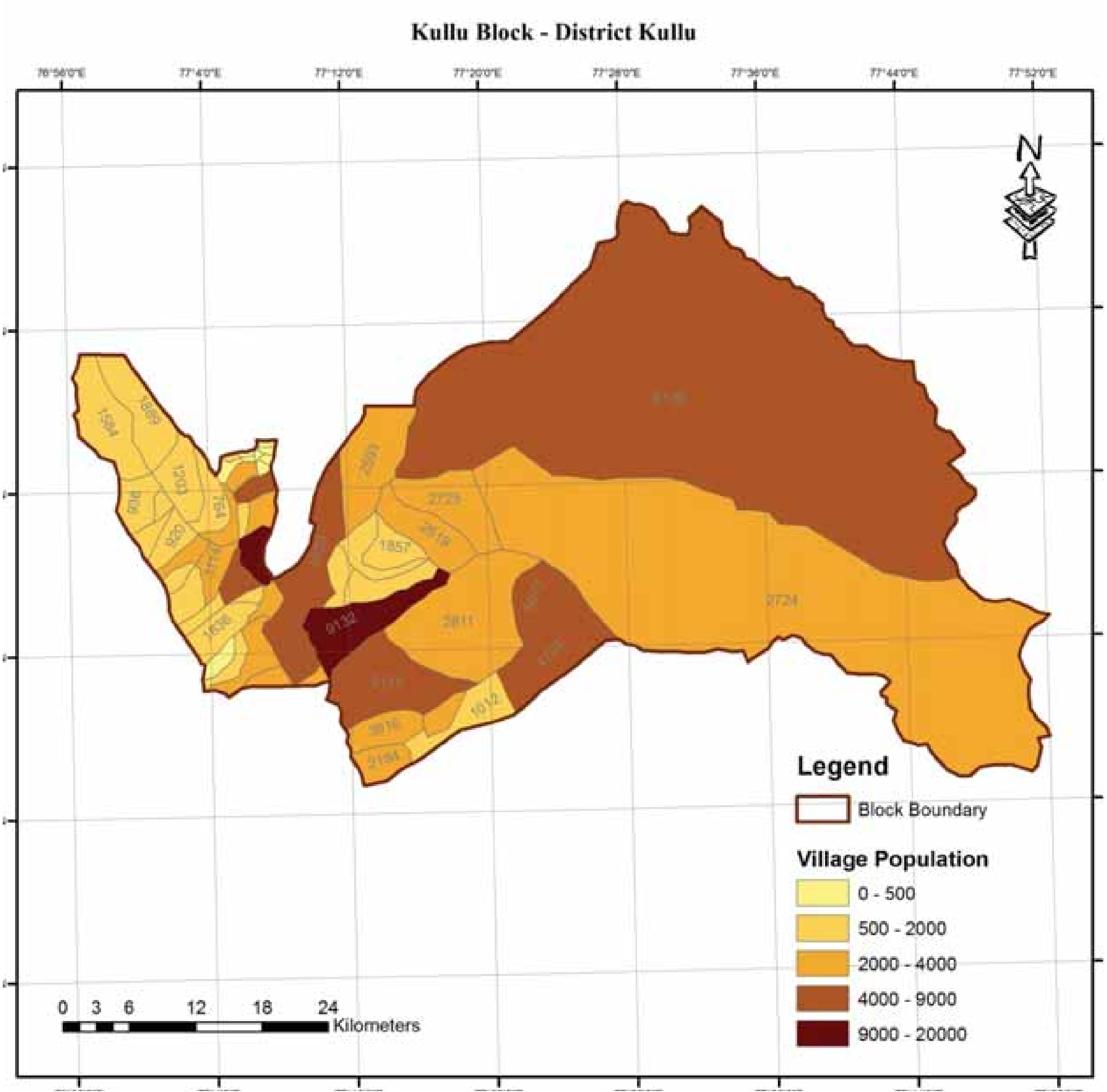
Village Code	Village Name	Panchayat Name	Area (Ha.)	Household	Population	Male	Female
012833	Up Muhal Shahadgran	Archandee	23.46	3	10	6	4
012831	Up Muhal Parsh	Archandee	43.61	57	285	143	142
012832	Up Muhal Sharan Gran	Archandee	38.16	77	355	174	181
012834	Up Muhal Ladi Chanon - Ist	Archandee	46.19	0	0	0	0
012835	Up Muhal Ladi Chanon - II nd	Archandee	3.53	1	4	1	3
012839	Up Muhal Sharnee	Archandee	67.2	27	136	67	69
012840	Up Muhal Archandee Ist	Archandee	36.01	138	607	300	307
012841	Up Muhal Archandee IInd	Archandee	15.69	18	86	49	37
012842	Up Muhal Mahilee	Archandee	17.94	42	228	119	109
012843	Up Muhal Baga Mahilee	Archandee	55.19	41	197	95	102
012844	Up Muhal Dhama	Archandee	59.91	14	60	34	26
012845	Up Muhal Junkhra Dham	Archandee	69.19	24	85	42	43
012712	Badgran (22/37)	Badagran	337.5	396	1771	898	873
012669	Bashisht (20/23)	Bashisht	110.91	420	1626	920	706
012670	Up Muhal Kaushala	Bashisht	86.52	244	906	495	411
012671	Up Muhal Dharanu	Bashisht	59.5	278	1141	594	547
012672	Up Muhal Chachoga	Bashisht	33.64	310	1256	644	612
012673	Up Muhal Aleu	Bashisht	124.25	416	1625	941	684
012674	Jangal Mehduda Mehfuja Aleu Vihal	Bashisht	26.7	34	101	59	42
012789	Benchi (27/58)	Benchi	122.82	330	1495	738	757
012694	Muhal Bran (22/29)	Bran	187.46	129	555	284	271
012696	Up Muhal Mandhon	Bran	83.77	0	0	0	0
012697	Up Muhal Shangchar	Bran	120.05	165	697	343	354
012698	Up Muhal Dobha	Bran	153	98	450	220	230
012699	Up Muhal Rampur	Bran	74.29	92	404	205	199
012662	Muhal Buruwa (21/25)	Buruwa	86.96	283	1294	693	601
012663	Up Muhal Buruwa Majhach	Buruwa	249.1	97	484	246	238
012664	Up Muhal Vyas Tibba	Buruwa	1.62	0	0	0	0
012668	Up Muhal Majhach	Buruwa	126.52	95	437	224	213
012870	Kharal (25/50)	Chansari	1409	2585	12384	6205	6179
012749	Dawara (22/34)	Dawara	139.2	373	1553	770	783
012750	Up Muhal Dachnee	Dawara	304.72	23	91	42	49
012751	Meha (22/33)	Dawara	161.91	73	291	155	136
012752	Up Muhal Bhujnu	Dawara	175.11	42	209	106	103
012773	Up Muhal Himri	Devgarh	198.25	56	306	164	142
012774	Up Muhal Parvi	Devgarh	103.17	26	124	63	61
012775	Up Muhal Kral	Devgarh	149.35	59	317	146	171
012776	Up Muhal Grahan	Devgarh	73.55	18	82	42	40
012777	Up Muhal Galchet	Devgarh	62.18	34	168	85	83
012778	Up Muhal Trisdee	Devgarh	52.78	61	281	141	140
012783	Up Muhal Dohlonallha	Devgarh	127.36	164	789	395	394
012720	Muhal Gojra (20/20)	Gojra	49.02	115	482	241	241
012721	Up Muhal Khakhanal	Gojra	105.1	152	656	342	314
012733	Hallan-I (24/42)	Hallan- I	85.82	112	524	265	259
012737	Up Muhal Kumartee	Hallan- I	125.07	68	347	185	162
012736	Up Muhal Sarsai	Hallan- I	74.56	296	1389	727	662
012735	Up Muhal chaki	Hallan- I	89.62	109	595	295	300
012734	Up Muhal Rangri	Hallan- I	185.75	88	372	194	178
012738	Up Muhal Raman	Hallan- I	196.53	131	643	313	330
012739	Up Muhal Batahar Bihal	Hallan- I	16.48	95	470	237	233
012707	Muhal Hallan-II (22/32)	Hallan II	232.5	66	303	151	152
012708	Up Muhal Magana	Hallan II	129.6	45	212	114	98
012709	Up Muhal Shilha	Hallan II	215.58	67	296	161	135
012710	Muhal Bari (22/36)	Hallan II	177.81	474	2100	1132	968
012711	Up Muhal Tarashi	Hallan II	203.85	66	312	171	141
012765	Fojal (29/63)	Hurang	74.47	102	492	252	240
012766	Up Muhal Runga - Ist	Hurang	88.58	35	180	95	85
012767	Up Muhal Runga - II nd	Hurang	46.56	7	26	16	10
012768	Up Muhal Dhara	Hurang	103.96	86	393	200	193
012769	Up Muhal challogee	Hurang	44.83	14	77	42	35
012770	Up Muhal Bulang Jhakdi	Hurang	44.4	65	296	146	150
012771	Up Muhal fozal Badon	Hurang	23.83	0	0	0	0
012723	Muhal Jagatsukh (20/21)	Jagatsukh	173.23	393	1719	903	816

Village Code	Village Name	Panchayat Name	Area (Ha.)	Household	Population	Male	Female
012724	Up Muhal Bhanara	Jagatsukh	163.06	72	346	181	165
012725	Up Muhal Chhalala	Jagatsukh	125.39	44	191	96	95
012726	Up Muhal Bahanu	Jagatsukh	34.84	36	170	97	73
012830	Jana (24/46)	Jana	53.93	174	884	456	428
012836	Up Muhal Mehra Bag	Jana	43.66	3	6	4	2
012837	Up Muhal Barnot	Jana	121.12	70	377	190	187
012838	Up Muhal Deogra	Jana	63.79	55	261	139	122
012846	Up Muhal Phata Ban	Jana	39.68	3	14	6	8
012847	Up Muhal Gohru	Jana	100.91	11	44	25	19
012848	Up Muhal Kalmidhar	Jana	162.74	4	20	11	9
012849	Kais (25/47)	Kais	860	1474	7234	3696	3538
012716	Karjan (23/40)	Karjan	154	263	1199	596	603
012717	Sajla (23/39)	Karjan	107.87	144	622	318	304
012718	Up Muhal Sajal Vihal	Karjan	24.98	48	201	104	97
012719	Up Muhal Dhamasu Kalaun	Karjan	95.2	39	171	83	88
012747	Katrain (22/35)	Katrain	191.12	482	2004	992	1012
012748	Up Muhal Jatehad	Katrain	119.87	571	2240	1135	1105
012722	Up Muhal Barnar	Khakhanal	100.6		0		
012882	Malana (24/44)	Malana	179	365	1722	888	834
012781	Up Muhal Shaldee	Manal Garh	39	50	249	129	120
012675	Muhal Manali (21/26)	Manali	48.3	178	831	408	423
012676	Up Muhal Dhungri -2nd	Manali	5.72	80	299	156	143
012677	Up Muhal Tyan Padhar	Manali	64.87	0	0	0	0
012678	Up Muhal Manali Koot	Manali	98.32	1	5	1	4
012679	Up Muhal Manu Nagar	Manali	77.44	146	750	381	369
012680	Up Muhal Manali Ser	Manali	53.43	11	43	22	21
012681	Up Muhal Kaliganch	Manali	61.88	31	120	64	56
012682	Aarkshit Van R-I Dhungri	Manali	14.5	0	0	0	0
012772	Mandalgarh (28/62)	Mandal Garh	97.69	29	185	88	97
012779	Up Muhal Khdihar	Mandal Garh	42	43	248	132	116
012780	Up Muhal salingcha	Mandal Garh	84.77	60	291	143	148
012782	Dobhi (28/61)	Mandal Garh	74.18	225	1033	510	523
012784	Up Muhal Mahiliser	Mandal Garh	83.94	75	266	128	138
012785	Up Muhal Shim	Mandal Garh	60.55	119	510	261	249
012740	Nagar (24/43)	Nagar	87.94	340	1556	780	776
012741	Up Muhal Pulag	Nagar	195.88	43	208	103	105
012743	Up Muhal chachogee	Nagar	216.74	98	476	244	232
012744	Up Muhal Madi	Nagar	32.54	217	879	453	426
012745	Up Muhal Mashda	Nagar	96.06	44	216	103	113
012746	Up Muhal Ghadopa	Nagar	86.22	18	91	51	40
012742	Up Muhal Rumsu	Nanar	198.72	226	1010	523	487
012683	Muhal Nasogi (21/27)	Nasogi	34.19	181	718	374	344
012685	Up Muhal Syal	Nasogi	38.99	515	2132	1105	1027
012686	Up Muhal Chhiyal	Nasogi	42.61	128	551	292	259
012687	Up Muhal Kanyal	Nasogi	79.86	73	330	173	157
012684	Up Muhal Simsa	Nasogi Simsa	68.1	139	559	323	236
012813	Nathan (24/45)	Nathan	55.62	73	325	174	151
012814	Up Muhal Dalashan	Nathan	64.01	84	338	155	183
012815	Up Muhal Nashalla	Nathan	26.42	108	527	267	260
012816	Up Muhal Laran Keloo	Nathan	52.13	170	833	434	399
012817	Up Muhal Ghod dor	Nathan	38.02	30	159	75	84
012818	Up Muhal Mahilee	Nathan	74.15	17	65	35	30
012819	Up Muhal Hirnee	Nathan	43.22	57	267	124	143
012820	Up Muhal Bhiyalee	Nathan	46.28	42	178	98	80
012821	Up Muhal Chatee	Nathan	37.53	23	92	51	41
012822	Up Muhal Nayanu sari	Nathan	24.47	94	427	207	220
012823	Up Muhal Paljot	Nathan	52.84	7	32	11	21
012824	Up Muhal Shanshr	Nathan	35.55	5	19	13	6
012825	Up Muhal Tilla Shadnee	Nathan	40.18	7	40	16	24
012826	Up Muhal Kharol	Nathan	28.98	1	7	4	3
012827	Up Muhal Dhanaseri	Nathan	10.57	0	0	0	0
012828	Up Muhal Thach	Nathan	1.15	0	0	0	0
012829	Up Muhal Ganesh Naggar	Nathan	41.51	121	542	266	276
012658	Palchan (21/24)	Palchan	176.81	280	1241	674	567
012659	UP Muhal Solang	Palchan	163.17	209	1016	661	355
012660	UP Muhal Kothi	Palchan	79.71	77	349	188	161

Village Code	Village Name	Panchayat Name	Area (Ha.)	Household	Population	Male	Female
012661	UP Muhal Kulang	Palchan	49.55	63	287	148	139
012700	Muhal Pangan (22/38)	Pangan	128.52	138	602	308	294
012701	Up Muhal Gumidhar	Pangan	44.29	132	434	187	247
012703	Up Muhal Defri	Pangan	127.86	77	388	188	200
012704	Muhal Shigli (22/31)	Pangan	266.33	27	136	77	59
012705	Up Muhal Kasheri	Pangan	227.35	28	126	61	65
012706	Up Muhal Nayalag	Pangan	118.83	50	219	111	108
012754	Up Muhal chukdee	Pchlihar	56.37	16	85	44	41
012753	Pichlihar (29/64)	Pichlihar	92.43	63	306	152	154
012755	Up Muhal Jalog	Pichlihar	70.44	0	0	0	0
012756	Up Muhal Jigling	Pichlihar	66.94	0	0	0	0
012757	Up Muhal Kabhi	Pichlihar	119.86	37	222	121	101
012758	Up Muhal Kaistha	Pichlihar	69.49	18	82	45	37
012759	Up Muhal Galang	Pichlihar	48.14	18	83	41	42
012760	Up Muhal Nari	Pichlihar	61.43	62	325	164	161
012761	Up Muhal Bagnee	Pichlihar	54.19	43	216	105	111
012762	Up Muhal Daral	Pichlihar	35.91	17	93	45	48
012763	Up Muhal Damchin	Pichlihar	173.64	37	199	101	98
012764	Up Muhal Pradee	Pichlihar	95.73	21	99	41	58
012727	Muhal Prini (20/22)	Prini	92.66	243	961	514	447
012728	Up Muhal Hamta	Prini	93.98	32	98	75	23
012729	Up Muhal Hamta 2/17	Prini	384.69	7	28	15	13
012730	Up Muhal Hamta 1/7	Prini	4.2	19	59	43	16
012731	Up Muhal Shuru	Prini	142.29	281	1212	622	590
012732	Up Muhal Jamari	Prini	102.98	2	8	5	3
012790	Up Muhal Pangan	Raison	83.99	132	586	296	290
012791	Up Muhal Chattanseri	Raison	70.55	97	400	209	191
012792	Up Muhal Raison	Raison	120.66	249	1061	563	498
012808	Manjhlihar (27/57)	Raison	50.88	24	106	56	50
012809	Up Muhal Kahudhar	Raison	51.27	19	86	50	36
012810	Up Muhal Lohadi	Raison	45.63	20	110	53	57
012812	Up Muhal Kharga	Raison	96	51	263	137	126
012811	Up Muhal Sajuni	Raison	40.32	26	111	54	57
012695	Up Muhal Chharogi	Riyara	119.29	1	1	1	0
012702	Muhal Riyara (22/30)	Riyara	122.24	90	432	207	225
012688	Muhal Shallin (21/28)	Shalin	90	90	374	185	189
012689	Up Muhal Klath	Shallin	147	169	607	310	297
012690	Up Muhal Parsha	Shallin	96	194	702	365	337
012691	Up Muhal Klaont	Shallin	39.67	3	13	8	5
012692	Up Muhal Jhunjhari	Shallin	1.2	2	6	4	2
012693	Up Muhal Gadherani	Shallin	53.9	209	1054	567	487
012665	Up Muhal Shanag	Shanag	159.97	181	850	425	425
012666	Up Muhal Gaushal	Shanag	106.36	178	823	391	432
012667	Up Muhal Bahang	Shanag	127.7	376	1567	916	651
012786	Shirar (27/59)	Shirar	44.37	82	366	186	180
012787	Up Muhal Shirar - Ist	Shirar	53.37	49	200	89	111
012788	Up Muhal Shirar - II nd	Shirar	51.43	76	338	179	159
012793	Shillihar (27/60)	Shirar	48.01	49	231	120	111
012794	Up Muhal Jallohra	Shirar	71.96	35	231	112	119
012795	Up Muhal Kamarda	Shirar	64.85	27	113	63	50
012796	Up Muhal Janehda	Shirar	111.56	27	126	60	66
012797	Up Muhal Mathi shil	Shirar	60.87	29	124	62	62
012798	Up Muhal Kufri	Shirar	1251.03	1	1	1	0
012713	Soil (23/41)	Soil	126.5	246	1053	528	525
012714	Up Muhal Haripur	Soil	161.68	194	805	428	377
012715	Up Muhal Somvan	Soil	28.43	11	49	26	23

3.2 Profile: Development Block – Kullu

Kullu is a Block positioned in Kullu district in Himachal Pradesh. Placed in urban region of Himachal Pradesh, it is one among the 5 blocks of Kullu district. According to the administration records, the block number of Kullu is 26. The block has 55 villages and there are total 26954 houses in this Block.



Map 3.3 Village Population Map of Kullu Block (Census 2011)

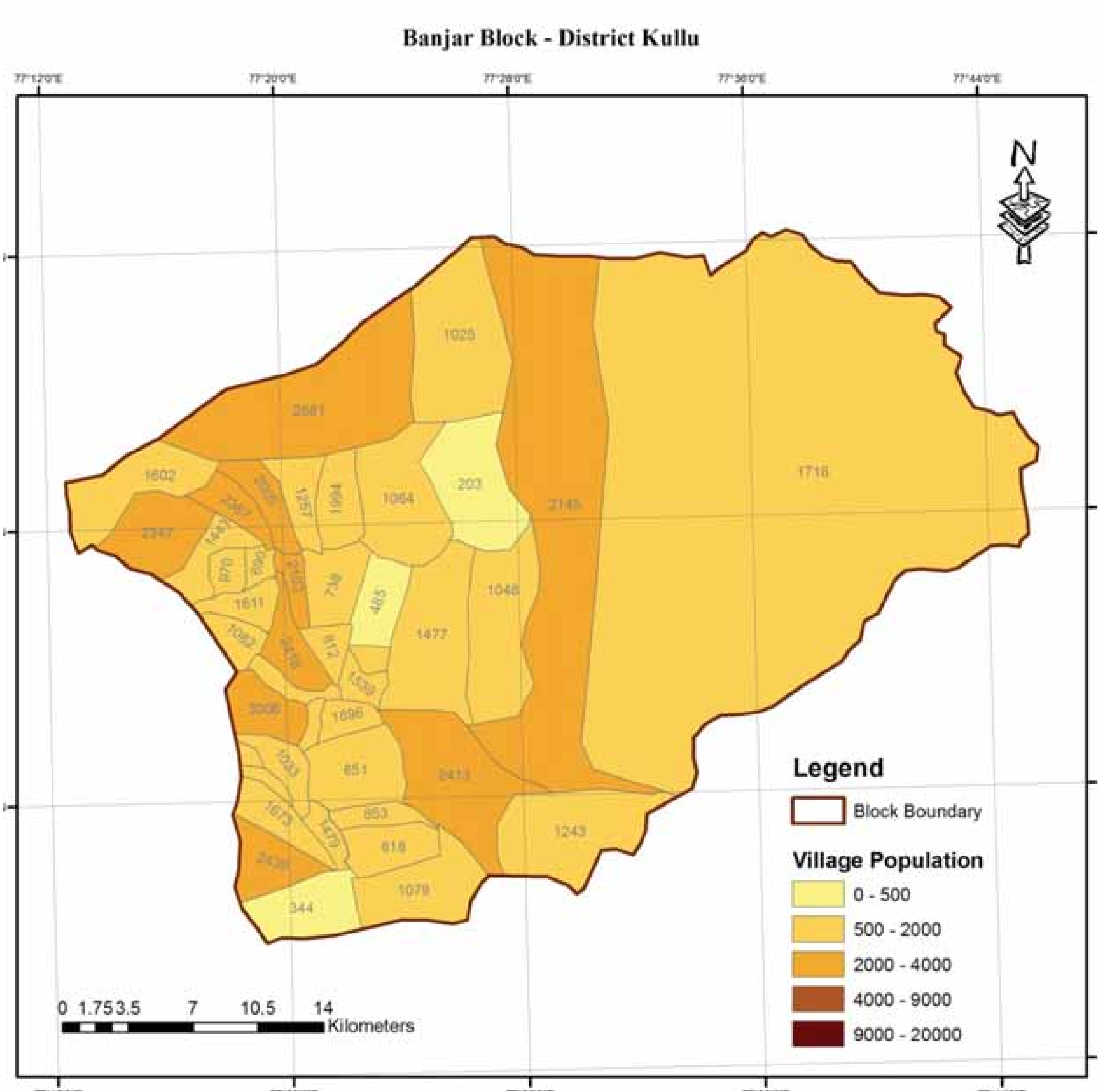
As per Census 2011, total population of Kullu Block is 130716. Out of this, 67415 are males while the females count 63301 here. This block has 15751 kids in the age bracket of 0-6 years. Out of this 8046 are boys and 7705 are girls. Literacy ratio in Kullu block is 69%. 90615 out of total 130716 population is literate here. In males the literacy ratio is 76% as 51750 males out of total 67415 are literate however female literacy rate is 61% as 38865 out of total 63301 females are educated in this Block. The dark portion is that illiteracy rate of Kullu block is 30%. Here 40101 out of total 130716 people are illiterate. Male illiteracy rate here is 23% as 15665 males out of total 67415 are illiterate. In females the illiteracy ratio is 38% and 24436 out of total 63301 females are illiterate in this block. The count of occupied person of Kullu block is 83015 whereas 47701 are un-employed. Out of 83015 working individual 40479 individuals are completely reliant on farming.

Population Table of Kullu Block

Village Code	Village Name	Panchayat Name	Area (Ha.)	Household	Population	Male	Female
012879	Shillihar (37/91)	Bada Bhuina	917.5	2018	9132	4627	4505
012877	Bajaura (36/89)	Bajaura	420	1255	5852	3015	2837
012867	Balh (34/79)	Balh	381	1074	4708	2402	2306
012799	Biasar (27/55)	Bandrol	148.05	152	691	362	329
012800	Up Muhal Thalli	Bandrol	66.35	0	0	0	0
012801	Up Muhal Ropa sari	Bandrol	34.9	27	114	58	56
012802	Up Muhal Mapak	Bandrol	53.74	7	28	15	13
012803	Bandrol (27/56)	Bandrol	24	59	282	144	138
012804	Up Muhal Nangabag	Bandrol	47.12	54	219	121	98
012805	Up Muhal Harabag	Bandrol	35.08	62	291	147	144
012806	Up Muhal Bagu Nalha	Bandrol	66.94	54	251	120	131
012807	Up Muhal Maltibag	Bandrol	46.61	68	316	159	157
012869	Barahar (34/80)	Barahar	298	277	1483	768	715
012883	Manikarn (40/101)	Barsaini	821	1295	6136	3241	2895
012851	Banogi (26/53)	Basing	625.65	804	4043	2219	1824
012853	Bastori (26/52)	Basotri	225	279	1483	803	680
012898	Bhalan-II (42/106)	Bhalan Ii	143	211	1012	523	489
012862	Bhalyani (33/75)	Bhalyani	424	375	2257	1140	1117
012880	Kashawri (25/49)	Bhrain	448	934	4603	2381	2222
012874	Bhullang (35/86)	Bhulang	150.15	368	1836	930	906
012865	Bhumtir (33/76)	Bhumtir	216	240	1322	660	662
012886	Bradha (39/99)	Bradha	337	527	2619	1337	1282
012863	Brahman (33/74)	Brahman	141	161	920	464	456
012864	Balh (33/73)	Brahman	122	218	1032	528	504
012861	Gramang (32/72)	Chaupadsha	176	240	1248	655	593
012854	Dughilag (30/67)	Dughilag	322	521	2508	1288	1220
012857	Dunkhri Gahar (30/65)	Dunkhari Gahar	204.24	366	1889	958	931
012893	Bhallan-I (42/106)	Gadsa	321.31	555	2593	1354	1239
012860	Gahar (32/71)	Gahar	209.68	145	720	376	344
012878	Hat (36/90)	Hat	164	504	2306	1186	1120
012891	Diar (37/92)	Hurla	700	1097	5114	2676	2438
012885	Jari (39/100)	Jari	373	584	2725	1402	1323
012850	Jandor (26/54)	Jindour	607.84	383	2104	1086	1018
012884	Sosan (40/102)	Kasol	397	562	2724	1415	1309
012868	Kharihar (34/81)	Kharihar	245.43	342	1881	936	945
012875	Khokhan (35/87)	Khokhan	246.84	692	3193	1634	1559
012852	Sari (26/51)	Kothi Sari	251	440	2120	1063	1057
012855	Majhat (30/68)	Majhat	102	161	764	387	377
012858	Pichhli (31/69)	Mangarh	268.05	287	1584	806	778
012894	Manjhli (37/93)	Manjhli	373.78	588	2811	1445	1366
012859	Mashna (31/70)	Mashana	190.1	171	936	491	445
012873	Mohal (35/84)	Mohal	160.85	737	3150	1576	1574
012876	Neol (35/88)	Neol	199.24	414	2203	1120	1083
012895	Parli (37/94)	Parli	521	949	5073	2637	2436
012866	Peej (34/77)	Peej	572	580	3114	1601	1513
012856	Phallan (30/66)	Phallan	204	217	1203	605	598
012881	Pini (25/48)	Pini	301	507	2593	1332	1261
012897	Raila (42/105)	Raila	569	980	4704	2430	2274
012871	Rajgiri (35/82)	Rajgiri	31.94	73	375	191	184
012872	Shillihar (35/83)	Rajgiri	165.34	317	1721	879	842
012888	Chong (38/96)	Ratocha	287	356	1706	860	846
012890	Ratocha (38/95)	Ratocha	217	265	1468	748	720
012892	Rote-II (42/107)	Roat	415	799	3916	2008	1908
012887	Shat (38/98)	Shat	231	291	1633	806	827
012889	Jallu (38/97)	Shat	234	376	1857	930	927
012899	Rote-I (42/107)	Talara	318	418	2184	1141	1043

3.3 Profile: Development Block – Banjar

Banjar is a Block placed in Kullu district in Himachal Pradesh. Positioned in rural region of Himachal Pradesh, it is one of the 5 blocks of Kullu district. As per the administration register, the block code of Banjar is 27. The block has 43 villages and there are total 12361 houses in this Block.



Map 3.4 Village Population Map of Banjar Block (Census 2011)

As per Census 2011, total population of Banjar Block is 62390. Out of this, 31834 are males while the females count 30556 here. This block has 8061 kids in the age group of 0-6 years. Among them 4017 are boys and 4044 are girls. Literacy ratio in Banjar block is 69%. 43248 out of total 62390 population is educated here. In males the literacy ratio is 76% as 24502 males out of total 31834 are educated whereas female literacy rate is 61% as 18746 out of total 30556 females are literate in this Block. The Negative part is that illiteracy rate of Banjar block is 30%. Here 19142 out of total 62390 individuals are illiterate. Male illiteracy rate here is 23% as 7332 males out of total 31834 are uneducated. In females the illiteracy ratio is 38% and 11810 out of total 30556 females are illiterate in this block. The count of employed individual of Banjar block is 41907 still 20483 are un-employed. Out of 41907 employed people 24339 individuals are fully dependent on agriculture.

Population Table of Banjar Block

Village Code	Village Name	Panchayat Name	Area (Ha.)	Household	Population	Male	Female
012924	Bahu (9/27)	Bahu	167.9	210	1033	503	530
012923	Bala Gad (7/23)	Bala Gad	460	620	3006	1538	1468
012905	Manyashi (2/6)	Benagi	209	235	1257	628	629
012920	Thati Bir (5/18)	Bir	167.57	300	1611	811	800
012935	Bihar (11/33)	Chahni	272.08	373	1896	953	943
012934	Bini (11/32)	Chaihni	105.29	130	651	316	335
012901	Chakurtha (1/2)	Chakurtha	329	279	1443	741	702
012916	Chanon (5/19)	Chanon	314	392	2103	1044	1059
012925	Chethar (7/22)	Chether	110.8	166	854	432	422
012914	Deotha (5/14)	Deotha	149	170	812	387	425
012915	Thani Char (5/15)	Deotha	169	150	738	370	368
012903	Dhaugi (1/4)	Dhaugi	399	503	2387	1203	1184
012904	Dusharh (2/5)	Dusharh	177	474	2005	1044	961
012908	Gara Parli (41/103)	Gara Parli	218	207	1025	514	511
012918	Sehuli (5/16)	Gopalpur	100.29	130	690	349	341
012919	Jauri ((5/17	Gopalpur	155.51	175	970	489	481
012913	Kalwari (4/12)	Kalwari	275	306	1539	805	734
012902	Kanon (1/3)	Kanon	242	337	1602	825	777
012926	Khabal (8/24)	Khabal	221.07	342	1882	979	903
012933	Rashala (10/31)	Khadagarad	101	184	853	414	439
012932	Ghiaghi (10/30)	Khadargar	63	124	618	317	301
012900	Kotla (1/1)	Kotla	308	467	2347	1185	1162
012921	Ratwah (6/21)	Manglaur	135	229	1082	541	541
012922	Tarangali (6/20)	Manglaur	155	279	1253	625	628
012941	Mashyar (14/39)	Mashyar	260	323	1716	855	861
012927	Mohni (8/25)	Mohni	211	345	1673	861	812
012937	Pakhari (12/37)	Nohanda	356	275	1477	765	712
012938	Tinder (13/36)	Nohanda	300	234	1048	562	486
012917	Palach (4/13)	Palach	362.7	456	2418	1230	1188
012906	Sachen (2/7)	Sachen	241	401	1994	1075	919
012931	Sajwar (10/29)	Sajwar	155	200	1079	556	523
012909	Shangarh (3/9)	Shangarh	171	200	1064	567	497
012910	Lapah (3/8)	Shangarh	107	32	203	104	99
012907	Shanshar (41/104)	Shanshar	374	566	2681	1362	1319
012936	Sharchi (12/34)	Sharchi	345	454	2413	1256	1157
012940	Shilhi (12/35)	Shilhi	148	225	1243	636	607
012911	Shapnil (4/11)	Shiri Kot	75	91	485	245	240
012912	Siri Kot (4/10)	Shiri Kot	140	113	648	335	313
012930	Tandi (9/28)	Tandi	211	295	1479	775	704
012928	Seraj (8/26)	Til	307.53	482	2439	1273	1166
012929	Karshai Gad-II (23/72)	Til	15.13	64	344	172	172
012939	Chippni (14/38)	Tung	261	405	2145	1051	1094

4

Climate Change: District Kullu

4 Climate Change: District Kullu

As per the references available, climate change is reality as far as farmers in Himachal Pradesh are concerned and more particularly farmers in Kullu valley are the worst affected. Failure of large number of crops and decline in apple production due to rising temperature and reducing chilling hours during the last two decades have affected more than 80% peoples livelihood dependent on agricultural pursuits. Following points indicates vulnerability of Kullu district to the changing climate.

(i) Kullu valley is witnessing unusual congestion of multiple economic processes happening simultaneously.
(ii) Dwindling population of honeybees in wild fauna, a cause of concern to apple production.
(iii) Dependence of 92% of cultivated area on rains for its water requirements as only 7.92% of the net cultivated area is under irrigation.
(iv) Dependence of large percentage of rural population on forests, agriculture and horticulture based livelihood.
(v) Agriculture is the main occupation of around three quarter of the total rural population and apple cultivation/ production is the major source of income.
(vi) The Beas River is the life line of the district on which the entire economic growth and livelihood about 90% people depends.
(vii) Indicators of warming trend of Himalayas have become perceptible, visible and measureable and have forced farmers to abandon one set of crops and adopt new ones as it has become unprofitable to grow apples in lower parts of the valley.
(viii) Himalayan glaciers and alpine grasslands two most sensitive hot spots identified and indicated at national level are having sizable presence in the Kullu valley.
(ix) 37% of the geographical area of the district lies in high sensitive seismic zone –V.
(x) Kullu valley is a part of Himalayan Geothermal Province (HPG) and a number of hot water spring are located here.

The manifestation of the climate change in Kullu valley has been noticed as below:

- The observations made by independent studies indicates that in the recent years temperature has risen in the Kullu valley more than anywhere else. The scenario for the valley would be very severe as indicated by future projections made based on regional climate model of the Hadley Centre (HaDRM3). The projection for Kullu indicates a rise of more than 2.47^{o}c temperature accompanied by substantial decline in precipitation during critical months.
- In consequence to the rising temperature and windward disposition glacier retreat in the valley has been observed to be more than anywhere else.
- Number of moraine dammed and glacial lakes formation posing GLOF threat is also relatively higher in comparison to other river basins.
- Decrease in rainfall and particularly in winter precipitation coupled with rising winter temperature has affected the apple belt more than in other valleys. The shift in apple belt is also more perceptible than in other parts of the State.
- The valley has maximum concentration of eco sensitive areas such as wildlife sanctuaries and an important Great National Park.
- The studies available so for indicate maximum shift in vegetation species recorded in the valley. Increasing anthropogenic stress on account of undesirable interference from power projects and tourism. The Kullu valley has the largest number of mega power projects under implementation.
- Increasing frequency of weather related hazards such as cloud bursts and flash floods. Exponential increase in the ecological foot prints of tourist towns such as Manali surpassing the carrying capacity.
- Identification of Kullu district for implementing water challenges by the technology mission war for water.
- Adverse impact on the livelihood of marginal farmers and increasing threat to social harmony in otherwise exclusive and contended society

– Fast rate of glacier melting and increasing frequency of natural disasters such as floods, flash-floods, and cloud burst etc. Shifting agriculture and horticulture areas is also threatening the cultural harmony changing social milieu.

In view of the fact that a large number of mega project such as construction of Rohtang tunnel is about to complete and projects for harnessing power potential worth 5500 MW are in the pipeline it would be imperative that a rigorous assessment of the situation made for understanding the sociological, biological, geophysical and livelihood implications of changing climate and a adaptation strategy is put in place for coping with the situation. The impact of change in weather components such as rainfall and temperature even on large number of crops and vegetable that are grown in the valley have been noticed. Significant impact on cauliflower and cabbage has been successfully documented. Over all one can conclude that the climate change is today's reality and need corrective measures.

4.1 Precipitation and Temperature Change

Kullu district receives heavy rainfall during the monsoon season from July to August. Heaviest rainfall occurs at Kothi near Manali while lowest occurs near Pulga in Parbati valley. The analysis of 15 years of average monthly rainfall for the basin indicate that maximum rainfall occurs during July and August and minimum rainfall occurs during October-January. There are rainguage stations that are located at different altitude locations they are at Bhunter (1080 m), Manali (1926m), Sainj (1348 m), Larji (995 m) & Bajaura (1000 m).

The studies to assess the impact of climate change on the behaviour of precipitation and temperature has been attempted at regional level by various researchers using long term data studies carried out by *Bhutiyani et. al. (2009)* for assessing the precipitation variations in the north western Himalayas using available instrumental records for the period from 1866-2006 observed significant decreasing trend in monsoon precipitation and increasing trend in annual temperature. The warming was observed to be more during the winter season. Negative relationship between mean winter air temperature and the decreasing snow fall on the wind word side of the Pir Panjal Himalayan range was also noticed. The study concluded that in the last century overall rise in air temperature in the northwest Himalayan region was as high as 1.6 degree C. Decrease of snowfall and reduction in effective duration of winter was also observed in Pir Panjal Himalayan ranges *(Bhutiyani et. al 2009)*

The study carried out by *Sontakke et. Al. (2005)* using quantitative subjective approach carried out analysis of rainfall fluctuation over 49 physiographic sub division provinces in the country made following observations for the Punjab Himalayan of which H.P is the part:

1) Winter rainfall shows decreasing trend.
2) Summer rainfall shows increasing trend.
3) Summer monsoon rainfall shows decreasing trend.
4) Post monsoon rainfall shows no trend.
5) June rainfall reflects decreasing trend.
6) July rainfall shows decreasing trend.
7) August rain fall shows decreasing trend.
8) September rain fall shows decreasing trend.

The observation made by *Shekhar et. al.* after analyzing the data from 18 high altitude observatories of SASE made startling inferences on the temperature variations. He observed that over Western Himalayas:

– Second (November-April) mean, maximum and minimum temperature have increased by about 2°C, 2°C and 1°C in the last two decades.

- The temperature maximum is increasing at a greater rate than the temperature minimum on the Pir Panjal range bordering the Kullu on its northern side.
- The seasonal snowfall has decreased by 280 cm, over the Pir Panjal and by 440 cm over the Greater Himalayan over the period 1988-89 to 2007-08. Both these ranges define the snowbound catchment of the Beas basin.
- There is decreasing trend in the number of WDs and reduction in the number of snowfall days during the months January to March.

Studies carried out by other researchers to understand the Long-term weather trends for NW Himalaya made the following observations:

- Maximum & Minimum mean annual temperatures shows significant rise with higher winter warming .
- Arise of 1.6^{o}C was observed in a century for NWH. Effect of physiographic setting was perceptible on net increase of Temperature at Shimla, Leh & Srinagar.
- Total annual rainfall for Punjab Himalaya showed a decreasing trend.
- Scanty rainfall during 1999-200 resulted in the outbreak of Army Worm.
- The gross rise in temperature in Himachal Pradesh and Kullu valley in the last two decades has been reported to be very substantial and significant at 95% confidence level.

Gross Increase in Winter Mean Air Temperature in The Last Two Decades in Himachal Pradesh

(Source: *Bhutiyani et al.* 2007)

Sr.	Station name	Mean Max in ^{o}C	Mean Min in ^{o}C	Average Winter ^{o}C
1.	**Bahang (2,192)**	4.0*	1.8*	3.8*
2.	**Solang (2,480)**	4.4*	2.0*	3.8*
3.	**Dhundi (3,050)**	5.6*	1.0	3.2*

Short term, local level trend analysis have been carried by using data from research stations of Agriculture universities and IARI stations located in the Kullu valley. Like in other parts of the Himalayas where significant increase in annual temperature have been recorded in the last century the temperature data for metrological station located in the vicinity of the Kullu valley have also shown an increasing trend.

From his study *Tej Pratap* reported that temperature in lower parts of the Kullu valley i.e. at Bajaura has been steadily rising resulting in shorting and warming of winter season and lengthening of warmer season. The weather station at Bajaura recorded a rise of 1^{0} C in average annual temperature and irregular precipitation. Likewise he observed retreat of glacier from upper parts and attributed reduction and irregular rainfall pattern responsible for changed season lengths. In *Kullu valley between the altitudinal zone 1200-1800 msl. me*an annual temperature showed an increase of 2.8^{O}C.

During *rabi* the temperature increased by 3^{o}C and *kharif* season showed no change in mean temperature during the past 34 years. Mean temperature showed increasing trend in all the months except June and October. June to September mean temperatures showed a decreasing trend .Rainfall showed a decreasing trend of 20.1 mm and Rabi winter seasons showed a decrease by 47.1 mm whereas Kharif season showed an increasing trend.

Vishva Kumara et. (2003) reported decreased in rain fall by about 7 cm, snow fall by about 12 cm. But the mean minimum and maximum temperature have increased by 0.25-1^{o}C in 1990s as compare to 1980s. Limited studies carried out at single station at Nagar by *Kumar et. al.* 2009 following observations were made:

- Very slight increase in annual snow accompanied by late snow fall in some years.
- Increasing trend of annual precipitation. In comparing to the period 1963-72 there was 5.22 mm more rainfall per annum during the period 1995-2004. In the month of April alone an increase of 1.81 cm was observed but in the month of May the rainfall exhibited a declining trend and June accounts for 1.79 cm rise in annual rainfall. The rainfall pattern also reflected delayed onset of autumn.
- The average minimum temperature showed an increase during 1962-2004 for all the months. The highest increase in monthly minimum temperature was recorded for the month of July (2.3^{o}C) and for the month of Dec. (0.89^{o}C). The study reported that average minimum temperature had gone up by (1.52^{0}C). Similarly, mean maximum temperature for all the months except Feb & June showed an increasing trend. The highest increase was observed for the month of April (2.37^{o}C) from 1963-72 to 1995-2004.
- Climate data recorded at Naggar in Kullu valley showed an increase in both minimum (0.35^{o}C) and maximum temperature (1.1^{o}C) and decline in average annual rainfall in the 9th decade. Decrease of nearly 9.01 cm in annual average rainfall in the second half of the century.

4.2 A1B Projections

The only attempt made pertaining to the state of Himachal Pradesh is part of NATCOM assessment by YS Parmar University Nauni Solan. This study has made the following projections for district Kullu.

- Increase in maximum and minimum temperature will be by 2.77^{o}C and 2.17^{o}C with a seasonal average of 2.47^{o}C The increase in winter will be higher.
- The district will have increased rainfall except in January April and June months
- The rain will be less by 5.70% in Jan. 8.57% in April and 2.3% in June
- The temperatures are projected to rise by 1.84^{o}C in Aug and by 3.55^{o}C in Nov
- The winter months will be warmer by 2.773 ^{o}C to 3.55 ^{o}C compared to summer when it may remain between 1.54 ^{o}C to 2.04 ^{o}C.

Trend of snow-fall at different altitudes in Himachal Pradesh

(Source: *Bhutiyani et al.* 2007)

S. No.	**Snowfall depth**		
	Station	**Time Period**	**Time Period**
1.	Bhang	(-) (1974-2005)	(-)* (1991-2005)
2.	Solang	(-) (1982-2005)	(-)* (1991-2005)
3.	Dhundi	(-) (1989-2005)	(-) (1991-2005)

(+), Increasing (-), decreasing trend, * Significant at 95% confidence level.

Bhutiyani et. al. (2007, 2009) after analyzing the data from stations of SASE located in Himachal & J&K observed as follows:

- Glaciers in the Himalaya owe their origins and persistence to precipitation brought by the Indian monsoon system (ISM) which forms a part of larger Asian Monsoon System (AMS). It is evident from the above account that like in other parts of Himalayas the data for Beas basin is very sparse and highly inadequate.

4.3 Aerosol/ Studies

Apart from rising temperature, decreasing precipitation and increasing GHG the other factor that has been attributed to be driving the mass balance losses of the glaciers is the atmospheric brown clouds *(Ramanathan et. al. 2007)*. China and India have been termed as global hotspots for black carbon. Using unmanned aircraft based measurements on the amount of sunlight absorbed by black carbon

Ramanathan et. al. found that black carbon contributes to the atmospheric warming in the region. He further estimated that combined effects of black crobon and GHGs may be sufficient to account for a warming trend of 0.25^{o}C per decade in the Himalaya. It is believed that dust storms originating from different desert regions of the world including Thar Desert are transported by wind over to Himalayas. These dust storms along with aerosol generated by various anthropogenic activities have been responsible for accelerating the retreat of glaciers in Himalayas. The desert dust mixed with aerosols resulting from anthropogenic sources complicates the interactions between the atmosphere and dynamics of glaciers in Himalayas *(Ramanathen et. Al. 2005)* Episodes of dust storms is common in pre-monsoon period when the dust storms have been found to be reaching high altitude over Himalayas. As reported by Anup et al during the year 2010 one dust storms is found to be reaching up to 7 km over the western Himalayas on May 27. The CALIPSO profile along with surface elevation profile indicates that height of dust extending over higher mountain ranges of Kashmir and Himachal Himalayas.

The studies on aerosols are being carried by scientists from GB Pant Institute in Kullu valley The on BC at Mohal in Kullu valley showed hourly average value always above 2500 ng m-^{3} *(Kuniyal 2010)* Kuniyal even observed BC value going up by 15657 ng m^{-3} in January 2010 and by 15006 ng m-^{3} in December 2009. According to him the BC recorded a peak in morning and evening hours due to shallow boundary layer in the morning and dispersion of carbon produced by Biomass burning, particular emission and other aerosols. AOD assessment made using Multi Wavelength Radiometer (MWR) showed highest ever AOD at 500 nm as 0.55∓0.03 in May 2009 which was 104% more than mean AOD value for April 2009 (Kuniyal et. al. 2009) Temperature rise due to radioactive forcing from aerosols in the atmosphere was calculated as high as 0.95 Kelvin (K) day^{-1} during summer (April-July) and as low as 0.51 K day^{-1} during the winter season from December to March *(Gulerial et. Al. 2010)*

An experiment conducted on Gara glacier in H.P by GSI for triggering artificial augmentation of glacier melt during lean season revealed that the coal dust of 30 mesh size spread at the rate of 400 g/m^{2} produced the maximum effect and increase in aerosol/dust cover over from 2 mm to 4 mm thickness was not likely to increase the glacier melt. The above account suggest that even though at present the level of understanding on the aerosols and their potential impact on glacial dynamics is not very clear yet contribution of black carbon cannot be overlooked when assessing the warming impact of glacial mass balance in Beas basin.

Several vulnerability assessment analysis have been carried out in different fields including climate, agricultural sciences, social sciences, geography and environmental sciences. Some analysts have used theoretical perspectives to define the nature of vulnerability *(Cutter 1996, Villa and McLeod 2002, Turner et al. 2003)*, while the others have developed some quantitative measures for vulnerability *(Gogu and Dassargues 2000, Cutter et al. 2003)*. Vulnerability assessments are subjective and difficult to quantify due to the complexity of issues.

4.4 Climate Change Vulnerability Assessments

The State of Himachal Pradesh through Department of Environment, Science & Technology has prepared a comprehensive "State Strategy & Action Plan on Climate Change (SAPCC)". Under this action plan block level climate change vulnerability assessment has been undertaken. The philosophy and concept of Exposure, Sensitivity and Adaptive Capacity has been used to analyse climate change vulnerability assessment. The findings of SAPCC are as under:

Climate Change Vulnerability Index of Kullu District (Block Level)

Sr. No.	Blocks	Components			Vulnerability Index
		Exposure	Sensitivity	Adaptive Capacity	
1.	**Naggar**	0.54	0.29	0.51	0.64

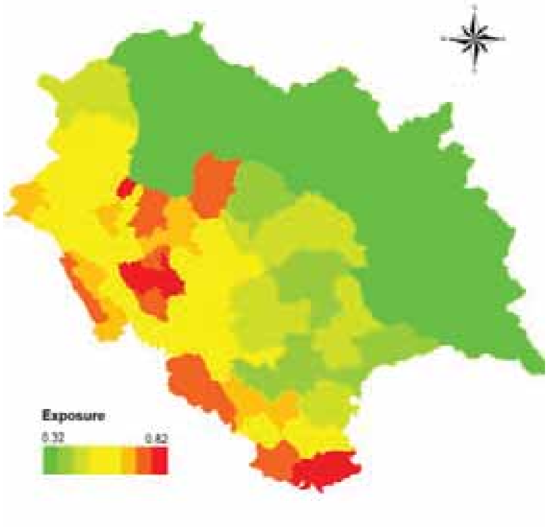
2.	**Kullu**	0.58	0.27	0.49	0.75
3.	**Banjar**	0.51	0.31	0.47	0.67
4.	**Ani**	0.55	0.28	0.49	0.70
5.	**Nirmand**	0.50	0.26	0.49	0.60

Higher the value, high is the vulnerability

Source: SAPCC, Himachal Pradesh

Exposure

The exposure has been determined in terms of climatic variables such as annual mean temperatures, annual mean rainfall pattern and no of extreme events, rainy days etc. It has been observed that the Himachal Pradesh is exposed to a range of climate conditions and extreme events. In particular, some of the key features of the region's climate are the influences of monsoons, the El Niño-Southern Oscillation, and cyclones on the rainfall in the State. Most part of the State is adapted to, and thus reliant upon, the annual monsoon occurrence, which makes it vulnerable if the monsoon fails and rainfall is significantly limited/less. Meanwhile, variability associated with the El Niño-Southern Oscillation, and particularly El Niño events, contributes to cyclic droughts. Besides, much of area gets affected by tropical disturbances and their associated high winds, snow, hail storms, and extreme rainfall. These climate challenges are the permanent features of the Himachal Himalayan region, but that may be significantly altered by anthropogenic climate change in the decades ahead as well.



Map 5.1 Exposure Map of HP

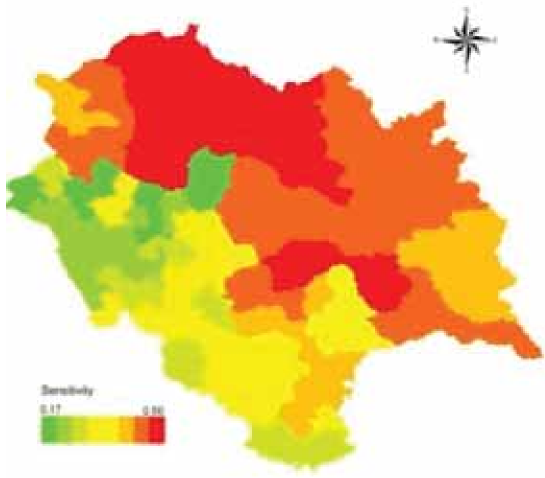
Temperature is a critical parameter of climate which strongly influences people, biodiversity and ecosystems, important driver of natural and man managed systems. As per the analysis, in the last few decades, the average temperatures have been found to vary from normal ranges for Himachal Pradesh and yearly variations in average temperature are indicative of this trend. Variability, leading to higher temperatures shows higher exposure level of the different Blocks in different districts.

Precipitation is an important component of the water balance and ecosystem. Normally, rainfall patterns are dependent on a range of factors such as topography, local climate and wind patterns. In Himachal Pradesh, as per analysis of the long term database it is observed that during the past century, some areas have experienced an average rainfall, some areas have experienced increase in the rainfall and few areas have faced reduction with variation in frequency and intensity. A change in the timing of run-off impacts the water availability, which will resultantly impact progress in developing areas, crops, agriculture, livelihoods and eventually the entire economy. Average rainfall and change in pattern in different region shows higher level of exposure to climate change.

*The analysis of results reveals that the low lying areas of Himachal Pradesh are highly exposed to climate change. The areas falling in Hamirpur, **Sirmaur**, Solan and Una districts are highly exposed whereas, Kangra, Chamba and Mandi districts are also exposed but comparatively less than the above districts. Likewise areas falling in and Shimla and Kullu districts are also moderately exposed to climate change.*

Sensitivity

The sensitivity component includes four indictors such as Agriculture-livelihoods, Water resources, Forests and Health. It has been observed that, Besides being exposed to a variety of climate hazards, the vulnerability of Himachal Pradesh in the Himalayan region also gets affected by the sensitivity of different neighbouring States and sectors to these hazards when they occur. For example, with much of their subsistence and economic growth dependent upon agriculture, the potential for widespread adverse impacts is enhanced in these areas. Likewise, the existing water resources are limited in many areas under development, as is subsequently, access to safe drinking water, sanitation, and irrigation. In case of drought or flood, the ability to safely and efficiently manage water storage, diversion, and delivery would be easily compromised. Settlements and



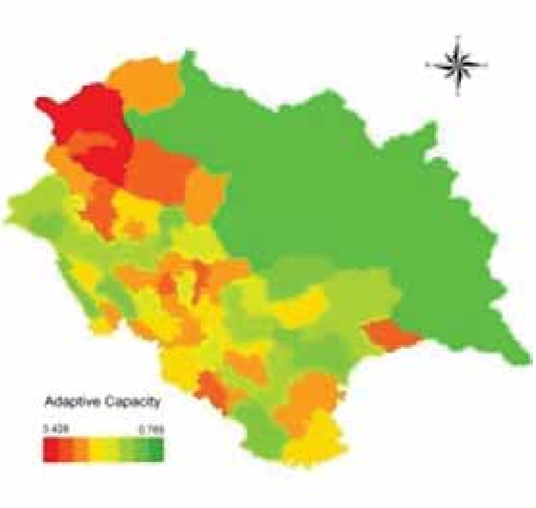
Map 5.2 Sensitivity Map of HP

infrastructure in Himachal Pradesh tend to be more susceptible to the effects of climate extremes and are more likely to be damaged. The analysis shows that low-lying river bed areas, including hydro power projects, are more sensitive to the effects of water level rise and flood like situations and thus have potentially more to lose from climate change than the other regions. Statistics indicate that extreme events in the region are associated with significant financial losses as well as the loss of lives, and as explained above such disasters in the region has increased in recent decades/years.

There are few regions where forest cover has decreased and less forest cover would thus be more sensitive and vulnerable to climate change if the same trend continues. Land use change has a direct linkage with climate change. The deforestation, habitat fragmentation, urban expansion and other developmental modifications have significantly changed the land use patterns. Extensive land use changes have an impact on livelihoods of people and ecosystems. The areas where agriculture workers are more would be more sensitive to climate change. Clearing of vegetation leads to degradation of area and enhances the sensitivity towards climate variability; resultantly the biodiversity gets impacted adversely. Further, an increase in gross sown area will raise the sensitivity levels of the different areas of various districts. Higher family size or the birth rate would increase the sensitivity since there will be competition for scarce resources. The analysis depicts different levels of sensitivity with different trends of indicators.

Adaptive Capacity

The socio economic conditions give measures on adaptive capacity which contain economic capacity, poverty rate and, roads connectivity, literacy rate, environment management infrastructure with population density. Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies. The presence of adaptive capacity has been shown to be a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (Brooks and Adger, 2005). Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season.



Map 5.3 Adaptive Capacity Map of HP

From analysis of database it is evident that the areas which have high percentage of poverty are more exposed shows low economic capacity and, therefore, has less adaptive capacity and more vulnerability. Higher literacy rate, road network shows higher adaptive capacity. More is the population, lesser the adaptive capacity in the region.

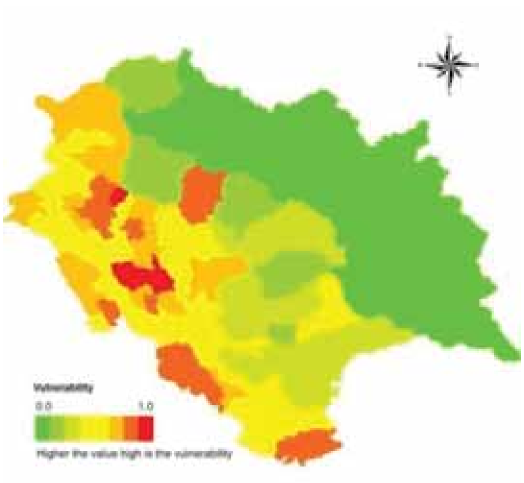
Vulnerability

The analysis of the index of vulnerability at the Block level of all districts of State has been calculated and analysed using index based approach which primarily is an outcome-based vulnerability measurement.

From the analysis it is observed that the adaptive capacity of Lahaul & Spiti, Kinnaur, some areas of Kangra, Shimla and Mandi districts is better. The adaptive capacity of District Chamba, Hamirpur, Una, Solan and Sirmaur is poor to cope with the impacts of climate change.

When combined together all the three components i.e. Exposure, Sensitivity and Adaptive Capacity, the results indicates that Hamirpur, Kangra, Una, Solan, Bilaspur, Sirmaur districts are highly vulnerable to climate change whereas, the districts Mandi, Shimla, Kullu, Chamba are moderately vulnerable.

The Vulnerability Index tries to capture a more comprehensive scale of vulnerability to give composite Vulnerability Index. It has been calculated by including many indicators that serve as proxies to look at different aspects of vulnerability. In other words, it has been assumed that vulnerability can arise out of a variety of factors. In particular, different sources of vulnerability; broadly climatic factors, demographic factors, agricultural factors and occupational factors has been taken into consideration.



Map 5.4 Vulnerability Map of HP

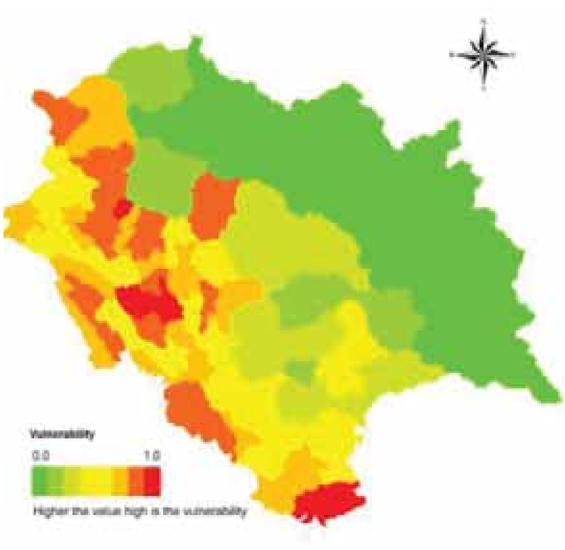
Projection of Scenarios 2020 and 2030

It has been observed that the Himachal Pradesh receives most of its rain during the monsoon season, which starts in the late June. The mean seasonal precipitation simulated by PRECIS shows variations for Indian sub continent. Under A1B scenario, mean annual rainfall is projected to increase marginally for the State by about (5% to 13%) i.e. 70-200 mm by 2030. Increase in monsoon season, and marginal increase in other seasons with increase in rainy days.

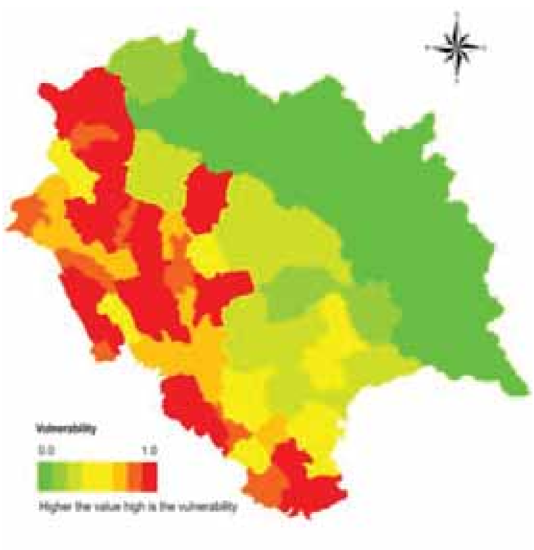
Besides, on the basis of available data base w.r.t. temperature (max & min) and precipitation form IMD Pune and after working out the decadal variation on average basis, decadal scenarios for climate variations i.e. variations in rain fall and temperature for 2020 and 2030 have been projected (No specific PRECIS or HADCM simulations have been worked out for Himachal Pradesh separately) and have been further analyzed for deriving Vulnerability Index while assuming that the sensitivity and adaptive capacity would continue to show the same pattern* (The adaptive capacity & sensitivity could not be analyzed for decadal scenarios in view of lack of data base for specific variables and also that the adaptive capacity or sensitivity will not show any change in its pattern in case projected on simple average methods).

* (Even if the increase in biodiversity or growth in infrastructural facilities is observed)

Therefore, the exposure based projections on decadal variations have been plotted on spatial maps to see the likely/ possible changes in 2020 & 2030.



Map 5.5 Vulnerability 2020 Scenario



Map 5.6 Vulnerability 2030 Scenario

It has been observed that the Climate Change vulnerability in 2020 scenario the areas of districts Sirmaur, Solan, Bilaspur, Una, Kangra, Mandi, Kullu, Chamba will be at risk, that means the regions falling under sub mountain zone will be at risk while other will have lower risk.

Similarly, the Climate Change Vulnerability Projections for 2030 indicates that the vulnerability of low lying areas i.e. sub mountain low hills sub tropical region, mid hills sub humid will be at higher risk and high hill temperate wet will be under moderate risk while dry region will be continue to have lower risk even in 2030.

5

Climate Change Hazard Scenarios: District Kullu

5 Climate Change Hazard Scenarios: District Kullu

5.1 Climate Change Induced Natural Hazards

Like in other parts of the Himalaya the glaciers are melting fast in the catchments of the Kullu valley. One of the most adverse consequence of this change that poses the greatest social, physical and economic risks to the people of the districts is the presence of glacial lakes in proximity to the melting glaciers. The glacier lake has the potential to sudden breach due to trigger like avalanche, slope failure and seismicity. The discharge of millions of cubic meters of water and debris from such lakes can destroy every thing that comes in its way. The vulnerability of Kullu is very high as most of the life line infrastructure and population is concentrated along or on either side of the river.

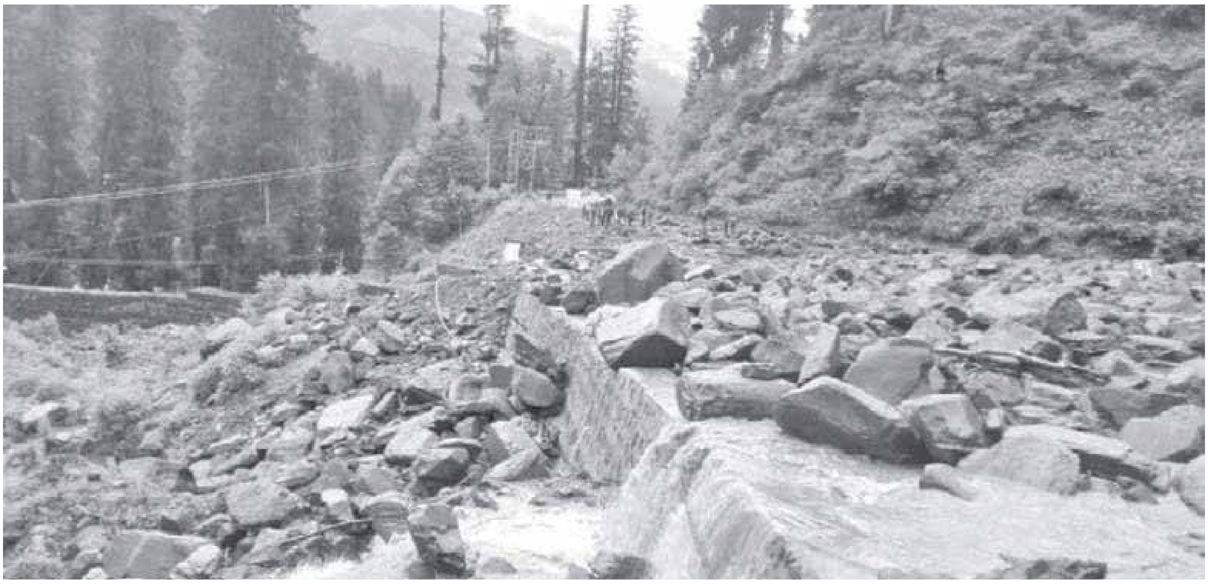
The other climate induced hazards that are likely to impact the Kullu district are the occurrence of cloud bursts accompanied by flash floods. Flash floods that occur with little warning are triggered by intense rainfall, and breech of natural and man made barriers and glacial lake out bursts. Presence of potential glacial lakes in the catchment of the Beas river coupled with the experience of past events poses a serious threat to the downstream people and infrastructure.

Kullu valley is prone to flash floods and the valley experienced noticeable flash floods during the years 1902, 1945, 1988, 1993, 1995, 2000 and 2003. Analysis of discharge data indicate 2100 cusecs at Manali which increases to 14000 cusecs at Bhuntar. Floods on account of high precipitation or cloud bursts cause inundation where carrying capacity of the streams is exceeded. Floods not only causes huge economic loss in the form of damage to houses, roads, bridges, power projects, public utilities but also cause immense loss of human and live stock.

The flash floods and cloud bursts has caused enormous loss of life and property in past. The risk has also grown many times as large number of power projects and drinking water supply infrastructure in the state are situated in the major river basins. During the floods of 2000 the economic loss was estimated to the tune of more than Rs. 1,000 crores and 150 peoples were killed. Every year the relief is distributed to compensate for the losses incurred due to floods of various kinds.

Cloud bursts

Cloud bursts are devastating weather phenomenon representing highly concentrated rainfall over a small area for a short time usually 100 mm of rainfall per hour is reported during such situation. The secondary consequence of cloud bursts is the occurrence of landslides and flash floods causing destruction of houses, dislocation of traffic and human miseries on a large scale. Exact mechanism responsible for cloud bursts is not yet understood. Cloud bursts are generally associated with thunderstorms clouds. The air currents rushing upwards in the clouds hold up a large amount of water. The geography configuration of Himachal valleys provides conducive situation for the vertical lifting necessary for the formation of cumulonimbus clouds of those upward currents suddenly cease the entire amount of water descends on to a small area with catastrophic force all of a sudden resulting in devastation.



The state experience cloud bursts during southwest monsoon period and the frequency is more during the months of July & August.

List of devastating important Floods in Kullu district, Himachal Pradesh

Sr. No.	***Prominent Flash Flood***	***History of Damage Occurred***
1.	*High magnitude floods were also recorded in Beas valley during the year 1902, 45, 93, 95. Continuous anthropogenic pressure on existing Geo-eco system has increased the severity and damaging impact of these flash floods.*	-
2.	*4th and 5th Sept, 1995 flash flood in Kullu valley*	*Flash flood in Kullu valley caused damage to the tune of Rs 759.8 million.*
3.	*4-5 and 12 Sept, 95*	*Flood and landslide along Beas river in Kullu valley killed 65 people. NH damaged at numerous places, loss to government and private property, road and bridges estimated US$ 182 million*
4.	*Cloud bursting Flash floods during the night of 2nd July 2001 in Sainj valley in district Kullu*	*Cloudbursts in the upper reaches of Satluj valley caused flash flood in two nallahs namely, Sainj and Jeeba affecting about 40 families, 2 bridges on Sainj and Jeeba nallahs and plenty of fertile land were washed away. Connecting road to Siund and Sainj was also washed away at a number of places. Two persons and 5 cattle perished. Some other areas in Kullu district were also affected due to excessive rains in July and the population of 6355 was adversely affected.*
5.	*Cloud bursting Flash floods Flash floods during the night of 21st and 22nd August*	*Due to flash flood in village Badhali 2 houses in which a couple was buried alive and their two*

	2001, cloudburst in Ani Sub Division of Kullu district occurred	*children were injured. In village Sarli 7 people lost their lives, 15 houses were washed away besides the loss of 12 cows, 18 oxen and 40 sheep and about 115 bighas of agriculture and horticulture land was washed away.*
6.	*Flash floods induced by cloudburst in Gharsa valley on 16th July 2003 in Kullu district*	*21 people lost their lives, 21 people suffered major injuries and 9 are still missing*
7.	*Flash floods in Kangni Nalla near Solang in Kullu district on 7th August 2003*	*30 people lost their lives, 19 injured, 9 people lost their lives due to landslide near Bhang nalla*
(Source: Bhandari, 1988; Sah et al, 1996; Sah and Mazari 1998; Sah and Bist, 1988; Paul et al, 2000, Revenue Department, Govt. Of Himachal Pradesh)		

5.2 Water Resources

It has been observed that climate change will affect the water balance, run off and recharge characteristics of the river systems. The water volumes stored in glaciers and snow cover are very likely to decline affecting a river flows during summer and autumn. It is also anticipated that resistance of many eco-systems is likely to exceed by an unprecedented combination of climate change and associated climate change drivers.

One of the negative consequence of the rising temperature will be the reduction in solid precipitation, depletion in snow cover and shrinking the size of glaciers. In the long run this will influence very seriously the discharge of rivers when water will be required the most in summer months. The decline in stream flow will trigger multiple impacts, affecting irrigation, agriculture, drinking water and energy sectors the most.

The Beas River a tributary of Indus is the lifeline of Kullu valley and all major activities revolves around this river. Originating from Beas Kund near Rohtang Pass at an altitude of 3978 m it traverse the Kullu district before joining the Pandoh reservoir. The major perennial tributaries of the Beas river in the Kullu districts includes the Parbati, Tirthan, Sainj in the east Solang, Manalsu, Fozal in the west.

All the tributaries joining the main channel from the northern & eastern side are fed by snow and glaciers. The river Beas run through Kullu valley flanked on either side by apple orchards on terraces that contribute 22% to the total production in the State. Assessment on snow and glacier melt contribution to the Beas river at Pandoh was recently carried out by *Kumer et. al.* (2010). It was observed that of the total catchment above Pandoh (5278 km) 45% area remain under snow cover during winter season and about 15% remain under permanent snow and glaciers.

The perennial character to the Beas basin is the result of melting of snow and monsoonal rainfall including the base flows. The variation of discharge over the 15 years of runoff data indicates high discharge during the month of July-September and minimum during January and February. Flow data analysis for the same period suggest that the contribution to the flow during pre-monsoon period (April-June) is mainly due to snow and glacier melt runoff. Whereas the contribution for the monsoon season (July-September) is primarily due to rains.

Using water balance approach Kumar et. al. observed that snow melt contribution to the Beas River varied from 30% to 40% except in 1997 when it was only 11%. This study concluded that average snow and glacier melt runoff contributions to the flow of the Beas River at Pandoh was 35%. This contribution is substantial when compared to the average contribution of Himalayan river which is 25 to 30%. From their study of Hydrological sensitivity of a large Himalayan Basin to climate change *Pratap et. al. (2004)* reported that the impact of climate is more perennial on seasonal rather than annual water availability. Hence it would be highly imperative to understand the over all impact of climate change on glacial balance of hydrological regime of the Beas basin the life line of Kullu district.

For the first time the attempt was made to establish correlation between lean season discharge of Sainj River (a tributary of Beas River) and winter snow fall in its catchment area. The relation between these variables had a high correlation of 0.906. Using this relationship simple linear regression model was evolved to forecast three to four months in advance the lean discharge of Sainj River.

5.3 Snow & Glaciers

Recent report published by ICIMOD identified 5400 glaciers covering 60,000 sq. kms and snow cover area of 0.76 million square kms. within the ten major river basins in Hindukush Himalaya on which 1.3 billion people depend. The intensity of glaciers in the Indian Himalayas is 17% and there are about 9575 glaciers with an area of 37466 Km^2 (Himalaya Glaciology Technical Report No. 2 1st 2012)

Distribution of glaciers in Beas Basin Himachal Pradesh

(Source**:** *Bhagat*, 2006)

S. No.	Basin	Glacier Number	Area (km2)	Ice reserve (km 3)
1	Beas	358	758.18	76.4

In earliest studies involving snow and glaciers assessment at Basin level was conducted by GSI during the year 1979 when aerial extent of snow cover was mapped using landsat data. The data generated as a result of this study provided information on periodic variation of area occupied by barren and continuous snow cover both at spatial and altitude wise. The study also attempted to access diurnal depletion studies at every hundred meters interval from 3200 *msl* to 4000 *msl* on Gulaba and Marhi Slopes. The study concluded that depletion of south facing was higher than on west facing slopes.

The distribution of glaciers and permanent snow fields in Beas basins in Himachal Himalayas

(Source: Kulkarni, et al., 2004)

Basin Name	No. of Glaciers	Aerial Extent (Sq. Km)	No. of snow fields	Aerial Extent (Sq. Km)
Beas Sub Basin	51	503.725	237	312.564
Parvati Sub Basin	36	450.627	131	188.188
Sainj Sub Basin	9	37.255	59	51.934
Satluj Basin	151	616.299	857	544.173

Subsequently again using IRS WiFS data systematic analysis of changes in snow cover was carried out in the Beas Basin *(Kulkarni)* Based on study of data pertaining to the season from October to June between the years 1997-98 and 2001-2002. The study concluded that increase in temperature had started affecting snow ablation and stream run off patterns. The study reported that even in the month of December and January seasonal snow was retreating at higher altitudes. The observations for altitude wise monitoring of snow cover starting from altitude of 1800 m at an interval of 600 m to 5400 m indicated that substantial retreat of snow extent at altitudes as high as 5400 m resulting even in January snow was observed at 4200 m altitude in the Beas Basin which was an usual phenomenon.

In the Beas basin the media started reporting concerns and perceptions of local farmers long back in the year 2003 *(Jagdish Bhat)*, when the report on melting of glaciers posing threat to the Kullu valley appeared in the leading papers. It was reported then that the minimum temperature in the valley had increased by 0.4 degrees from 1960-1990 due to melting of glaciers and formation of moraine dammed lakes is posing a potential threat.

In fact the studies carried out during the period 2003-04 as part of Asia Pacific Network for Global Change Research by ICIMOD provided the first authentic information on the Glacier resource in the Himachal Pradesh.

This database provided the base line data for Himachal Himalayas in general and the Beas Basin in particular. The studies reported through a technical report (TR SAC 2011) also provided information on long term monitoring of snow cover over the Himalayas. Snow cover monitoring for the period 1997-2001 carried out in the Beas Basin by *Kulkarni et. al.* 2011 reported the presence of 304 Km^2 Glacial area in Beas basin.

More recently the studies carried out by *Dutta et. al.* (2012) using satellite images on glacier fluctuations in the Beas basin. According to them the Beas basin witnessed a degradation of about 48.77 km^2 during the period between 1972-2006 which was 11.6% of the glaciated area available in 1972. Another interesting finding made was that smaller glaciers with aerial extent ranging from 2 to 5 km^2 had undergone more de-glaciations in comparison to the larger one having extent more than 5 km^2. As a result of fragmentation the number of glaciers also increased from 224 in 1972 to 236 in 2006.

Similarly shift in average elevation value for the ablation area was also reported from 4486 m in 1972 to 4680 m in 2006.

From the secular movement studies carried out by GSI average retreat of 18.8 m /year was observed for Beas Kund glacier *Kulkarni et. al.* (2007) from their study of 90 glaciers located in Parbati Basin observed that the glacier aerial extent in the year 1962 was 493 (sq. kms) which reduced to 390 sq. kms in 2004 resulting in a loss of 20%. Parbati glacier was identified to be one of the fastest retreating glaciers in the Himalayan region as 96% of its area falls below the altitude of 5200 mtrs.

According to him the area altitude distribution is a dominant factor that influence the retreat of glacier and since in the Himalaya snow line is approximately 5200 m and large part of Parbati glacier is below 5200 m hence it is retreating at a faster rate.

The glacier inventory carried out by Sangwar & Shukla 2009 for the Indus basin have reported the number of 277 glaciers in the Beas basin having total glaciarised area of 599.06 sq. kms. and the glacier parameters in the major river basins in Himachal as per the assessment of *Dobbhal* 1992. Shruti Dutta et. al. from their study of satellite images have mapped the presence of 226 glaciers.

The only glacier that has been studied in greater detail is the Parbati glacier which has been termed as fastest retreating glacier in the Himalayas. Another study recently completed in the Beas basin mapped 226 glacier and 11.6% de-glaciations between the period 1972-2006.

Kulkarni from his study of Parbati glacier observed a massive glaciers retreat of 6.8 km (178 m/year) during the year 1962 to 2000. He observed an overall 19% retreat in glacier area and 23% in glacier volume for the glaciers monitored in H.P. The study also reported that the Parbati glacier continue to retreat gradually the amount of retreat with maximum length that they take place between 2001 % 2022 as 1461 mtrs.

The satellite data study for the years 1990, 1998, 2000 and 2001 carried out to assess the retreat trend of the Parbati glacier the largest glacier in the Beas basin. The study reported that glacier retreated by 578 m between 1990 and 2001 with almost 52 m/year. The rate of retreat was also confirmed by field observations glacier terrain as 2003. The specific mass balance of the glacier is estimated using Accumulation Area Ratio for the year 2001.

5.4 Agriculture & Horticulture

Kullu valley has experienced the most evident and much talked about impact of climate change reflecting equally the perception of both the common man and the scientists. There is a common belief that apple belt has moved 30 kms over the last 50 years. Earlier Bajaura at the lower end of valley at an altitude of was the starting point for apple which now have shifted to Raison in the middle of the valley. In Kullu valley the apple production has declined over time.

Agriculture production is likely to alter due to temperature expected to be much higher in winter than in rainy season. The declining trend in snow fall and rising winter temperature has been attributed to be responsible for reduction in productivity of apple from 7.06 t/ha in 1980-81 to 4.65 f/ha in 2004-05. Climate Change will cause shift in areas suitable for cultivation of a wide range of crops and also geographic distribution of species.

The studies carried out to assess the impact on agriculture sector point out gap in knowledge on present and future impact of global warming agriculture. More research need to be carried out to enhance understanding of likely impacts. Agriculture is the dominance source of livelihood for the people of Kullu. It is therefore imperative that new model are worked out for sustainable farming for the Kullu valley where the farmers at present are experiencing the pressure of second cycle of change after the failure of apple economy.

Hail Storm damaging orchards

Trend analysis of the last few decades reflects that fruit trees, vegetables and agriculture crops were the most affected at the lower altitude in mountain regions where the farmers have shifted from apple cultivation to vegetables like cabbage, peas, carrot and fruit crops like pomegranate, Kiwi, and mid altitudes. At higher elevation the farmers are at advantage situation with opening up of new opportunities due to increased temperature and lengthening of growing period. Hence the farmers have adopted apple cultivation and abandoned the cultivation of traditional crops such as buck wheat, barley, finger millet.

The climate change may affect the agriculture activity in the Kullu district in the following manner:

- Climate change will affect the present land utilization and cropping pattern with the change in weather pattern.
- The areas at high altitude may now support new crops which requires to be explored.
- Crops grown at lower altitude may disappear.

A 4x4 assessment on sectoral regional analysis for 2030 predicted that existing trend of decline in apple production and upward shift in apple cultivation will continue with the increasing temperature through out the Himalayan region. The assessment also reports that livestock productivity is expected to rise in many parts of Himalayan region during March-September with maximum during April-July in 2030 s with respect to 1970s.

The impact of climate has been manifested both positively as well as negatively. On the one hand reduction in chilling hours in the lower parts of valley have caused in the crash in apple economy and on the other hand availability of required chilling has opened up new opportunities and options for the apple farming. People have already reaped the benefits of this new options and the land use status indicates increasing area under cultivation at higher altitude where at present the yield are low but the quality is super.

100% farmers feel that in the Kullu valley snow fall has reduced, temperature increased, glaciers receded, long summers, short winters and erratic rainfall.

When they shifted vegetable and vegetable seed crops the production of these crops are also reported adversely affected and near future diversify is being feel by the farmers. Hence there is a need to develop new viable model regarding the farmers traditional knowledge base. The existing experience and knowledge available within the farming community is adequate to identify and define adaption requirements while the research for better understanding the science may continue. Agriculture is most sensitive and valuable sector to climate change as it is highly sensitive to climate change and it has large direct and indirect effects on the population at large.

The other important impacts of global warming will be change in crop selection and increase in altitude range of cultivable land.

From their study on the importance of pollinators and pollinations in vegetable seed production in Kullu valley Kumar et. al. reported on the temperatures are rising in the valley accompanied with unpredictable period have of rains. The snow fall period shifted and the amount reduced. In consequence of the erratic weather the crop failure have become common. Farmers are of the opinion that crop seasons is preponed by about one month. Even swarming of bees now occurs in February-March instead of April. Reduced and untimely rainfall has affected the sowing and harvesting time especially in rainfall areas. Hybrid seeds are more sensitive to humidity and their germination and development is directly hampered by the changing weather conditions. The farmers have shifted from apple and almond farming to fresh & seed crop of vegetables. Dry spells on account of rising temperature will also affect the quality of vegetable seed production.

Scientists are of the opinion that impact of global warming is already visible on agriculture and several crops may be phased out from the Kullu valley. Temperature fluctuation have affected the cauliflower seed crop. Unpredicted and sporadic rains at Bajaura, Kullu have also resulted into shift from growing vegetable crops for seed production to fresh/table purpose in Kullu valley.

The study carried out by *Bhoomika et. al.* (2007) for investigating the positive and negative effects of climate change on the farmer economy interacted with farmers of four villages located at northern and southern parts of the valley. The findings reported shift in apple belt upward due to climbing temperature rendering lower parts unsuitable for apple cultivation and simultaneously creating new opportunities for the upper valley area resulting in the change of economic status of farmers.

Farmer Perceptions

From the various studies conducted in the valley for capturing the perceptions of the farmers following issues emerged:

i) The farmers generally feel that not only the amount of snowfall has decreased but there is an apparent shift in snow fall timing as well.
ii) The decline in apple production and quality is due to the reduction in chilling hour as the requirement of chilling period of about 10 weeks below 5^{0}C necessary for bud break is not met.
iii) Late snow is less durable and more watery which restricts the activity of bees as effective pollinators.
iv) Watery snow at the time of ripening is seen as source of diseases, damaging fruit quality.
v) Incidence of Canker has increased resulting in demand for more pesticides spray.

Farmers also reported the deteriorating traditional crop base in the valley. Farmers observed that earlier maize could not grow in Manali but now even growing at higher altitude. Similarly, chili that used to stay green now turns red in higher altitude. The crops like *Safed Mash*, wheat that earlier were confined to low height are now even grown at higher elevations as well.

5.5 Forest and Biodiversity

The forests in Himachal Pradesh are highly vulnerable and the climate change will have adverse impact on forest biodiversity, forest regeneration and production. Forest type shifts are expected to occur in more than 80% of forest grids and the vulnerability of higher altitude forests is relatively more. It is believed that incidents of forest fires will increase with the rising temperature. The other impact that is expected is the initial increase in forest productivity.

The forest cover in the state broadly falls under 6 forest type with subtropical covering 3853 sq. kms. Himalayan moist temperate forests covering the maximum area of 4064 sq. km. followed by tropical dry deciduous 2140 sq. kms and sub alpine and alpine forests 2512 sq. kms sub tropical dry evergreen forests and tropical thorn forests 43 sq kms.

The vegetation pattern in the State of HP are closely associated with climate as plant linkage communities with climatic regimes. It is apprehended that climate change will bring about noticeable change in the biodiversity, increase in temperature, changes in vegetation, rapid deforestation and scarcity of water, coupled with habitat destruction and corridor fragmentation may lead to a great threat to the existence of both flora and fauna. Negi (1989) observed that plant texa are impacted differently by climate change. He found that at about 200 m altitude leaf initiation was advanced by a week in 1985 as compared to that in 1986 but this annual shift in occurrence of phenophases was not

observed for all the species. During 1985 when the spring temperature were higher the flowering was advanced by 1-3 weeks in trees like Rhododendron arboseam. Invasion of alien species like lantana in the natural forests is also anticipated due to climate change.

The climate parameters when changes beyond the tolerance limit of species phenotype plasticity the inward and outward movement of species causing change in species composition is inevitable. From their study of species response in Shimla hills *Rana et. al.* (2009) observed that many temperate species had shifted their location by 200-600 m higher than their location during the year 1902.

The alpine ecology nurture very important natural resources and influence the geo-hydrological cycle considerably. Alpine area in the State are particularly vulnerable as many species start their growth with the supply of snow melt. Reduction in snow fall will disturb the growth cycle of such species. Moreover the species within the alpine zone are narrowly distributed limiting scope for expansion due to changing climate as compared to low land vegetation community. *Rana et. al.* have observed that species depending on snow cover for protection are now being exposed to frost at altitude above 2000 m and other requiring winter chilling for bud break may not get sufficient low temperature over long period. He observed that specie like sea buckthorn, Bhojpatra lack suitable corridors to move in response of changing weather condition. The Rhododendrons and other woody species of lower ranges have begun to invade alpine meadows. The most pertinent observation is that of *Dubey et. al*. From this study in Parbati valley of Kullu district they observed higher upward shift rate of 19 m/decade on south and 14m/decade on north slope for Pinus wallichiana at Saram. The species have been reported shifting their location by tracking rather than by evolving new form in a static situation.

Parveen et. al. (2004) from their study on the traditional phytotherapy among the inhabitants of different ethnic groups inhabiting the Parbati valleys observed that these inhabitants are depended on plants for food, fuel, fodder, timber, household articles and medicines to a great extent. They have recorded fifty plant species belonging to 45 families found locally and being used by the ethnic groups as medicines.

The projected impacts on mountain eco-system in Himachal Pradesh:

- Certain biomes such as the evergreen warm mixed forests likely to show marked expansion.
- Tundra and wooded tundra will probably shrink under all possible scenarios.
- Species composition in the new biomes will be different from the existing ones.
- Increased occurrence of fire, erratic rainfall and anthropogenic pressure may inhibit the ability of some species to migrate and establish in new locations.
- Decline in economically and socially important species such as deodar, cedar and oak due to increased climatic and biotic interactions.
- Increase in Blue and Chir Pine species due to elimination of competing species.

In view of the changes observed and projected in Kullu district it would be important to undertake studies for impact assessment and developing adaptation models because the changes such as loss of biodiversity will be irreversible and there is long gestation period in developing and implementation of adaption practices. Moreover the forest sector has large ecological, economic and social implications.

6

Climate Change Vulnerability Assessment - Conceptual framework

6. Climate Change Vulnerability Assessment - Conceptual framework

Vulnerability to climate change is the degree to which a system has the capacity to sustain the damage due to climate change, including climate variability and extremes. The process of identification, quantification and prioritization of vulnerability in a system is referred to as vulnerability assessment. The study of vulnerability or the degree to which the people, environment or agriculture is affected, requires mainly three types of information: (1) exposure, i.e. patterns of exposure to occurrences of hazards such as droughts and floods; (2) sensitivity, i.e. the degree to which the system can experience damages due to a particular event; and (3) adaptive capacity, i.e. the capacity of a system to recover from disaster and hazards.

- ***Exposure*** *can be interpreted as the direct danger (i.e., the stressor), and the nature and extent of changes to a region's climate variables (e.g., temperature, precipitation, extreme weather events).*
- ***Sensitivity*** *describes the human–environmental conditions that can worsen the hazard, ameliorate the hazard, or trigger an impact.*
- ***Adaptive capacity*** *represents the potential to implement adaptation measures that help avert potential impacts.*

The study follow the IPCC Third Assessment Report according to which vulnerability is defined as "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (McCarthy et al.2001). Thus as per this definition, vulnerability has three components: exposure, sensitivity and adaptive capacity.

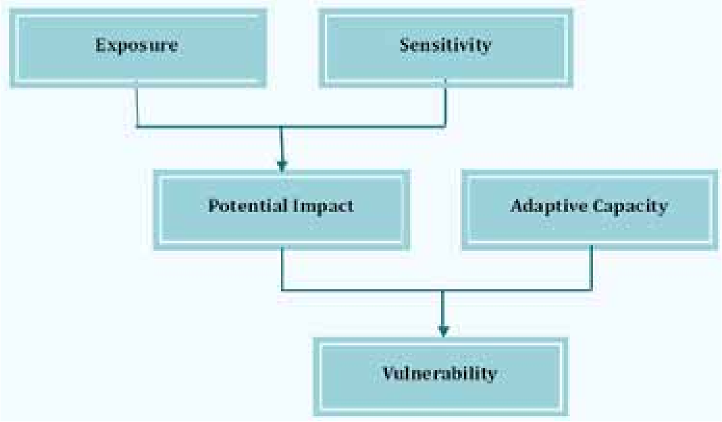


Figure 5.1: Vulnerability

The first two components together represent the potential impact and adaptive capacity is the extent to which these impacts can be averted. Thus vulnerability is potential impact (*I*) minus adaptive capacity (*AC*). This leads to the following mathematical equation for vulnerability:

$$V= f(I-AC)$$

A higher adaptive capacity is associated with a lower vulnerability, while a higher impact is associated with a higher vulnerability. Given the above equation, vulnerability is defined as a function of a range of biophysical and socio-economic factors, aggregated into three components: exposure, sensitivity and adaptive capacity to climate variability and change. This study adopted the IPCC framework of vulnerability.

Exposure

The effects of climate change are different at different locations. Some regions will be warmer than the others. Also, the precipitation patterns shift in different areas will be varying resulting in uneven distribution of rainfall. Some regions will see prolonged dry periods and some will experience both warm and intense rainfall. In correlations with the above statements, exposure relates to the degree of climate stress at a particular location. The exposure can also be determined by the long-term climatic changes or the variation in climate including the magnitude and frequency of hazards (O'Brien et al. 2004).

Sensitivity

The relative importance of the effects of climate change differs for different regions, groups and sectors in society. For example, highly intense rainfall may lead to devastating results in some region, whereas the same may not be of much harm in some other region. The degree to which a system is modified or affected by internal, external, or sometimes both disturbances is defined as sensitivity (Gallopin 2003). The measure that reflects the responsiveness of a system to climatic influences determines the degree to which a group will be affected by the environmental stress (SEI 2004).

Adaptive Capacity

Depending upon sensitivity and exposure, the extent of response to the effects of climate change differs across regions. For example, frequent droughts can be addressed by some farmers by using appropriate irrigation technology, whereas other farmers may not be able to afford such technology or may lack the skills to operate it. Therefore, the ability to adapt to certain changes in condition is very important to determine the vulnerability of a system towards the change. Adaptability, coping ability, stability, management capacity, flexibility, robustness and resilience, all together form the ability of a system to adapt to the changes effectively. Therefore, 'Adaptive capacity' is a significant factor in characterizing vulnerability (Smit and Wandel 2006). Adaptive capacity is also defined as the potential or ability of a system, region or community to adjust to the effects or impacts of climate change (IPCC, 2001). Different countries, communities, social groups, individuals and times have different capacities to adapt (IPCC 2001, Smit and Wandel 2006). The adaptive capacity of a system or society is to deal with the changes in conditions to modify its own characteristics and behaviour (Brooks 2003).

The increase in literacy levels enhances the capability of people to access information and cope up with adversities, resulting in reduced vulnerability (Leichenko and O'Brien 2002). The farms with larger agricultural income, land area, farm value assets and latest technology are able to prepare and respond better as compared to the farms with lower technology. Also, the farms with traditional technologies are assumed to be less economically diversified and more vulnerable to climatic events. The availability of facilities like electricity, education, health care, etc. determines the state of poverty in a region. When two different agricultural regions having the same crops and similar climate are compared with each other, the exposure to climate changes might be similar, but the adaptive capacity and vulnerability could be very different based on the socio-economic factors.

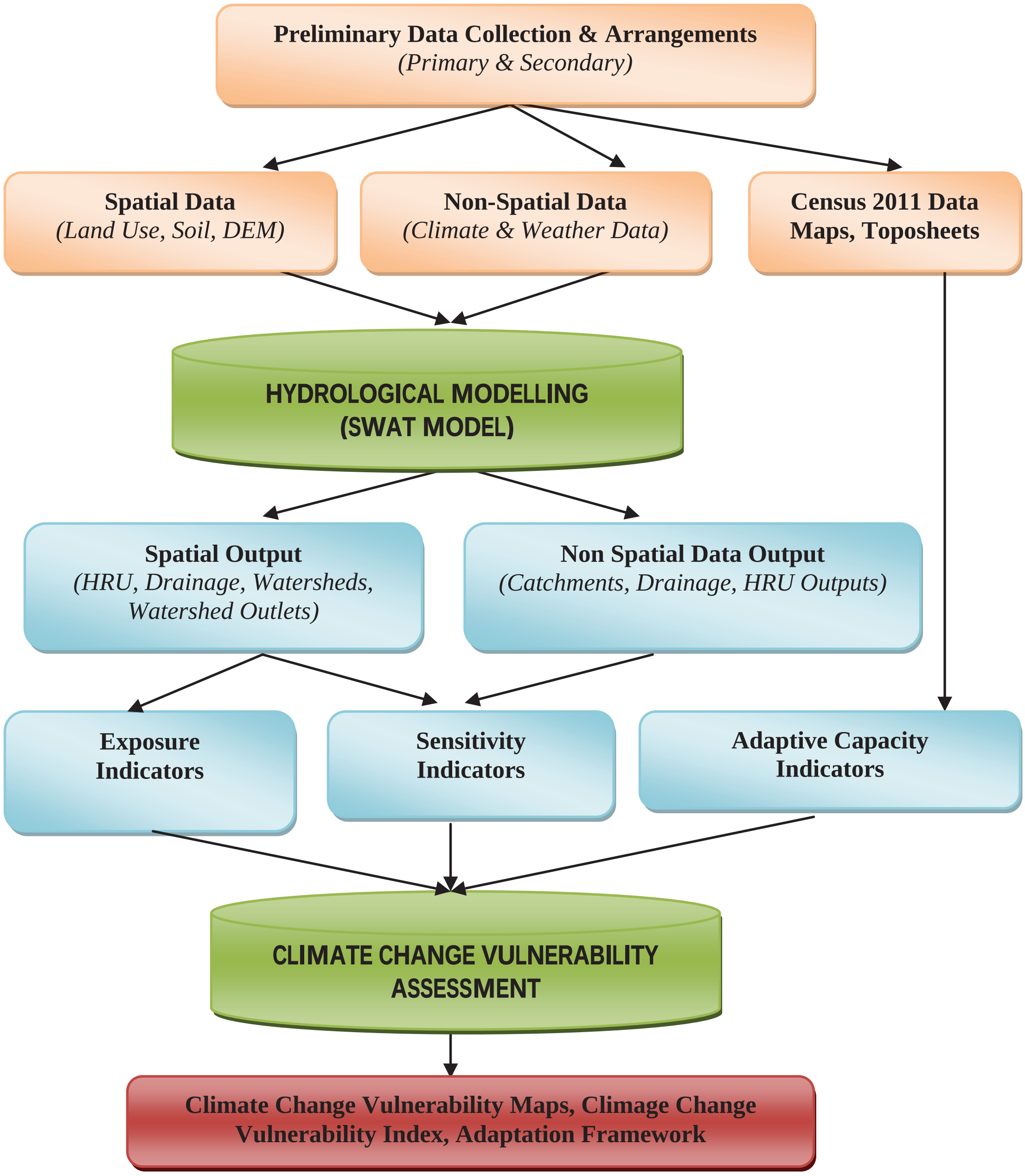
In addition to identification of threat, the analysis of vulnerability also involves resilience or responsiveness of the system and its ability to exploit opportunities and recover from the environmental and climatic changes. Therefore, asset ownership goes hand in hand with vulnerability. The people having more assets are less vulnerable to climate change.

7

Methodology Adopted for Vulnerability Assessment

7. Methodology Adopted for Vulnerability Assessment

Flow Chart
Climate Change Vulnerability Assessment



7.1 Data collection & arrangements

The present study is designed to investigate how climate change is affecting indigenous agricultural based rural community, what makes them vulnerable and how they are coping with the and adapting to the changing climate. The relevant information and data for the study is collected mainly from secondary sources available in publication and reports of various government department and academic institutions. However, some information is collected by conducting primary sample survey at Panchayat & village level.

- **Secondary data Collection**

  An extensive review of the available literature on agricultural, horticultural and water resource sector collected from available published documents/reports/databases of the concerned stakeholder department/ organizations.

- **Primary data collection**

  Primary data collected through semi-structured questionnaire field survey and interviewing stakeholders in all the selected blocks of district Kullu. Interviewees reflected a cross section of age, gender and livelihoods in the indigenous community, including fulltime agriculturists/horticulturists, worker group etc. During present study primary survey is conducted to find out the impact of changing climate in various sectors like traditional cultivation and extraction of different type of agricultural/ horticultural/livestock produce, availability of water source and other important sectors.

Interaction with panchayat representatives

Meeting with panchayat representatives & villagers (Raison Panchayat of Naggar Block)


Consultation Meeting with District Administration at DC Office Kullu

- **Spatial data collected/ generated**
  - Toposheets from Survey of India
  - Administrative Map collection/generation (District, Block, Panchayat/Village)
  - Land use map collection/generation
  - Soil map collection/ generation
  - Digital Elevation Models

- **Non Spatial data collected/ generated**
  - Data collection survey questionnaire.
  - Panchayat & village wise Demographic data.
  - Agricultural, Horticultural, Irrigation, Water resource data
  - Climate/Weather Data [Temperature, Precipitation, Solar Radiation, Related Humidity etc.]

7.2 Mapping & Data Projection

The expert team assessed the situation and arrived at conclusion that preparation of climate change vulnerability assessment report require/ involves several variables.

MAPPING OF THE AREA FOR ANALYSIS

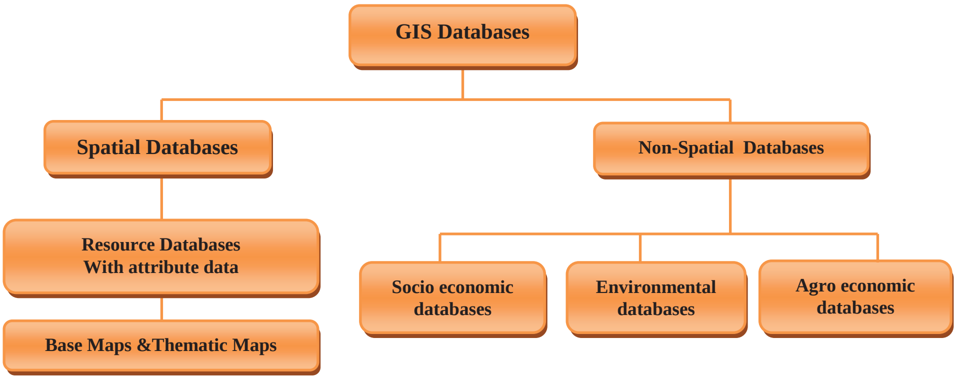


Figure 7.1 Mapping of the Area for Analysis

The mapping and superimposing of data shall not only reduce the volume but also help in area specific problem identification. After primary assessment and identification of thrust areas, climatically vulnerable areas mapping on higher resolution has been prepared for detailed analysis possibly at panchayat level to village level.

7.3 Hydrological Modelling

Hydrology is the study of distribution and movement of water on and below the surface of the earth. When studying the hydrology of a landscape, it is critical to consider the role of environmental changes such as land-use and climate. The implications of land use changes on hydrology have been an area of intense interest to research hydrologists over the last fifty or more years. Issues of land use change affecting hydrology include increasing urbanization, changing vegetative cover, land drainage, and changing agricultural practices.

Hydrological modelling and prediction consists of:
(1) Getting to know the landscape through field visits and expert observation;
(2) Collection of field information to feed into the model, including spatial (e.g. topography, land-use/land-cover, soil), and tabular (e.g. weather and climate) data;
(3) Delineation of the watershed – i.e. mapping drainage areas based on topography;
(4) Simulation of the model to represent and quantify water movement and distribution across the landscape using multiple parameters; and
(5) Parameterization – the process of comparing model generated output with field measured information. The final model helps to quantify the amount of surface runoff, infiltration, evaporation, groundwater recharge, snow melting, evapotranspiration based on a water balance equation.

Predictive hydrological modelling is important for water resource managers, as they require information on the amount of flow required to sustain river ecological processes, and to ascertain how much water is available for out of stream use (e.g. irrigation, municipal water use).

The predictive capability of a hydrologic model is also important for “what-if” scenario analysis. Scenario analysis allows the modeller to play around with different land-use and management scenarios to come up with the optimal scenario for water conservation and utilization.

Hydrological modelling is becoming increasingly complex due to climate change. One can not deny the fact that developments in computer technology have revolutionized the study of hydrologic systems and water resources management. Several computer-based hydrologic/water quality models have been developed for applications in hydrologic modelling and water resources studies. Distributed parameter models, necessary for basin-scale studies, have large input data requirements. One such model available is the Soil and Water Assessment Tool (SWAT), a distributed parameter model developed by the United States Department of Agriculture.

SWAT was developed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long period of time. SWAT is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds. Soil and Water Assessment Tool (SWAT) model (Arnold et al., 1998; Arnold and Fohrer, 2005) has proven to be an effective tool for assessing water resource for a wide range of scales and environmental conditions across the globe.

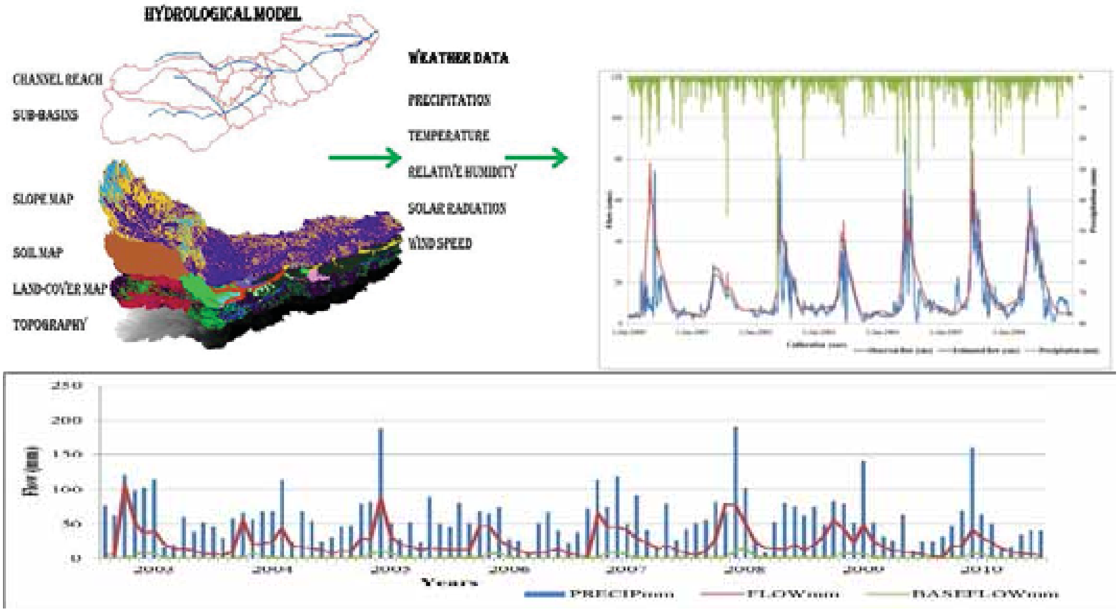


Figure 7.2 Hydrological Modelling Processes

The SWAT model allows basin to be divided into subbasins/sub-watersheds, which can further be divided into hydrological response units (HRUs) which are a unique combination of soil and land cover (Gosain et al., 2013). This model has been used in various studies with a wide range of applications.

7.3.1 Open Source Interface for SWAT

The drainage system of three developmental blocks of district Kullu contributes to Beas River Basin which further merge into Indus River System. Using SWAT model panchayat/village level micro-watershed maps, drainage maps, hydrological response unit maps developed. An open source GIS interface for the QSWAT Model with Quantum GIS (mapping software) used for modelling. QSWAT uses a suite of programs called Terrain Analysis Using Digital Elevation Models to perform various geo-processing functions. It also interact with QGIS itself, particularly the layers panel which shows legend information, and the map canvas where the maps are displayed. QSWAT accepts any raster or vector and several spatial databases. QSWAT can delineate watersheds with the capabilities of DEM pit (depression) removal using flooding approach, calculation of flow paths and slopes, calculation of contributing areas using single and multiple flow direction methods, delineation of stream networks using contributing area threshold etc.

QSWAT creates a number of database tables from the watershed delineation and HRU (Hydrological Response Unit) creation steps.

7.3.2 Datasets/Model Inputs

- **Spatial data**
  - **Administrative Maps**
    District Boundaries, Block Boundaries and Panchayat/Village Boundaries digitized from available toposheets.

  - **DEM (Digital Elevation Model)**
    SRTM (Radar Topography Mission of NASA) Digital Elevation Model data with 30 meter resolution used for drainage and micro-watershed delineation.

- o **Land use Land Cover**
  MODIS (Moderate-resolution Imaging Spectro-radiometer) - based Global Land Cover with 500 meter resolution used.

– **Climate/Weather Data (Non-spatial data)**
  Following climate/weather data is required:
  - o Temperature (C)
  - o Precipitation (mm)
  - o Wind (m/s)
  - o Relative Humidity (fraction)
  - o Solar Radiation

  SWAT requires hourly data on above perimeters. Long term global data for these parameter is used for hydrological modelling.

7.3.3 SWAT Model Results

– SWAT Model generates micro-watershed drainage maps and following output:

OUTPUT
Area drained by reach (km2).
Average daily streamflow into reach during time step (m3/s).
Average daily streamflow out of reach during time step (m3/s).
Average daily rate of water loss from reach by evaporation during time step (m3/s).
Average daily rate of water loss from reach by transmission through the streambed during time step (m3/s).
Sediment transported with water into reach during time step (metric tons).
Sediment transported with water out of reach during time step (metric tons).
Concentration of sediment in reach during time step (mg/L).
Organic nitrogen transported with water into reach during time step (kg N).
Organic nitrogen transported with water out of reach during time step (kg N).
Organic phosphorus transported with water into reach during time step (kg P).
Organic phosphorus transported with water out of reach during time step (kg P).
Nitrate transported with water into reach during time step (kg N).
Nitrate transported with water out of reach during time step (kg N).
Ammonium transported with water into reach during time step (kg N).
Ammonium transported with water out of reach during time step (kg N).
Nitrite transported with water into reach during time step (kg N).
Nitrite transported with water out of reach during time step (kg N).
Mineral phosphorus transported with water into reach during time step (kg P).
Mineral phosphorus transported with water out of reach during time step (kg P).
Algal biomass transported with water into reach during time step (kg chl-a).
Algal biomass transported with water out of reach during time step (kg chl-a).
Carbonaceous biochemical oxygen demand of material transported into reach during time step (kg O2).
Carbonaceous biochemical oxygen demand of material transported out of reach during time step (kg O2).
Amount of dissolved oxygen transported into reach during time step (kg O2).
Amount of dissolved oxygen transported out of reach during time step (kg O2).
Soluble pesticide transported with water into reach during time step (mg active ingredient)
Soluble pesticide transported with water out of reach during time step (mg active ingredient).
Pesticide sorbed to sediment transported with water into reach during time step (mg active ingredient).
Pesticide sorbed to sediment transported with water out of reach during time step (mg active ingredient).
Loss of pesticide from water by reaction during time step (mg active ingredient).
Loss of pesticide from water by volatilization during time step (mg active ingredient).
Transfer of pesticide from water to river bed sediment by settling during time step (mg active ingredient).
Transfer of pesticide from river bed sediment to water by resuspension during time step (mg active ingredient).
Transfer of pesticide from water to river bed sediment by diffusion during time step (mg active ingredient).
Loss of pesticide from river bed sediment by reaction during time step (mg active ingredient).
Loss of pesticide from river bed sediment by burial during time step (mg active ingredient).
Pesticide in river bed sediment during time step (mg active ingredient).

Number of persistent bacteria transported out of reach during time step (# cfu/100 mL).
Number of less persistent bacteria transported out of reach during time step (# cfu/100 mL).
Conservative metal #1 transported out of reach (kg).
Conservative metal #2 transported out of reach (kg).
Conservative metal #3 transported out of reach (kg).

– SWAT Model also generates micro-watershed maps and following output variables:

OUTPUT
Subbasin number
Daily time step
Area of the subbasin (km2).
Total amount of precipitation falling on the subbasin during time step (mm H2O).
Amount of snow or ice melting during time step (water-equivalent mm H2O).
Potential evapotranspiration from the subbasin during the time step (mm H2O).
Actual evapotranspiration from the subbasin during the time step (mm).
Soil water content (mm). Amount of water in the soil profile at the end of the time period.
Water that percolates past the root zone during the time step (mm).
Surface runoff contribution to streamflow during time step (mm H2O).
Groundwater contribution to streamflow (mm).
Water yield (mm H2O).
Sediment yield (metric tons/ha).
Organic N yield (kg N/ha).
Organic P yield (kg P/ha).
NO3 in surface runoff (kg N/ha).
Soluble P yield (kg P/ha).
Mineral P yield (kg P/ha).

– SWAT Model also generates Hydrological Response Unit (HRU) maps and following output variables:

OUTPUT
Four letter character code for the cover/plant on the HRU. (code from crop.dat file)
Hydrologic response unit number
GIS code reprinted from watershed configuration file (.fig). See explanation of subbasin command (Chapter 2).
Topographically-defined subbasin to which the HRU belongs.
Management number. This is pulled from the management (.mgt) file. Used by the SWAT/GRASS interface to allow development of output maps by landuse/management type.
Daily time step: the julian date, Monthly time step: the month (1-12), Annual time step: 4-digit year, Average annual summary lines: number of years averaged together
Drainage area of the HRU (km2).
Total amount of precipitation falling on the HRU during time step (mm H2O).
Amount of precipitation falling as snow, sleet or freezing rain during time step (water-equivalent mm H2O).
Amount of snow or ice melting during time step (water-equivalent mm H2O).
Irrigation (mm H2O). Amount of irrigation water applied to HRU during the time step.
Potential evapotranspiration (mm H2O). Potential evapotranspiration from the HRU during the time step.
Actual evapotranspiration (soil evaporation and plant transpiration) from the HRU during the time step (mm H2O).
Soil water content (mm H2O). For daily output, this column provides the amount of water in soil profile at beginning of day. For monthly and annual output, this is the average soil water content for the time period. The amount of water in the soil profile at the beginning of the day is used to calculate daily curve number values.
Soil water content (mm H2O). Amount of water in the soil profile at the end of the time period (day, month or year).
Water that percolates past the root zone during the time step (mm H2O). There is usually a lag between the time the water leaves the bottom of the root zone and reaches the shallow aquifer. Over a long period of time, this variable should equal groundwater recharge (PERC = GW_RCHG as time $\rightarrow \infty$).
Recharge entering aquifers during time step (total amount of water entering shallow and deep aquifers during time step) (mm H2O).
Deep aquifer recharge (mm H2O). The amount of water from the root zone that recharges the deep aquifer during the time step. (shallow aquifer recharge = GW_RCHG - DA_RCHG)
Water in the shallow aquifer returning to the root zone in response to a moisture deficit during the time step (mm H2O). The variable also includes water uptake directly from the shallow aquifer by deep tree and shrub roots.

OUTPUT
Irrigation from shallow aquifer (mm H2O). Amount of water removed from the shallow aquifer for irrigation during the time step.
Irrigation from deep aquifer (mm H2O). Amount of water removed from the deep aquifer for irrigation during the time step.
Shallow aquifer storage (mm H2O). Amount of water in the shallow aquifer at the end of the time period.
Deep aquifer storage (mm H2O). Amount of water in the deep aquifer at the end of the time period.
Surface runoff generated in HRU during time step (mm H2O).
Surface runoff contribution to streamflow in the main channel during time step (mm H2O).
Transmission losses (mm H2O). Water lost from tributary channels in the HRU via transmission through the bed. This water becomes recharge for the shallow aquifer during the time step. Net surface runoff contribution to the main channel streamflow is calculated by subtracting TLOSS from SURQ.
Lateral flow contribution to streamflow (mm H2O). Water flowing laterally within the soil profile that enters the main channel during time step.
Groundwater contribution to streamflow (mm H2O). Water from the shallow aquifer that enters the main channel during the time step. Groundwater flow is also referred to as baseflow.
Water yield (mm H2O). Total amount of water leaving the HRU and entering main channel during the time step. (WYLD = SURQ + LATQ + GWQ – TLOSS – pond abstractions)
Average curve number for time period. The curve number adjusted for soil moisture content.
Average daily air temperature (°C). Average of mean daily air temperature for time period.
Average maximum air temperature (°C). Average of maximum daily air temperatures for time period.
Average minimum air temperature (°C). Average of minimum daily air temperatures for time period.
Soil temperature (°C). Average soil temperature of first soil layer for time period.
Average daily solar radiation (MJ/m2). Average of daily solar radiation values for time period.
Sediment yield (metric tons/ha). Sediment from the HRU that is transported into the main channel during the time step.
Soil loss during the time step calculated with the USLE equation (metric tons/ha). This value is reported for comparison purposes only.
Nitrogen fertilizer applied (kg N/ha). Total amount of nitrogen (mineral and organic) applied in regular fertilizer operations during the time step.
Phosphorus fertilizer applied (kg P/ha). Total amount of phosphorus (mineral and organic) applied in regular fertilizer operations during the time step.
Nitrogen fertilizer auto-applied (kg N/ha). Total amount of nitrogen (mineral and organic) auto-applied during the time step.
Phosphorus fertilizer auto-applied (kg P/ha). Total amount of phosphorus (mineral and organic) auto-applied during the time step.
Nitrogen applied during grazing operation (kg N/ha). Total amount of nitrogen (mineral and organic) added to soil by grazing operation during the time step.
Phosphorus applied during grazing operation (kg P/ha). Total amount of phosphorus (mineral and organic) added to soil by grazing operation during the time step.
Nitrogen applied during continuous fertilizer operation (kg N/ha). Total amount of nitrogen (mineral and organic) added to soil by continuous fertilizer operation during time step.
Phosphorus applied during continuous fertilizer operation (kg P/ha). Total amount of phosphorus (mineral and organic) added to soil by continuous fertilizer operation during time step.
Nitrate added to soil profile by rain (kg N/ha).
Nitrogen fixation (kg N/ha). Amount of nitrogen fixed by legumes during the time step.
Fresh organic to mineral N (kg N/ha). Mineralization of nitrogen from the fresh residue pool to the nitrate (80%) pool and active organic nitrogen (20%) pool during the time step. A positive value denotes a net gain in the nitrate and active organic pools from the fresh organic pool while a negative value denotes a net gain in the fresh organic pool from the nitrate and active organic pools.
Active organic to mineral N (kg N/ha). Movement of nitrogen from the active organic pool to the nitrate pool during the time step.
Active organic to stable organic N (kg N/ha). Movement of nitrogen from the active organic pool to the stable organic pool during the time step.
Fresh organic to mineral P (kg P/ha). Mineralization of phosphorus from the fresh residue pool to the labile (80%) pool (P in solution) and the active organic (20%) pool. A positive value denotes a net gain in solution and active organic pools from the fresh organic pool while a negative value denotes a net gain in the fresh organic pool from the labile and active organic pools.
Organic to labile mineral P (kg P/ha). Movement of phosphorus between the organic pool and the labile mineral pool during the time step. A positive value denotes a net gain in the labile pool from the organic pool while a negative value denotes a net gain in the organic pool from the labile pool.
Labile to active mineral P (kg P/ha). Movement or transformation of phosphorus between the "labile" mineral pool (P in solution) and the "active" mineral pool (P sorbed to the surface of soil particles) during the time step. A positive value denotes a net gain in the active pool from the labile pool while a negative value denotes a net gain in

OUTPUT
the labile pool from the active pool.
Active to stable P (kg P/ha). Movement or transformation of phosphorus between the "active" mineral pool (P sorbed to the surface of soil particles) and the "stable" mineral pool (P fixed in soil) during the time step. A positive value denotes a net gain in the stable pool from the active pool while a negative value denotes a net gain in the active pool from the stable pool.
Denitrification (kg N/ha). Transformation of nitrate to gaseous compounds during the time step.
Plant uptake of nitrogen (kg N/ha). Nitrogen removed from soil by plants during the time step.
Plant uptake of phosphorus (kg P/ha). Phosphorus removed from soil by plants during the time step.
Organic N yield (kg N/ha). Organic nitrogen transported out of the HRU and into the reach during the time step.
Organic P yield (kg P/ha). Organic phosphorus transported with sediment into the reach during the time step.
Sediment P yield (kg P/ha). Mineral phosphorus sorbed to sediment transported into the reach during the time step.
NO3 in surface runoff (kg N/ha). Nitrate transported with surface runoff into the reach during the time step.
NO3 in lateral flow (kg N/ha). Nitrate transported by lateral flow into the reach during the time step.
NO3 leached from the soil profile (kg N/ha). Nitrate that leaches past the bottom of the soil profile during the time step. The nitrate is not tracked through the shallow aquifer.
NO3 transported into main channel in the groundwater loading from the HRU (kg N/ha).
Soluble P yield (kg P/ha). Soluble mineral forms of phosphorus transported by surface runoff into the reach during the time step.
Soluble phosphorus transported by groundwater flow into main channel during the time step (kg P/ha).
Water stress days during the time step (days).
Temperature stress days during the time step (days).
Nitrogen stress days during the time step (days).
Phosphorus stress days during the time step (days).
Biomass (metric tons/ha). Total biomass, i.e. aboveground and roots at the end of the time period reported as dry weight.
Leaf area index at the end of the time period.
Harvested yield (metric tons/ha). The model partitions yield from the total biomass on a daily basis (and reports it). However, the actual yield is not known until it is harvested. The harvested yield is reported as dry weight.
Number of persistent bacteria in surface runoff entering reach (# cfu/100 mL).
Number of less persistent bacteria in surface runoff entering reach (#cfu/100 mL).
Water table from above the soil profile (mm) (daily output only; not used in tile flow equations)
Water table depth from the bottom of the soil surface (mm) (daily output only; not used in tile flow equations)
Snow water content (mm)
Current soil carbon for first soil layer (kg/ha).
Current soil carbon integrated for all soil layers (kg/ha)
Drain tile flow in soil profile for the day (mm)
Amount of NO3-N in tile flow in HRU (kg N/ha).
Amount of NO3-N in lateral flow in HRU (kg N/ha).

These outcomes is helpful for further identification of various soil and water parameters like water balance, water quality and water scarcity pockets at panchayat/village level. The hydrological results and maps generated is used as inputs for Climate Change Vulnerability Assessment Analysis.

7.4 Climate Change Vulnerability

Index approach methodology to determine Vulnerability has been adopted for analysis. This index is based on several set of indicators that indicates the vulnerability of a region. It produces a single number, which is used to compare vulnerability levels of different regions. Literature on index number construction specifies that there should be good internal correlation between these indicators. The relevance of this criterion depends on the relationship between the indicators and the construct they are supposed to measure. For this we must know whether the index is based on a ‘reflexive’ or a ‘formative’ measurement model. In the reflexive measurement model, the construct is thought to influence the indicators. For example, a poverty index is a good example of reflexive measurement because poverty influences the indicators such as literacy; expenditure and so on and all these indicators are correlated. On the other hand in the formative model the indicators are assumed contribute to the construct. In the case of vulnerability index, all the indicators chosen by the researcher have impact on vulnerability of the region to climate change. For example, frequency of extreme events such as flood, drought earth-quakes, and length of coastline all contribute to vulnerability of the region to climate change. Hence vulnerability index is a formative measurement and the indicators chosen need not have internal correlation.

7.4.1 Arrangement of Data

For each component of vulnerability, the collected data is arranged in the form of a rectangular matrix with rows representing regions/areas/panchayats/village and columns representing indicators. Let there be M regions/districts and let us say we have collected K indicators. Let X_{ij} be the value of the indicator *j* corresponding to region *i*. Then the table will have M rows and K columns as shown below:

Panchayat/Village	Indicator					
	1	2	-	J	-	K
1	X_{11}	X_{12}	-	X_{1j}	-	X_{1K}
2	-	-	-	-	-	-
-	-	-	-	-	-	-
L	X_{i1}	X_{i2}	-	X_{ij}	-	X_{iK}
-	-	-	-	-	-	-
M	X_{m1}	X_{M2}	-	X_{Mj}	-	X

7.4.2 Normalization of Indicators using Functional Relationship

Obviously the indicators are in different units and scales. The methodology used in UNDP's Human Development Index (HDI) (UNDP, 2006) is followed to normalize them. That is, in order to obtain figures which are free from the units and also to standardize their values, first they are normalized so that they all lie between 0 and 1. Before doing this, it is important to identify the functional relationship between the indicators and vulnerability. Two types of functional relationship are possible: vulnerability increases with increase (decrease)in the value of the indicator. Assume that higher the value of the indicator more is the vulnerability. For example, suppose we have collected information on change in maximum temperature or change in annual rainfall or diurnal variation in temperature. It is clear that higher the values of these indicators more will be the vulnerability of the region to climate change as variation in climate variables increase the vulnerability. In this case we say that the variables have ↑ functional relationship with vulnerability and the normalization is done using the formula

$$x_{ij} = \frac{X_{ij} - Min_i\{X_{ij}\}}{Max_i\{X_{ij}\} - Min_i\{X_{ij}\}}$$

It is clear that all these scores will lie between 0 and 1. The value 1 will correspond to that region/area/panchayat/village with maximum value and 0 will correspond to the region with minimum value.

On the other hand, consider adult literacy rate. A high value of this variable implies more literates in the region and so they will have more awareness to cope with climate change. So the vulnerability will be lower and adult literacy rate has ↓ functional relationship with vulnerability. For this case the normalized score is computed using the formula

$$y_{ij} = \frac{Max_i\{X_{ij}\} - X_{ij}}{Max_i\{X_{ij}\} - Min_i\{X_{ij}\}}$$

It can be easily checked that $x_{ij} + y_{ij} = 1$ so that y_{ij} can be calculated as $y_{ij} = 1 - x_{ij}$. For the above table the functional relationship of the variables with vulnerability can be given as:

Variables	Functional Relationship
Variance in annual rainfall (mm^2)	↑
Diurnal variance in temperature	↑
Total food grains (tonnes)/Net Sown Area (NSA)	↓
Cropping Intensity	↓
Agrl. labourers / Ha of NSA	↓
Literacy Rate (%)	↓

7.4.3 Construction of Vulnerability Index

Construction of vulnerability index consists of several steps. First is the selection of study area which consists of several regions. In our case we have selected the area of Beas River Basin covering three development block of district Kullu i.e. Naggar, Kullu & Banjar. In each region a set of indicators have been selected for each of the three components of vulnerability i.e. Exposure, Sensitivity, Adaptive Capacity. The indicators have been selected based on the availability of data and previous research. Since vulnerability is dynamic over period, it is important that all the indicators relate to the particular year selected. We have tried to assess vulnerability assessment over the years, depending upon the availability of data for each year for all the indicators in each block that too at village level.

After computing the normalized scores the index is constructed by giving either equal weights to all indicators/components. When equal weights are given we use simple average of all the normalized scores to construct the vulnerability index by using the formula:

$$V = f(I - AC)$$

The first two components together represent the potential impact and adaptive capacity is the extent to which these impacts can be averted. Thus vulnerability is potential impact (I) minus adaptive capacity (AC).

Finally, the Vulnerability Indexes will be used to rank the different regions in terms of vulnerability. A region with highest index is said to be most vulnerable and it is given the rank1, the region with next highest index is assigned rank 2 and so on.

7.5 Climate Change Adaptation Framework

Based upon the results of the climate change vulnerability analysis a village/ panchayat level climate change vulnerability maps will be generated and all the villages/ panchayates will be placed under six levels of vulnerability i.e. extreme, very high, high, moderate, low and very low. Based upon the position of the villages/ panchayates corresponding to the vulnerability values/ level the suggestive adaptive plan/framework will be formulated.

8

Hydrological Modelling Outputs

8 Hydrological Modelling Outputs

The project basically aims to formulate climate change adaptation plan based upon the climate change vulnerability assessment at village/ panchayat level of district Kullu. Through earlier studies it has been observed that Kullu district is climatically vulnerable, but in absence of availability regional information on water balance, water quality and water yield several challenges remain unattended. Climate changes have had marked impacts on the natural systems. However its impact will be significant with the hydrological cycle, therefore, hydrological modelling is essential in the analysing process. It is agreed that climate change have adverse impacts on socio-economic development. The hydrological modelling is a valuable tool to aid in quantification of water quality and yield. Since the study is being carried out in three developmental blocks of the district Kullu at panchayat/village level, it is appropriate to narrow down the scale from catchment to micro-watershed level.

8.1 Open Source Interface Management (QGIS & QSWAT)

The Open-source geospatial techniques is used to prepare various thematic maps of study area influence land use, soil, drainage, and slope used as input for SWAT model. SWAT model proves as an effective tool in simulating the hydrology of large basins at watershed scale. This gives simulated results of each parameter. The estimated parameters therefore used for many purposes of study such as agricultural water management, climate change impact assessment, flow forecasting, water quality assessment etc. This water balance study minimizes risk of drought and mismanagement, and hence lead to a proper utilization of water resource available. Water regime of the specific area is well understood by assessment of resources. Water balance is best way of determining availability of water in different components of hydrological cycle and changes in between these components.

QGIS (Quantum GIS) is a cross-platform free and open-source desktop geographic information system (GIS) application that is used for creating, viewing, editing, and analysis of geospatial data. Block boundaries, Census villages and other maps are developed using QGIS.

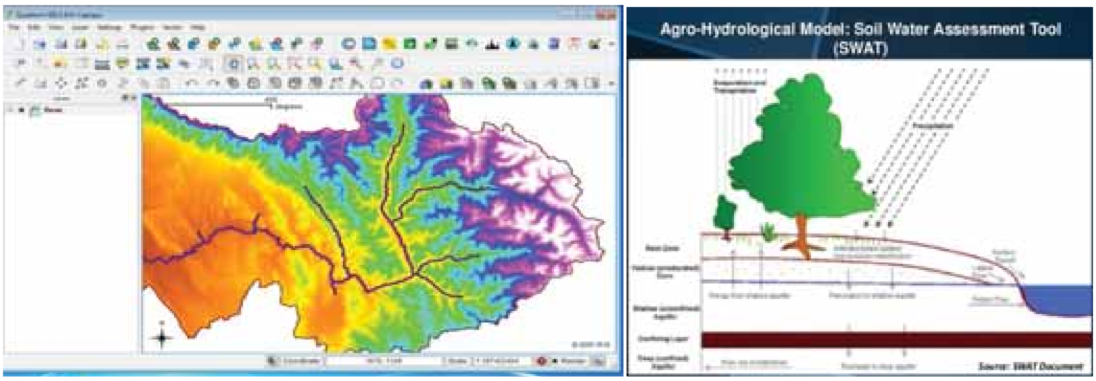


Figure 8.1 QGIS Application Interface & Hydrological Model

An open source GIS interface for the QSWAT Model with Quantum GIS (mapping software) is used for hydrological modelling.

8.2 Datasets/Model Inputs (Spatial & Temporal)

Spatial data

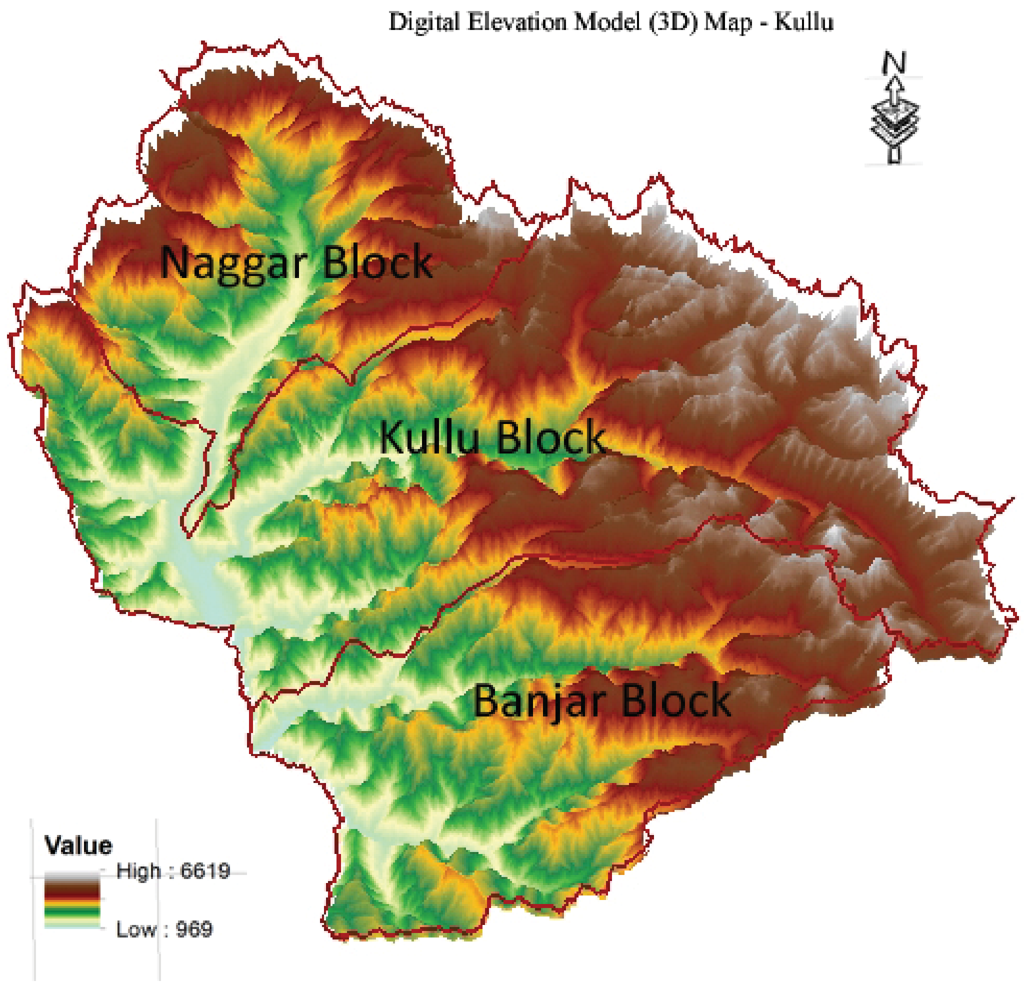
- **Administrative Maps**

Digitization of District, Blocks, Village map boundaries of district Kullu toposheets of Survey of India prepared on 1:50,000 scales for the use of general public/civilians for supporting development activities in the country. Technically maps of this series are based on WGS-84 Datum and UTM Projection.

Map 8.1 Administrative Map – Kullu District

- **DEM (Digital Elevation Model)**

The Digital Elevation Model (DEM) used in this study is taken from National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM), at 3 arc second (30 meter resolution). SRTM generated elevation data for near global scale. The USGS has begun to distribute global Shuttle Radar Topography Mission (SRTM) elevation data at 1 arc-second (~30m) resolution. Previously SRTM data at this resolution have only been available for the US and its territories.



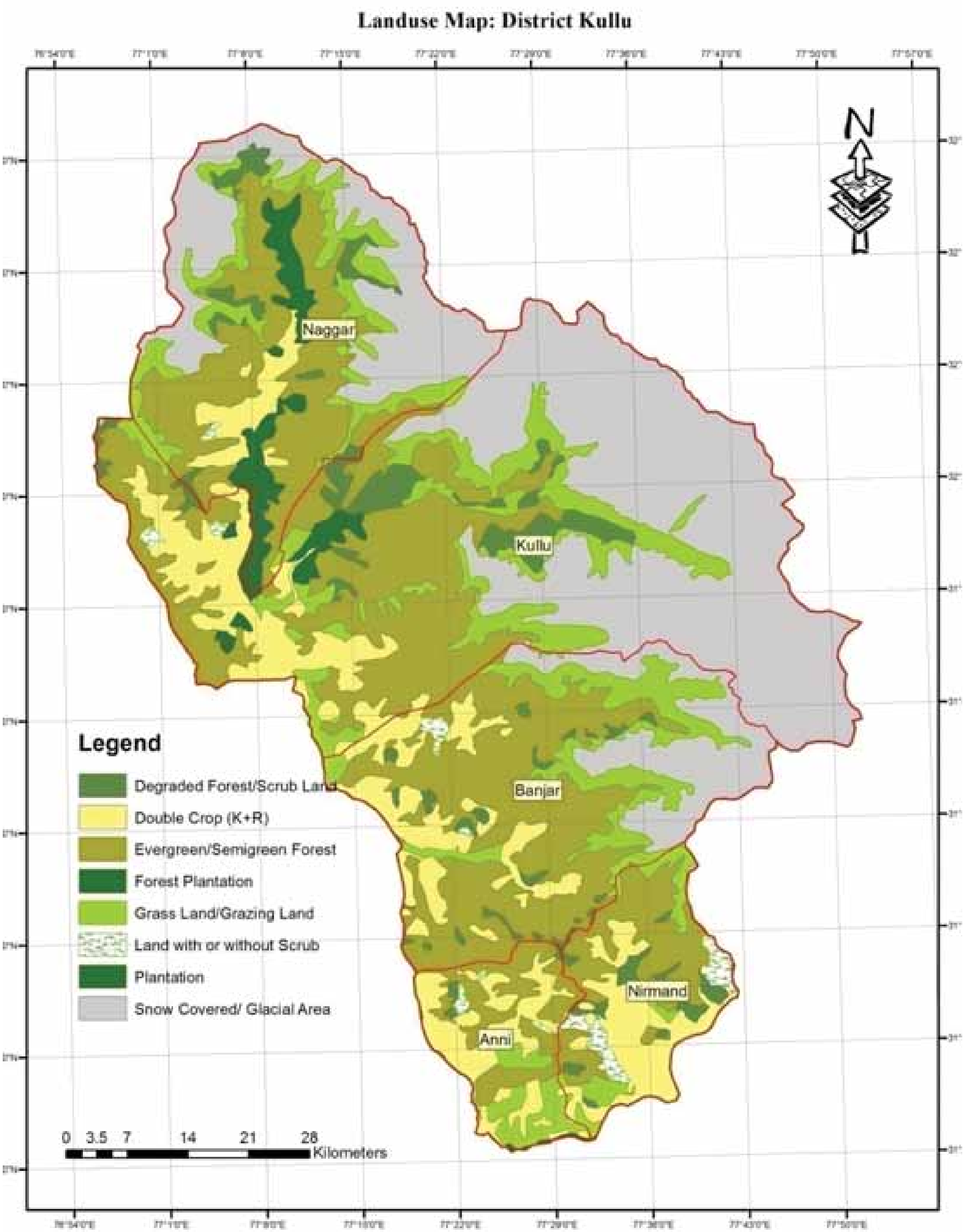
Map 8.2 Digital Elevation Model - 3D (Beas Basin - District Kullu)

The above map shows the Digital Elevation Model Map of Beas Basin falling in district kullu. The minimum elevation values are 969 mtrs. and maximum elevation values are 6619 meters. It covers area of three developmental blocks Naggar, Kullu & Banjar falling within the area of Beas River Basin the area of rest of two developmental blocks falls in Satluj River Basin.

- **Land use Land Cover & Soil Map**

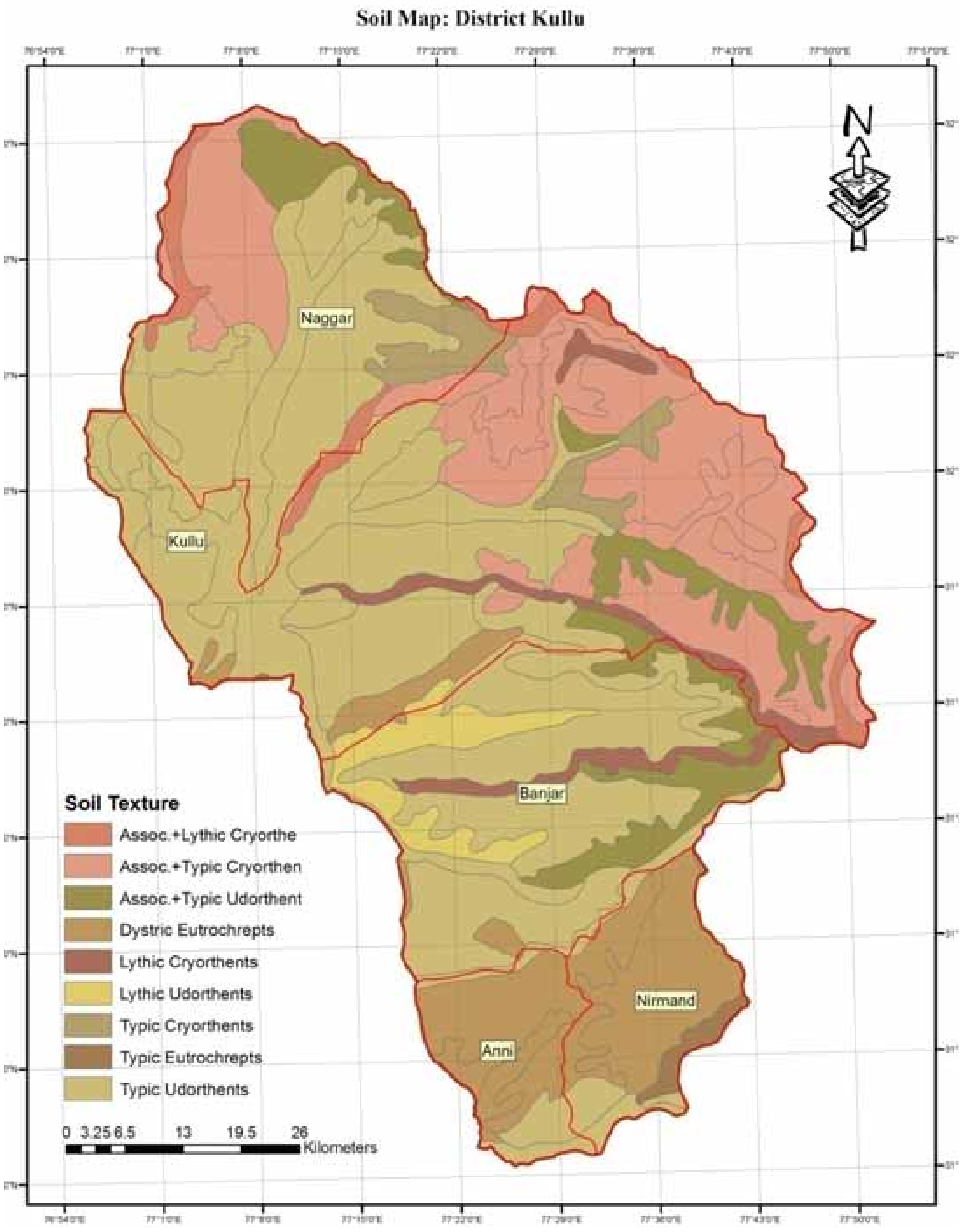
Maps that reflect the land resources and types of land use in the national economy. Land use maps are subdivided into land resource, land in service, and agricultural land use maps. Land use maps are the basis for the registration and qualitative and economic evaluation (cadastres) of land resources. They show the relationship between lands in service and natural conditions, knowledge of which is essential for scientific planning of the rational use of land.

Land use data for hydrological modelling and climate change assessment studies was obtained from the U.S. Geological Survey (USGS) Land Cover Institute (LCI), i.e. Global Land Cover 2000 (GLC 2000).



Map 8.3 Landuse Map

The district is comprised of many fertile valleys as well as high elevation areas. The cultivation is possible in small terraces of holdings in the high hills and the stream/khad basins in most parts of the district. In the valleys, the cultivation is spread over a vast area. The cultivation of crops is confined mostly to flat valleys areas while orchards cover the upper slopes of the valleys and river basins. Except the valley area and stream/khad basins most of the land is either under shrub forests or grassy land with Chil trees upto the height of 1,500 metres from the mean sea level and Kail, Deodar, Spruce, Poplar on the high altitudes. It is only in the valleys that the land is mostly flat and fertile and the cultivation of cereals is done. Most of the North and North-Eastern part of district is snow covered.



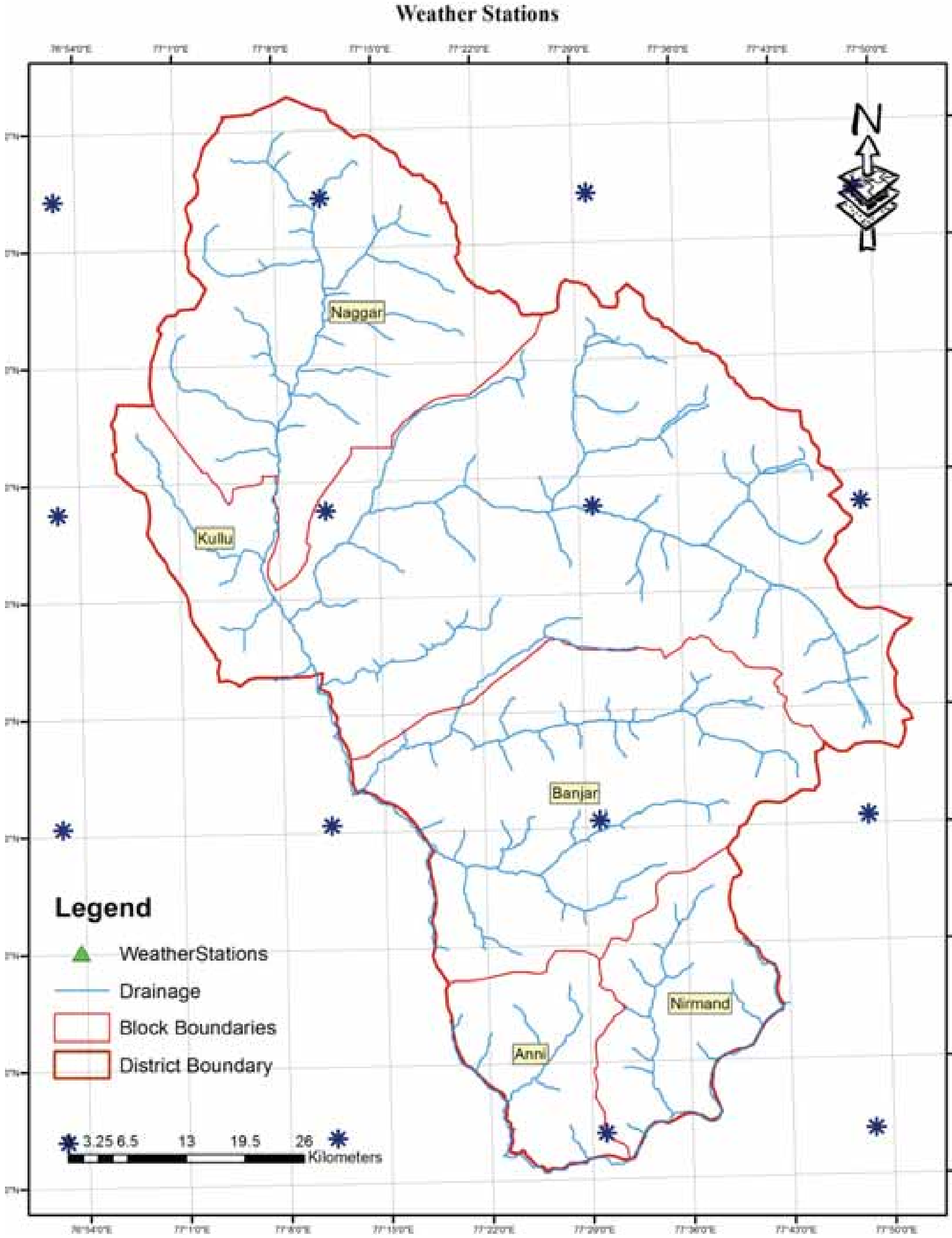
Map 8.4 Soil Map

The geology of this region is mainly composed of middle proterozoic formations. The northern fringe of this region contains Granites (unclassified), while south-eastern part has sholi – Deoban and Largi groups and Rampur- Banjar formations. Soil of this region are mainly covered with orthents – ochrepts (58) while in the northern extreme, it contains Udalfs (20) type of soil. The texture of soil ranges from sandy loam to clay loam and the colour of the soil also vary from brown to dark brown. Generally the soil is acidic in nature. Depth of the soil varies from 50 to 100 cms. But despite this, all the agro climatic conditions provide a range of potentialities for growing cash crops like, off season vegetables, seed potatoes, pulses and temperate fruits.

- **Climate/Weather Data (Non-spatial data)**

  Following climate/weather data has been acquired to run SWAT:
  - Temperature (C)
  - Precipitation (mm)
  - Wind (m/s)
  - Relative Humidity (fraction)
  - Solar Radiation

  SWAT requires hourly data on above perimeters. Long term global data for these parameter has been used for hydrological modelling.



Map 8.5 Weather Station Location Map

The National Centers for Environment Prediction (NCEP) Climate Forecast System analysis (CFSR) developed a 34 year climate data sets (1979 to 2013). The CFSR integrated two types of precipitation data sets for land area which are the CPC Merged Analysis of Precipitation (CMAP) with 2.5^{o} resolution and the CPC unified global daily gauge analysis data at 0.5^{o} resolution. Climate data sets for the study area such as precipitation, solar radiation, relative humidity, air temperature, wind speed was obtained from the CFSR.

The weather data for station nearby study area was downloaded from http://globalweather.tamu.edu site. The daily data such as precipitation (mm), Temperature (^{o}C), Wind velocity (m/s) and solar radiation (MJ/ m2) available for station has been used. To generate weather database for QSWAT input, various parameters related temperature, precipitation and dew point temperatures were calculated. Calculation of TMPMX, TMPMN, TMPSTDMX, SOLARAV, WNDAV has been carried out with the help of Microsoft excel. Then all the results have been copied to the WGEN_WatershedGan.xls file.

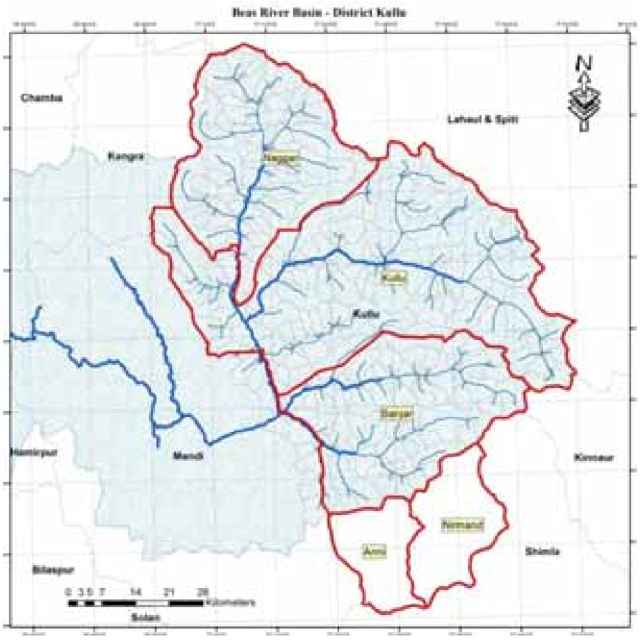
8.3 Watershed Delineation & SWAT Model Run

Watershed delineation based on digital elevation models (DEMs) is the prerequisite to set up SWAT model. Based on QGIS and QSWAT, improved DEM-based method and pre-defined method applied in watershed delineation. In the first method, "Burn-in" and drawing reach and sub-basin boundary manually applied. First, the digital channel network (DCN) was imported using the "Burn-in" function, and the streams and sub-basins delineated based on DEM and DCN. Then the "watershed" and "reach" layers edited in QGIS, where the location, range, and hydrologic connection could be adjusted.

8.3.1 Beas River Basin – Kullu District

Beas River is the principal river of the district. The river Beas originates from the Beas Kund, a small spring of Pir Panjal Ranges at Rohtang Pass at a height of 3,900 metres approximately and flows southwards for about 120 kms. till it reaches Larjee. In this area tributaries are on the east bank spread out in the shape of a fan based on the length of the river between Bhuin and Larjee. On the right of West bank of the main affluent are the Solang, Manalsu, Fozal nullahs and the Sarwari khad at Kullu.

The Parvati also receives the water of the Malana nullah at Jari and other tributaries of the Parvati are on its right bank. The Parvati after flowing in the north-westerly direction then flows in a south-westerly course before merging with Beas. Between its basin and that of the Sainj nullah lie the Hurlagad, which rises from a glaciated area. It joins the Beas opposite Bajaura.

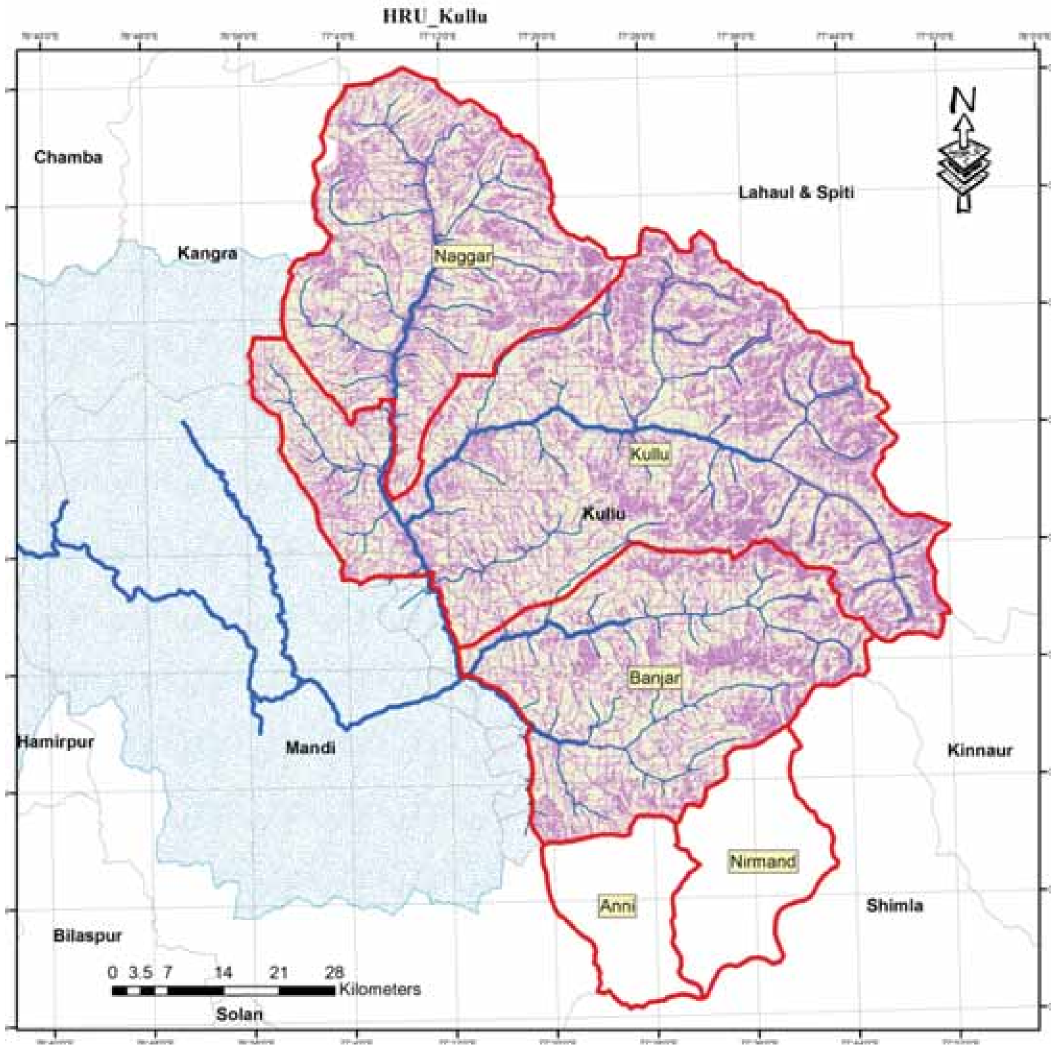


Map 8.6 Drainage Map

The Sainj river originates from Supa Kuni a high peak located on the boundary of Spiti and after running through the Sainj valley, it merges with river Beas at Larjee. The Tirthan stream joins the Sainj a little above the junction of the latter with the Beas. The flow of river Beas and its tributaries are at its lowest during the winter months of December, January and February and highest during June, July and August. In July and August, these rivers and their tributaries are in flood and overflow their banks.

Hydrological Response Unit (HRU)

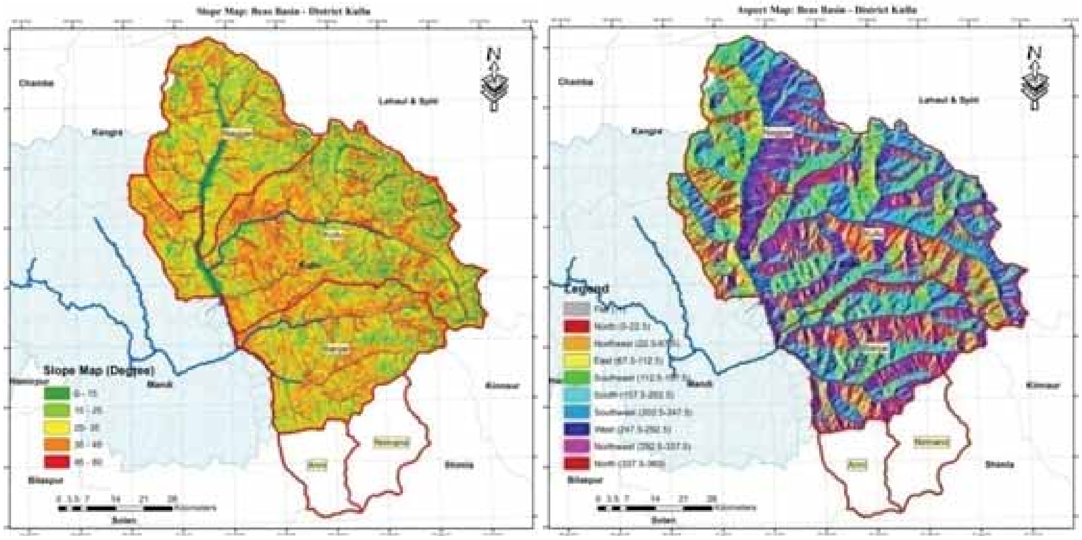
The Soil and Water Assessment Tool (SWAT) is widely used to relate farm management practices to their impacts on surface waters at the watershed scale, yet its smallest spatial unit is not generally defined by physically meaningful boundaries. The hydrologic response unit (HRU) is the smallest spatial unit of the model, and the standard HRU definition approach lumps all similar land uses, soils, and slopes within a subbasin based upon user-defined thresholds.



Map 8.7 Hydrological Response Unit Map

Average Hill Slope (in Degree) & Aspect Ratio

The slope map for each basin using Digital Elevation Model were also calculated/ generated through SWAT modelling. The slope (in Degree) output generated for all river basins of the study area i.e. three blocks of Kullu district further clubbed. Thereafter, the average degree of slope for each census village is calculated to be used as indicator for Sensitivity to further calculate vulnerability:



Map 8.8 Beas River Basin – Slope & Aspect Ratio Map

8.4 Hydrological Model Results & Conclusions

It is a fact that the demand for water has already increased manifold over the years due to urbanization, agriculture expansion, increasing population, rapid industrialization and economic development. Presently, changes in the cropping pattern and land-use pattern, overexploitation of water resources, and changes in irrigation and drainage systems are changing the hydrological cycle with many climatic reasons and river basins of the district Kullu.

As per the working group presentation of the IPCC 5th Assessment report, there is medium confidence that the Indian summer monsoon circulation will weaken, but this will be compensated by increased atmospheric moisture content, leading to more precipitation. There is medium confidence that the increase of the Indian summer monsoon rainfall and its extremes throughout the 21st century will be the largest among all monsoons. Studies based on the observed precipitation records of India Meteorological Department (IMD) have shown that the occurrence of extreme precipitation events and their variability has already gone up in many parts of India.

The possible impacts of climate change on water resources of the river basins of Kullu district have been assessed using the hydrologic model QSWAT (Quantum Soil and Water Assessment Tool). The required input/ information on terrain, soil profile, land use area and weather data obtained from the global resources have been provided to the model.

The potential impacts of climate change on water yield and other hydrologic budget components are quantified by performing SWAT hydrological modelling with current climate scenarios for the regional systems.

Detailed outputs have been analyzed with respect to the two major water balance components of water yield and actual evapo-transpiration (ET) that are highly influenced by the weather conditions dictated by temperature and allied parameters. Majority of the river systems show increase in the precipitation at the basin level.

The major reason for such an increase in ET is on two accounts:

(i) Increase in the temperature and
(ii) Increase in precipitation, which enhances the opportunity of ET.

Evapo-transpiration is a very important component of water balance with respect to the biomass and agricultural activities. The potential evapo-transpiration is driven by the weather conditions, but the actual evapo-transpiration is also dependent on the moisture conditions prevalent under the weather conditions (assuming that the land-use and soil characteristics are not changing). The outcome of actual evapo-transpiration has been obtained after the continuous simulation on daily basis for all the sub-basins of various river systems by using QSWAT model.

The implications of changes in precipitation have also been quantified in the form of resulting water yields through the SWAT modelling exercise. The response of water yield is dependent on a combination of factors such as terrain, land use, soil type, and weather conditions. It may be observed that in the case of river systems of district Kullu, there is an improvement in the average water yield this is because of melting of snow glaciers due to increase in average temperature.

After delineating the basin-wise watershed map using QSWAT taking Digital Elevation Model (DEM) as input data, the additional required inputs i.e. soil map, land use map and weather data for the period of 34 years (1979-2013) is provided to SWAT model. After running the model the watershed wise maps & results/output on following parameters are generated:

Output generated on each monitoring point of the watershed drainage

S.NO.	VARIABLE	DEFINITION
1	RCH	Reach number.
2	GIS	GIS number reprinted from watershed configuration (.fig) file.
3	MON	Daily time step: the julian date, Monthly time step: the month (1-12), Annual time step: 4-digit year, Average annual summary lines: number of years averaged together
4	AREA	Area drained by reach (km2).
5	FLOW_IN	Average daily streamflow into reach during time step (m3/s).
6	FLOW_OUT	Average daily streamflow out of reach during time step (m3/s).
7	EVAP	Average daily rate of water loss from reach by evaporation during time step (m3/s).
8	TLOSS	Average daily rate of water loss from reach by transmission through the streambed during time step (m3/s).
9	SED_IN	Sediment transported with water into reach during time step (metric tons).
10	SED_OUT	Sediment transported with water out of reach during time step (metric tons).
11	SEDCONC	Concentration of sediment in reach during time step (mg/L).
12	ORGN_IN	Organic nitrogen transported with water into reach during time step (kg N).
13	ORGN_OUT	Organic nitrogen transported with water out of reach during time step (kg N).
14	ORGP_IN	Organic phosphorus transported with water into reach during time step (kg P).
15	ORGP_OUT	Organic phosphorus transported with water out of reach during time step (kg P).
16	NO3_IN	Nitrate transported with water into reach during time step (kg N).
17	NO3_OUT	Nitrate transported with water out of reach during time step (kg N).
18	NH4_IN	Ammonium transported with water into reach during time step (kg N).
19	NH4_OUT	Ammonium transported with water out of reach during time step (kg N).
20	NO2_IN	Nitrite transported with water into reach during time step (kg N).
21	NO2_OUT	Nitrite transported with water out of reach during time step (kg N).
22	MINP_IN	Mineral phosphorus transported with water into reach during time step (kg P).
23	MINP_OUT	Mineral phosphorus transported with water out of reach during time step (kg P).
24	ALGAE_IN	Algal biomass transported with water into reach during time step (kg chl-a).
25	ALGAE_OUT	Algal biomass transported with water out of reach during time step (kg chl-a).
26	CBOD_IN	Carbonaceous biochemical oxygen demand of material transported into reach during time step (kg O2).
27	CBOD_OUT	Carbonaceous biochemical oxygen demand of material transported out of reach during time step (kg O2).
28	DISOX_IN	Amount of dissolved oxygen transported into reach during time step (kg O2).
29	DISOX_OUT	Amount of dissolved oxygen transported out of reach during time step (kg O2).

S.NO.	VARIABLE	DEFINITION
30	SOLPST_IN	Soluble pesticide transported with water into reach during time step (mg active ingredient)
31	SOLPST_OUT	Soluble pesticide transported with water out of reach during time step (mg active ingredient).
32	SORPST_IN	Pesticide sorbed to sediment transported with water into reach during time step (mg active ingredient).
33	SORPST_OUT	Pesticide sorbed to sediment transported with water out of reach during time step (mg active ingredient).
34	REACTPST	Loss of pesticide from water by reaction during time step (mg active ingredient).
35	VOLPST	Loss of pesticide from water by volatilization during time step (mg active ingredient).
36	SETTLPST	Transfer of pesticide from water to river bed sediment by settling during time step (mg active ingredient).
37	RESUSP_PST	Transfer of pesticide from river bed sediment to water by resuspension during time step (mg active ingredient).
38	DIFFUSEPST	Transfer of pesticide from water to river bed sediment by diffusion during time step (mg active ingredient).
39	REACBEDPST	Loss of pesticide from river bed sediment by reaction during time step (mg active ingredient).
40	BURYPST	Loss of pesticide from river bed sediment by burial during time step (mg active ingredient).
41	BED_PST	Pesticide in river bed sediment during time step (mg active ingredient).
42	BACTP_OUT	Number of persistent bacteria transported out of reach during time step (# cfu/100 mL).
43	BACTLP_OUT	Number of less persistent bacteria transported out of reach during time step (# cfu/100 mL).
44	CMETAL#1	Conservative metal #1 transported out of reach (kg).
45	CMETAL#2	Conservative metal #2 transported out of reach (kg).
46	CMETAL#3	Conservative metal #3 transported out of reach (kg).
47	TOT_N	Total nitrogen transported with water out of reach during time step (kg N).
48	TOT_P	Total phosphorus transported with water out of reach during time step (kg P).
49	NO3CONC	Nitrate concentration transported with water out of reach during time step (mg/l).

Output generated for each watersheds of the river basin

S.NO.	VARIABLE	DEFINITION
1	SUB	Subbasin number.
2	GIS	GIS code reprinted from watershed configuration file (.fig). See explanation of subbasin command.
3	MON	Daily time step: the julian date, Monthly time step: the month (1-12), Annual time step: 4-digit year, Average annual summary lines: number of years averaged together
4	AREA	Area of the subbasin (km2).
5	PRECIP	Total amount of precipitation falling on the subbasin during time step (mm H2O).
6	SNOMELT	Amount of snow or ice melting during time step (water-equivalent mm H2O).
7	PET	Potential evapotranspiration from the subbasin during the time step (mm H2O).
8	ET	Actual evapotranspiration from the subbasin during the time step (mm).
9	SW	Soil water content (mm). Amount of water in the soil profile at the end of the time period.
10	PERC	Water that percolates past the root zone during the time step (mm). There is potentially a lag between the time the water leaves the bottom of the root zone and reaches the shallow aquifer. Over a long period of time, this variable should equal groundwater percolation.
11	SURQ	Surface runoff contribution to streamflow during time step (mm H2O).
12	GW_Q	Groundwater contribution to streamflow (mm). Water from the shallow aquifer that returns to the reach during the time step.
13	WYLD	Water yield (mm H2O). The net amount of water that leaves the subbasin and contributes to streamflow in the reach during the time step. (WYLD = SURQ + LATQ + GWQ – TLOSS – pond abstractions)
14	SYLD	Sediment yield (metric tons/ha). Sediment from the subbasin that is transported

S.NO.	VARIABLE	DEFINITION
		into the reach during the time step.
15	ORGN	Organic N yield (kg N/ha). Organic nitrogen transported out of the subbasin and into the reach during the time step.
16	ORGP	Organic P yield (kg P/ha). Organic phosphorus transported with sediment into the reach during the time step.
17	NSURQ	NO3 in surface runoff (kg N/ha). Nitrate transported by the surface runoff into the reach during the time step.
18	SOLP	Soluble P yield (kg P/ha). Phosphorus that is transported by surface runoff into the reach during the time step.
19	SEDP	Mineral P yield (kg P/ha). Mineral phosphorus attached to sediment that is transported by surface runoff into the reach during the time step.
20	LATQ	Lateral flow contribution to streamflow during timestep (mm H2O)
21	LAT_Q_NO3	Lateral flow nitarte contributions to streamflow (kh/ha)
22	GWMO3	Groundwater nitarte contributions to streamflow (kh/ha)
23	CHOLA	CHLOROPHYLL-A LOADING ON DAY FROM SUBBASIN (kg chl-a) (only printed for daily – other options print 0.0)
24	CBODU	CARBONACEOUS BIOLOGICAL OXYGEN DEMAND LOADING ON DAY FROM SUBBASIN (kg cbod) (only printed for daily – other options print 0.0)
25	DOXQ	DISSOLVED OXYGEN LOADING ON DAY FROM SUBBASIN (kg O2) (only printed for daily – other options print 0.0)
26	TNO3	NO3 IN TILE FLOW IN DAY IN SUBBASIN (kg N/ha)

Output generated for each Hydrological Response Unit

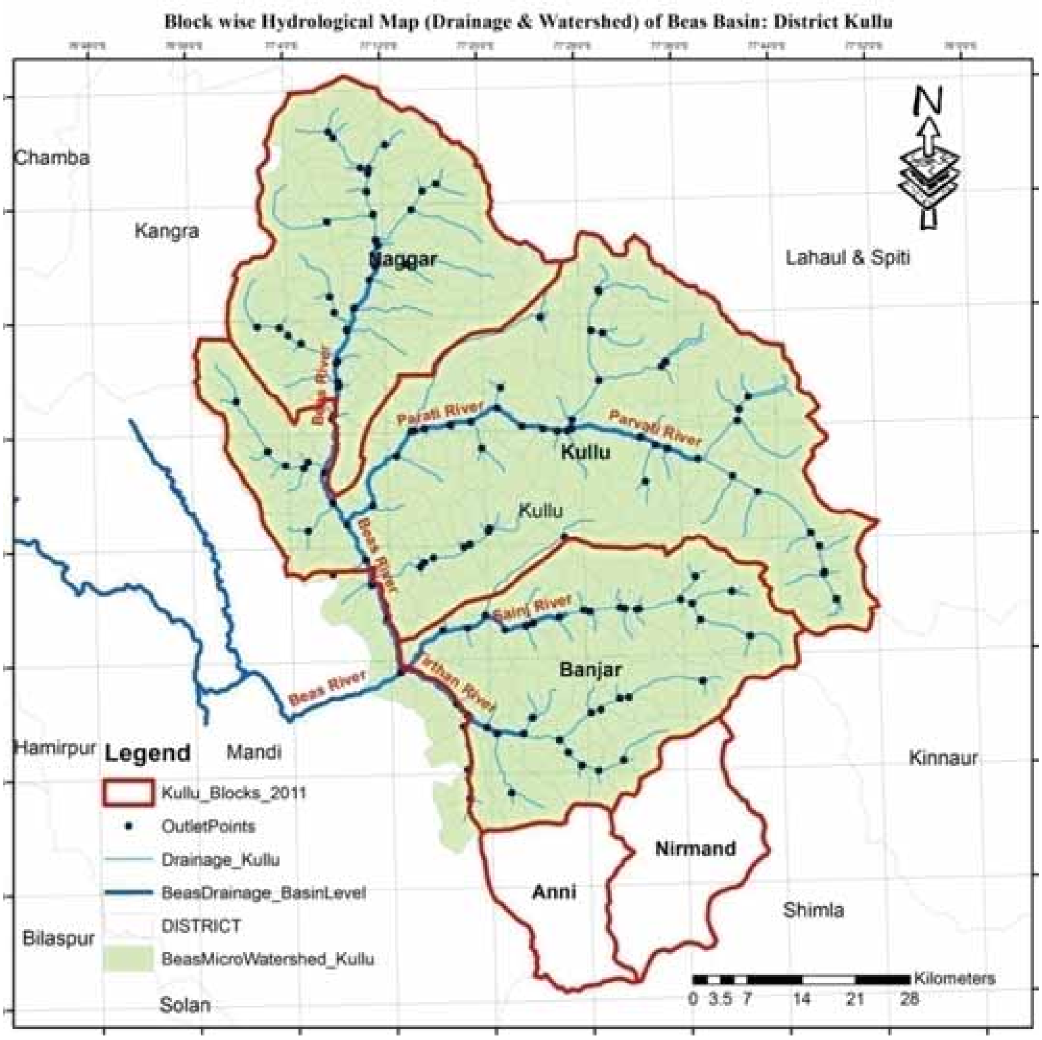
S.NO.	VARIABLE	DEFINITION
1	LULC	Four letter character code for the cover/plant on the HRU. (code from crop.dat file)
2	HRU	Hydrologic response unit number
3	GIS	GIS code reprinted from watershed configuration file (.fig). See explanation of subbasin command (Chapter 2).
4	SUB	Topographically-defined subbasin to which the HRU belongs.
5	MGT	Management number. This is pulled from the management (.mgt) file. Used by the SWAT/GRASS interface to allow development of output maps by landuse/management type.
6	MON	Daily time step: the julian date, Monthly time step: the month (1-12), Annual time step: 4-digit year, Average annual summary lines: number of years averaged together
7	AREA	Drainage area of the HRU (km2).
8	PRECIP	Total amount of precipitation falling on the HRU during time step (mm H2O).
9	SNOFALL	Amount of precipitation falling as snow, sleet or freezing rain during time step (water-equivalent mm H2O).
10	SNOMELT	Amount of snow or ice melting during time step (water-equivalent mm H2O).
11	IRR	Irrigation (mm H2O). Amount of irrigation water applied to HRU during the time step.
12	PET	Potential evapotranspiration (mm H2O). Potential evapotranspiration from the HRU during the time step.
13	ET	Actual evapotranspiration (soil evaporation and plant transpiration) from the HRU during the time step (mm H2O).
14	SW_INIT	Soil water content (mm H2O). For daily output, this column provides the amount of water in soil profile at beginning of day. For monthly and annual output, this is the average soil water content for the time period. The amount of water in the soil profile at the beginning of the day is used to calculate daily curve number values.
15	SW_END	Soil water content (mm H2O). Amount of water in the soil profile at the end of the time period (day, month or year).
16	PERC	Water that percolates past the root zone during the time step (mm H2O). There is usually a lag between the time the water leaves the bottom of the root zone and reaches the shallow aquifer. Over a long period of time, this variable should equal groundwater recharge (PERC = GW_RCHG as time $\rightarrow \infty$).
17	GW_RCHG	Recharge entering aquifers during time step (total amount of water entering shallow and deep aquifers during time step) (mm H2O).

S.NO.	VARIABLE	DEFINITION
18	DA_RCHG	Deep aquifer recharge (mm H2O). The amount of water from the root zone that recharges the deep aquifer during the time step. (shallow aquifer recharge = GW_RCHG - DA_RCHG)
19	REVAP	Water in the shallow aquifer returning to the root zone in response to a moisture deficit during the time step (mm H2O). The variable also includes water uptake directly from the shallow aquifer by deep tree and shrub roots.
20	SA_IRR	Irrigation from shallow aquifer (mm H2O). Amount of water removed from the shallow aquifer for irrigation during the time step.
21	DA_IRR	Irrigation from deep aquifer (mm H2O). Amount of water removed from the deep aquifer for irrigation during the time step.
22	SA_ST	Shallow aquifer storage (mm H2O). Amount of water in the shallow aquifer at the end of the time period.
23	DA_ST	Deep aquifer storage (mm H2O). Amount of water in the deep aquifer at the end of the time period.
24	SURQ_GEN	Surface runoff generated in HRU during time step (mm H2O).
25	SURQ_CNT	Surface runoff contribution to streamflow in the main channel during time step (mm H2O).
26	TLOSS	Transmission losses (mm H2O). Water lost from tributary channels in the HRU via transmission through the bed. This water becomes recharge for the shallow aquifer during the time step. Net surface runoff contribution to the main channel streamflow is calculated by subtracting TLOSS from SURQ.
27	LATQ	Lateral flow contribution to streamflow (mm H2O). Water flowing laterally within the soil profile that enters the main channel during time step.
28	GW_Q	Groundwater contribution to streamflow (mm H2O). Water from the shallow aquifer that enters the main channel during the time step. Groundwater flow is also referred to as baseflow.
29	WYLD	Water yield (mm H2O). Total amount of water leaving the HRU and entering main channel during the time step. (WYLD = SURQ + LATQ + GWQ – TLOSS – pond abstractions)
30	DAILYCN	Average curve number for time period. The curve number adjusted for soil moisture content.
31	TMP_AV	Average daily air temperature (°C). Average of mean daily air temperature for time period.
32	TMP_MX	Average maximum air temperature (°C). Average of maximum daily air temperatures for time period.
33	TMP_MN	Average minimum air temperature (°C). Average of minimum daily air temperatures for time period.
34	SOL_TMP	Soil temperature (°C). Average soil temperature of first soil layer for time period.
35	SOLAR	Average daily solar radiation (MJ/m2). Average of daily solar radiation values for time period.
36	SYLD	Sediment yield (metric tons/ha). Sediment from the HRU that is transported into the main channel during the time step.
37	USLE	Soil loss during the time step calculated with the USLE equation (metric tons/ha). This value is reported for comparison purposes only.
38	N_APP	Nitrogen fertilizer applied (kg N/ha). Total amount of nitrogen (mineral and organic) applied in regular fertilizer operations during the time step.
39	P_APP	Phosphorus fertilizer applied (kg P/ha). Total amount of phosphorus (mineral and organic) applied in regular fertilizer operations during the time step.
40	NAUTO	Nitrogen fertilizer auto-applied (kg N/ha). Total amount of nitrogen (mineral and organic) auto-applied during the time step.
41	PAUTO	Phosphorus fertilizer auto-applied (kg P/ha). Total amount of phosphorus (mineral and organic) auto-applied during the time step.
42	NGRZ	Nitrogen applied during grazing operation (kg N/ha). Total amount of nitrogen (mineral and organic) added to soil by grazing operation during the time step.
43	PGRZ	Phosphorus applied during grazing operation (kg P/ha). Total amount of phosphorus (mineral and organic) added to soil by grazing operation during the time step.
44	CFERTN	Nitrogen applied during continuous fertilizer operation (kg N/ha). Total amount of nitrogen (mineral and organic) added to soil by continuous fertilizer operation during time step.
45	CFERTP	Phosphorus applied during continuous fertilizer operation (kg P/ha). Total amount of phosphorus (mineral and organic) added to soil by continuous

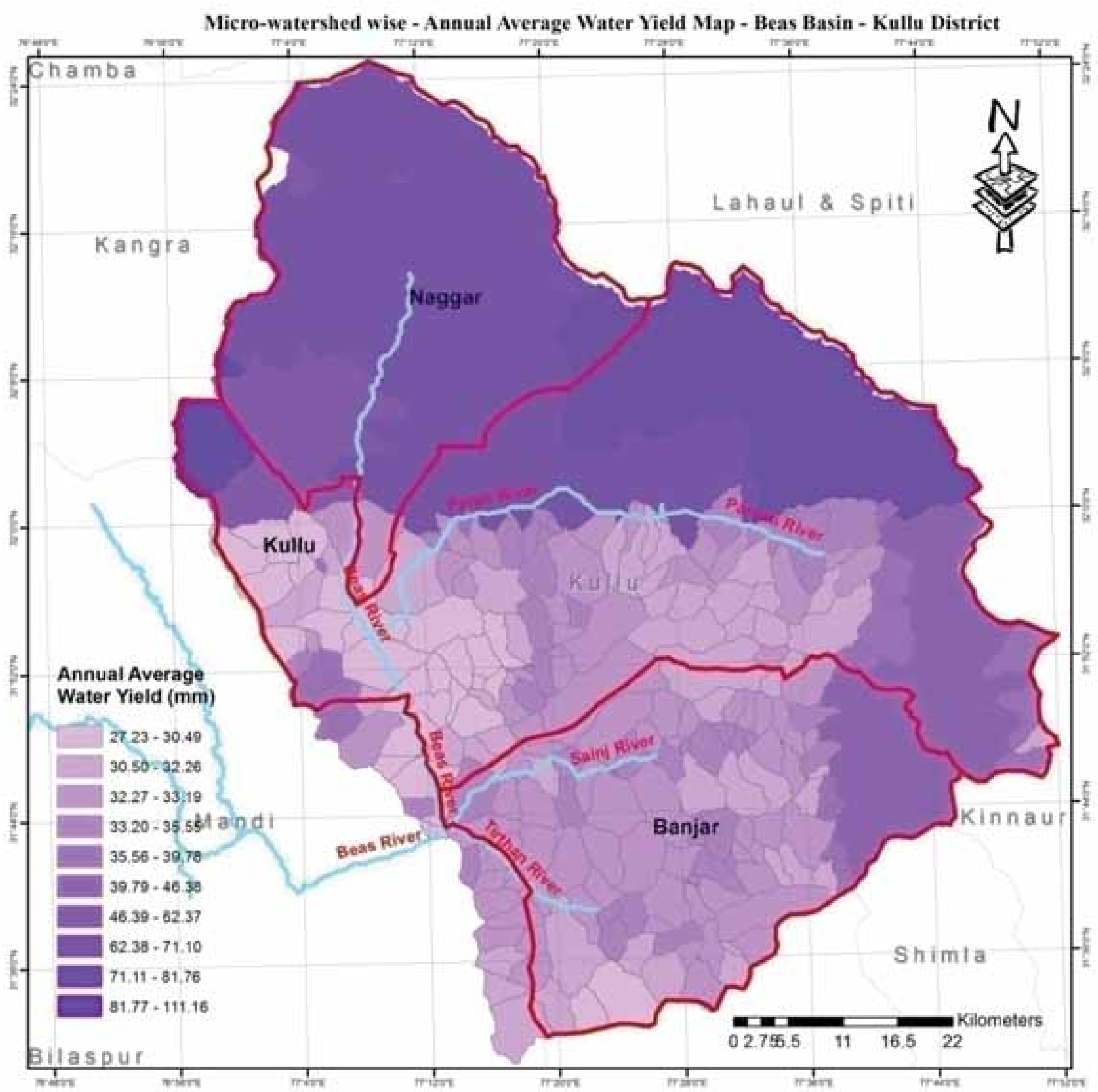
S.NO.	VARIABLE	DEFINITION
		fertilizer operation during time step.
46	NRAIN	Nitrate added to soil profile by rain (kg N/ha).
47	NFIX	Nitrogen fixation (kg N/ha). Amount of nitrogen fixed by legumes during the time step.
48	F-MN	Fresh organic to mineral N (kg N/ha). Mineralization of nitrogen from the fresh residue pool to the nitrate (80%) pool and active organic nitrogen (20%) pool during the time step. A positive value denotes a net gain in the nitrate and active organic pools from the fresh organic pool while a negative value denotes a net gain in the fresh organic pool from the nitrate and active organic pools.
49	A-MN	Active organic to mineral N (kg N/ha). Movement of nitrogen from the active organic pool to the nitrate pool during the time step.
50	A-SN	Active organic to stable organic N (kg N/ha). Movement of nitrogen from the active organic pool to the stable organic pool during the time step.
51	F-MP	Fresh organic to mineral P (kg P/ha). Mineralization of phosphorus from the fresh residue pool to the labile (80%) pool (P in solution) and the active organic (20%) pool. A positive value denotes a net gain in solution and active organic pools from the fresh organic pool while a negative value denotes a net gain in the fresh organic pool from the labile and active organic pools.
52	AO-LP	Organic to labile mineral P (kg P/ha). Movement of phosphorus between the organic pool and the labile mineral pool during the time step. A positive value denotes a net gain in the labile pool from the organic pool while a negative value denotes a net gain in the organic pool from the labile pool.
53	L-AP	Labile to active mineral P (kg P/ha). Movement or transformation of phosphorus between the "labile" mineral pool (P in solution) and the "active" mineral pool (P sorbed to the surface of soil particles) during the time step. A positive value denotes a net gain in the active pool from the labile pool while a negative value denotes a net gain in the labile pool from the active pool.
54	A-SP	Active to stable P (kg P/ha). Movement or transformation of phosphorus between the "active" mineral pool (P sorbed to the surface of soil particles) and the "stable" mineral pool (P fixed in soil) during the time step. A positive value denotes a net gain in the stable pool from the active pool while a negative value denotes a net gain in the active pool from the stable pool.
55	DNIT	Denitrification (kg N/ha). Transformation of nitrate to gaseous compounds during the time step.
56	NUP	Plant uptake of nitrogen (kg N/ha). Nitrogen removed from soil by plants during the time step.
57	PUP	Plant uptake of phosphorus (kg P/ha). Phosphorus removed from soil by plants during the time step.
58	ORGN	Organic N yield (kg N/ha). Organic nitrogen transported out of the HRU and into the reach during the time step.
59	ORGP	Organic P yield (kg P/ha). Organic phosphorus transported with sediment into the reach during the time step.
60	SEDP	Sediment P yield (kg P/ha). Mineral phosphorus sorbed to sediment transported into the reach during the time step.
61	NSURQ	NO3 in surface runoff (kg N/ha). Nitrate transported with surface runoff into the reach during the time step.
62	NLATQ	NO3 in lateral flow (kg N/ha). Nitrate transported by lateral flow into the reach during the time step.
63	NO3L	NO3 leached from the soil profile (kg N/ha). Nitrate that leaches past the bottom of the soil profile during the time step. The nitrate is not tracked through the shallow aquifer.
64	NO3GW	NO3 transported into main channel in the groundwater loading from the HRU (kg N/ha).
65	SOLP	Soluble P yield (kg P/ha). Soluble mineral forms of phosphorus transported by surface runoff into the reach during the time step.
66	P_GW	Soluble phosphorus transported by groundwater flow into main channel during the time step (kg P/ha).
67	W_STRS	Water stress days during the time step (days).
68	TMP_STRS	Temperature stress days during the time step (days).
69	N_STRS	Nitrogen stress days during the time step (days).
70	P_STRS	Phosphorus stress days during the time step (days).
71	BIOM	Biomass (metric tons/ha). Total biomass, i.e. aboveground and roots at the end of the time period reported as dry weight.

S.NO.	VARIABLE	DEFINITION
72	LAI	Leaf area index at the end of the time period.
73	YLD	Harvested yield (metric tons/ha). The model partitions yield from the total biomass on a daily basis (and reports it). However, the actual yield is not known until it is harvested. The harvested yield is reported as dry weight.
74	BACTP	Number of persistent bacteria in surface runoff entering reach (# cfu/100 mL).
75	BACTLP	Number of less persistent bacteria in surface runoff entering reach (#cfu/100 mL).
76	WATB_CLI	Water table from above the soil profile (mm) (daily output only; not used in tile flow equations)
77	WATB_SOL	Water table depth from the bottom of the soil surface (mm) (daily output only; not used in tile flow equations)
78	SNO	Snow water content (mm)
79	CMUP	Current soil carbon for first soil layer (kg/ha).
80	CMTOT	Current soil carbon integrated for all soil layers (kg/ha)
81	QTILE	Drain tile flow in soil profile for the day (mm)
82	TNO3	Amount of NO3-N in tile flow in HRU (kg N/ha).
83	LN03	Amount of NO3-N in lateral flow in HRU (kg N/ha).

Results of the above parameters are available on different drainage outlet points of each microwatershed. The area of Beas River Basin falling in district Kullu is divided into total 489 micro-watersheds with the average area of 10 km^2. The Blockwise Watershed maps and hydrological modelling results of drainage outlet points at each three blocks are depicted as follows:



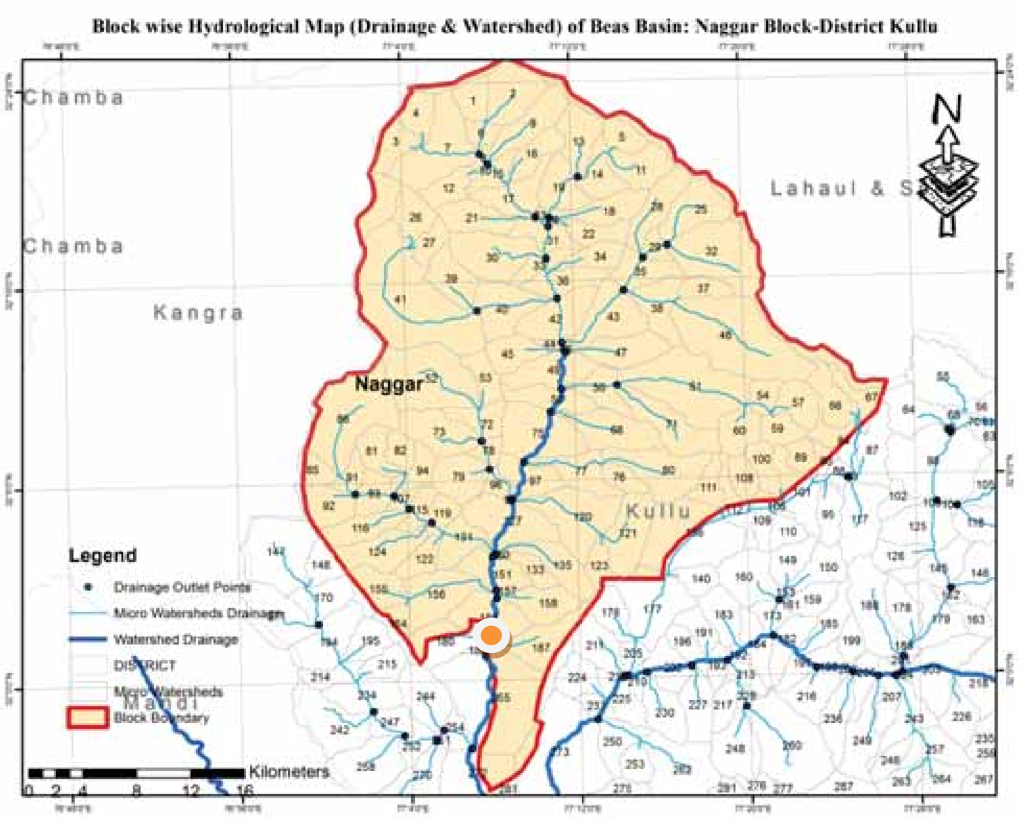
Map 8.9 Hydrological Map (SWAT Model)



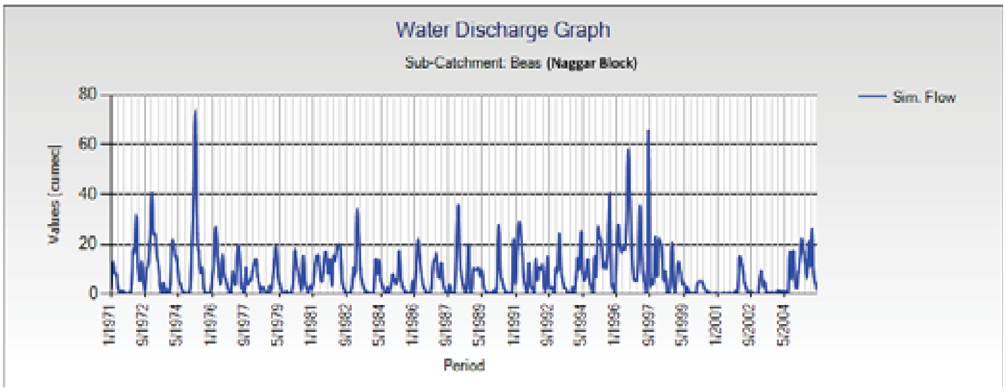
Map 8.9 Microwatershed of Beas Basin - Annual Average Water Yield (mm)

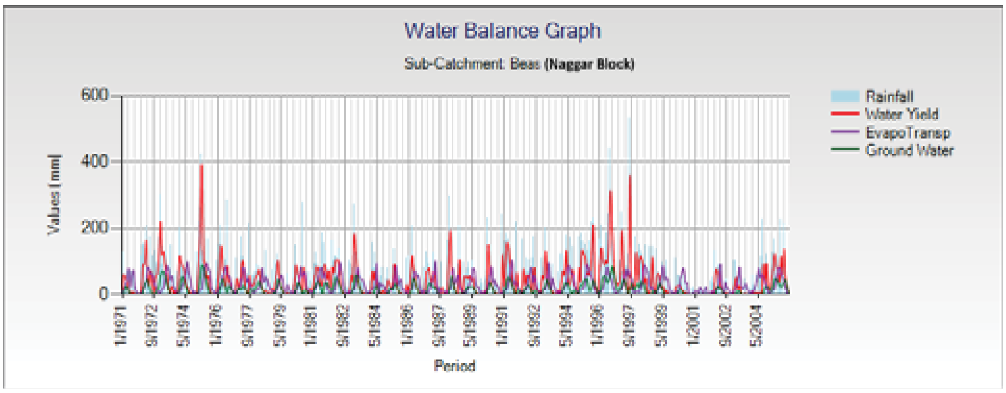
As per the SWAT model outputs above map 8.9 depicts that the annual average water yield in the watersheds falling in Naggar Block and Northern Part of Kullu Block is between 39 mm to 111 mm, However the water yield of watersheds lying in Banjar and rest of the areas of Kullu Block is less than 39 mm per annum. This analysis reveals that, from climate change point of view these areas are more sensitive and need more attention in adaptive measures.

The area of Beas River Basin falling in Naggar block of district Kullu is divided into about 111 micro-watersheds with the average area of 10 km^2. As depicted in the watershed map of Beas River Basin the up-stream of Beas rivers flow in the Naggar Block the water discharge and the water balance (Rainfall, Water Yield, Evapo Transpiration & ground water) generated from the hydrological model for the period from 1971-2004 (simulated results) at the outlet point of Beas River is as follows:

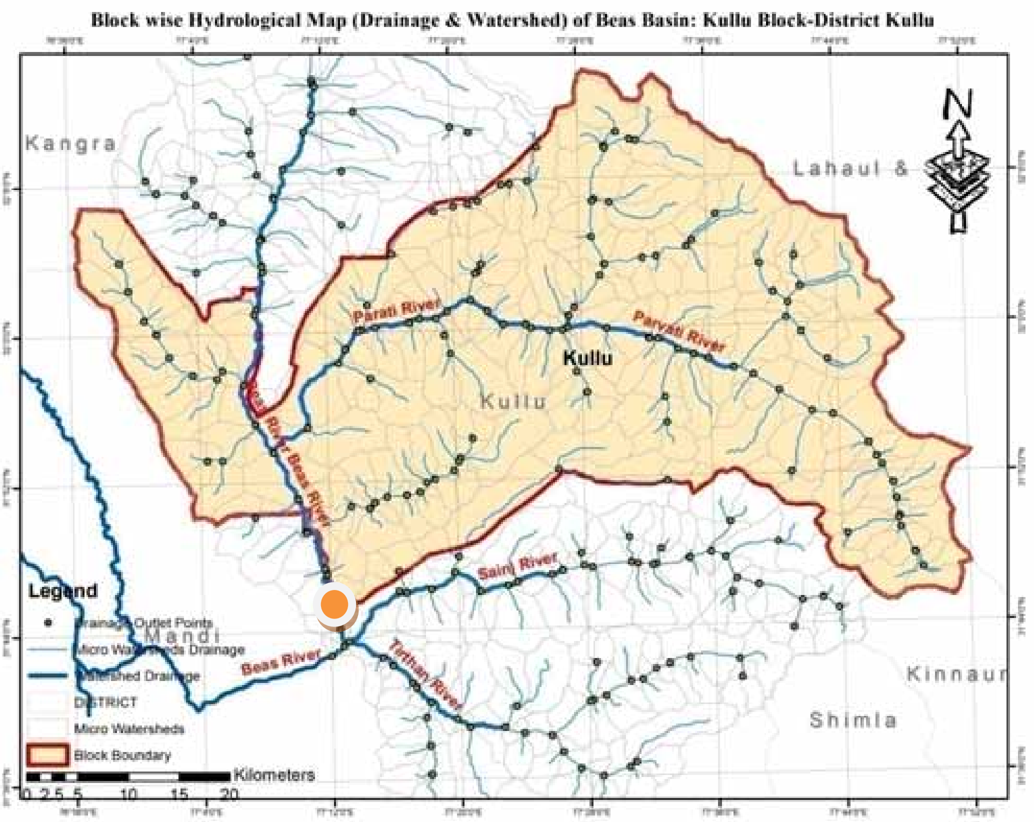


Map 8.10 Hydrological Map – Naggar Block (SWAT Model)

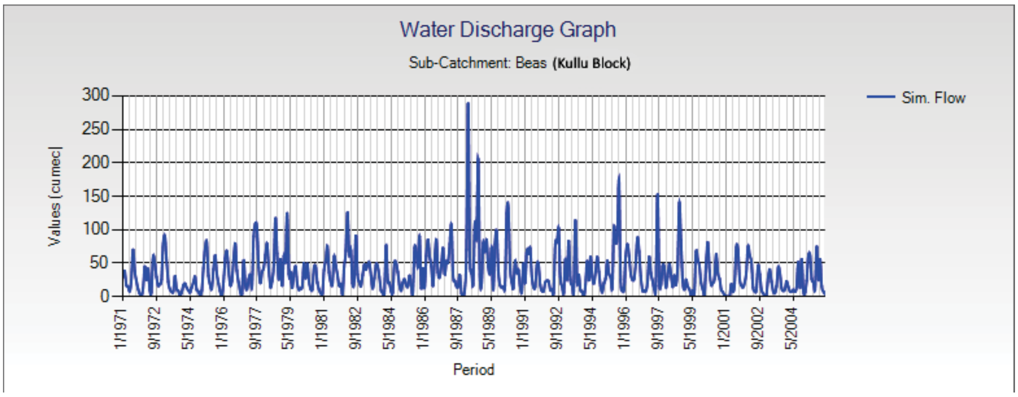


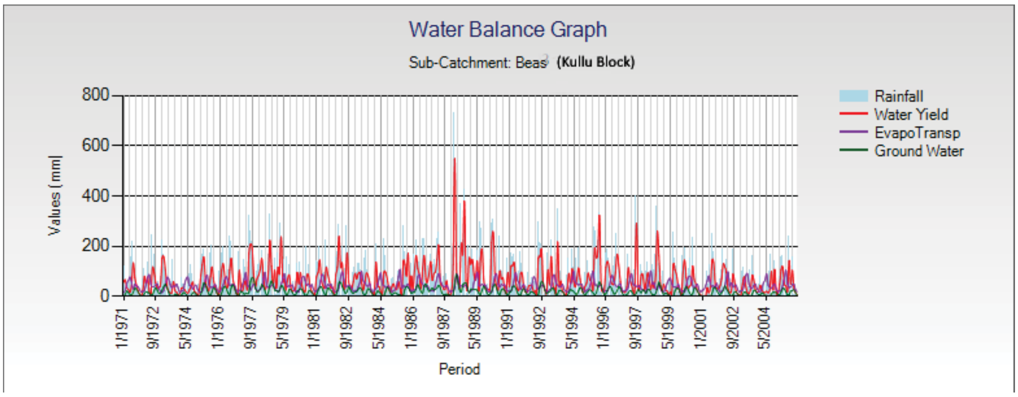


The area of Beas River Basin falling in Kullu block of district Kullu is divided into about 236 micro-watersheds with the average area of 10 km^2. As depicted in the watershed map of the Parvati River one of the tributary of Beas River in the Kullu Block, the water discharge and the water balance (Rainfall, Water Yield, Evapo Transpiration & ground water) generated from the hydrological model for 30 years of period from 1971-2004 (simulated results) of Beas River after confluence point of Parvati River is as follows:

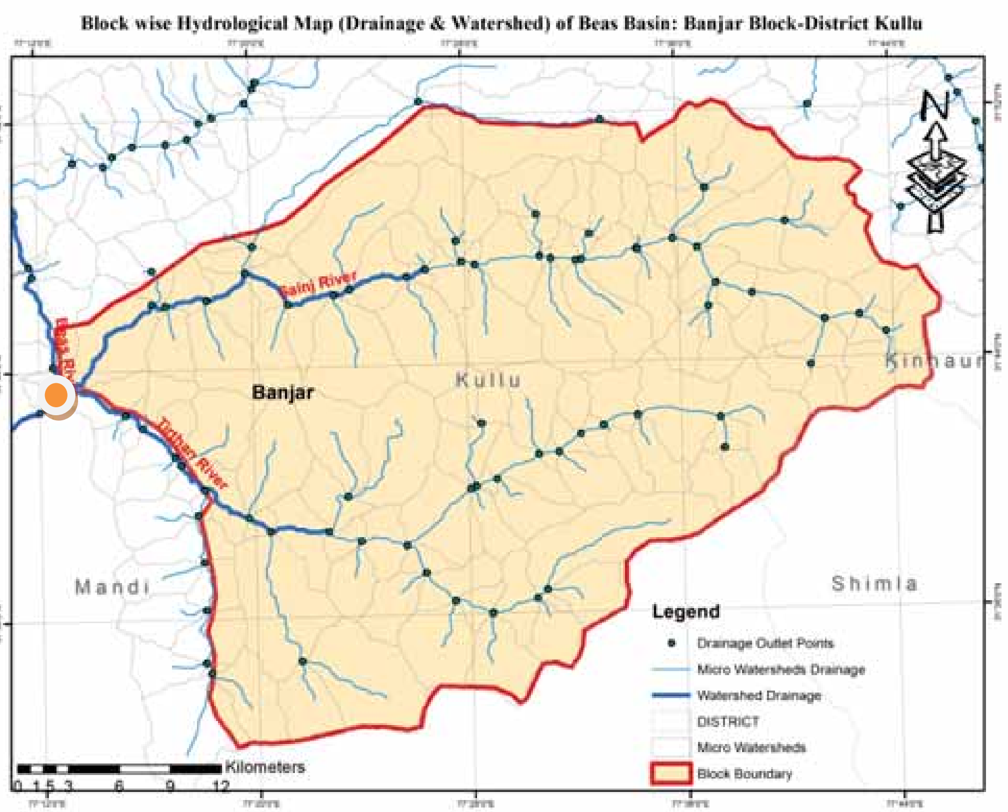


Map 8.11 Hydrological Map – Kullu Block (SWAT Model)

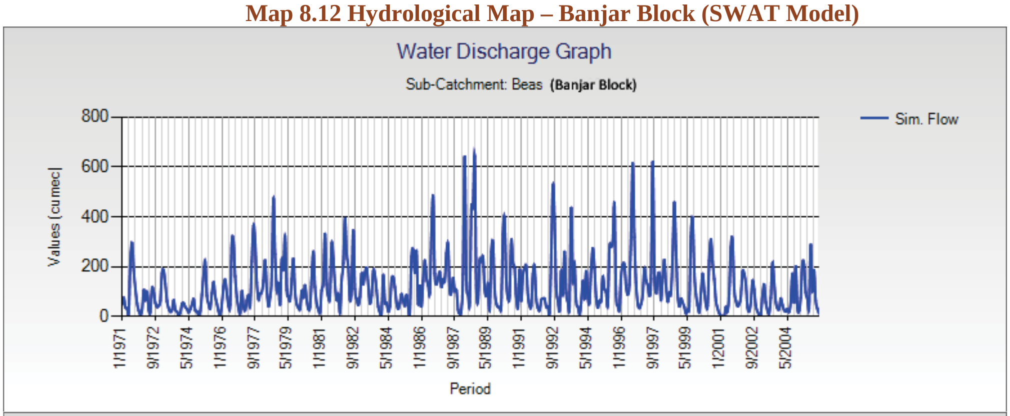


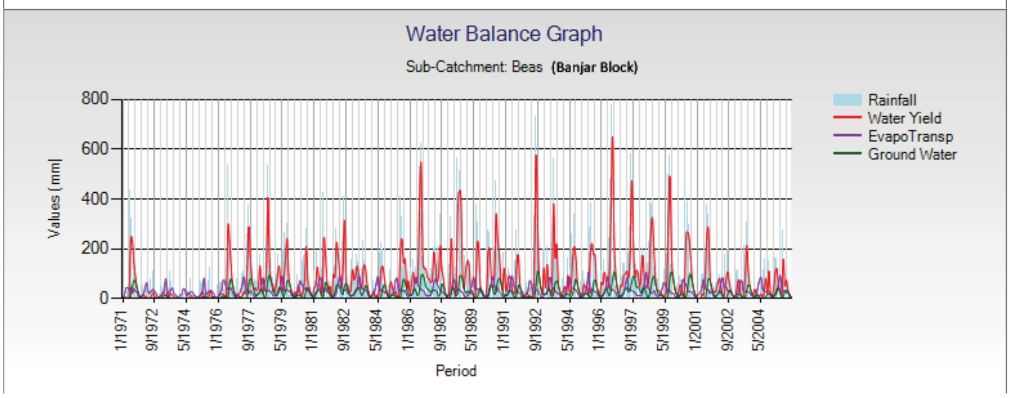


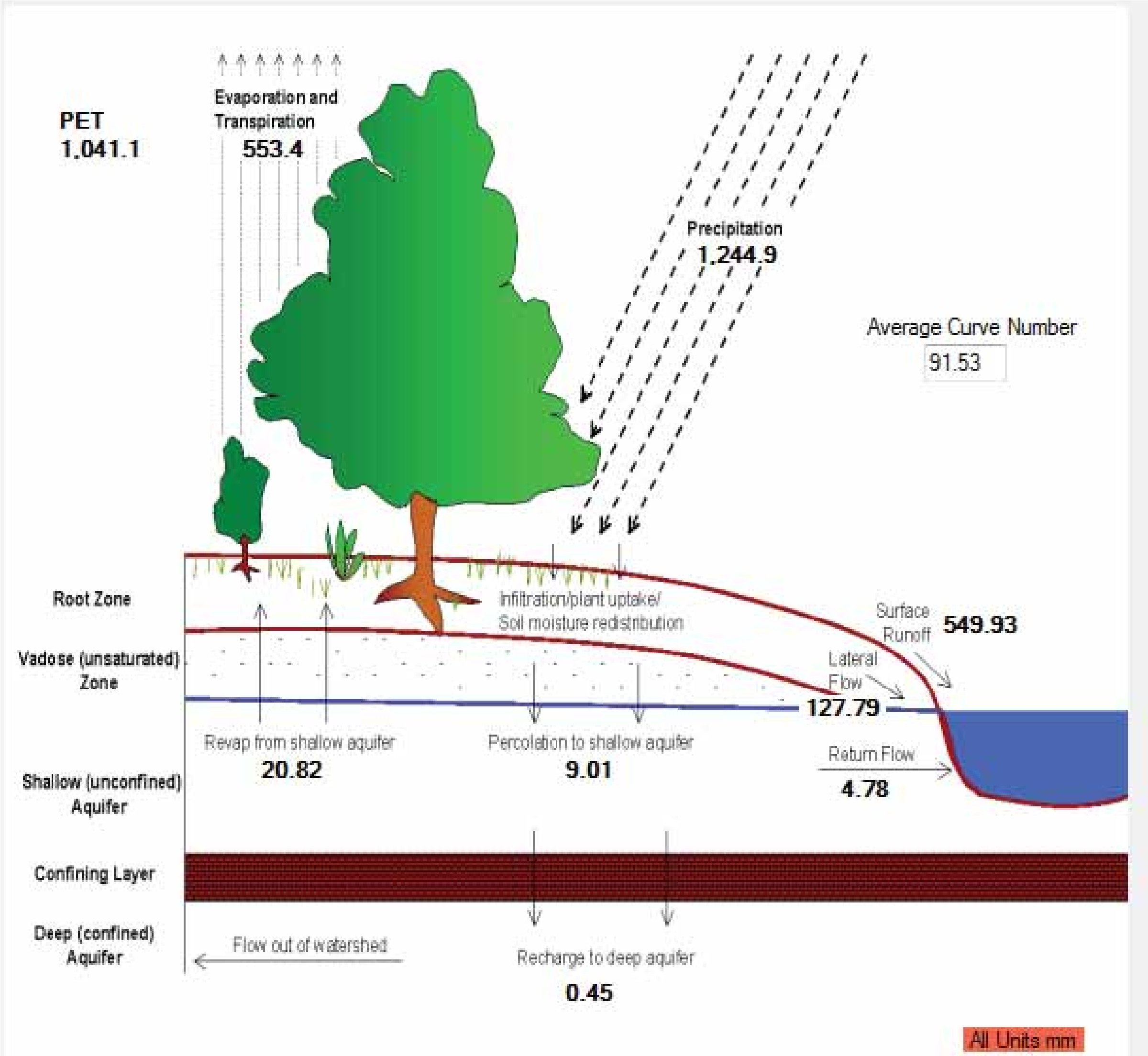
The area of Beas River Basin falling in Banjar block of district Kullu is divided into about 118 micro-watersheds with the average area of 10 km^2. As depicted in the watershed map of the Tirthan & Sainj Rivers of the tributary of Beas River in the Banjar Block, the water discharge and the water balance (Rainfall, Water Yield, Evapo Transpiration & ground water) generated from the hydrological model for the period from 1971-2004 (simulated results) after confluence point of Tirthan & Sainj River at Beas River is as follows:



Map 8.12 Hydrological Map – Banjar Block (SWAT Model)







As depicted above SWAT model outputs with respect to hydrology of the Beas River Basin falling in Kullu district on relevant perimeters are further used as input for climate change vulnerability assessment to represent Exposure & Sensitivity indicators/ variables. The indicators used in climate change vulnerability assessment are watershed level temperature values, precipitation values, water yield, water stress, temperature stress, slopes etc.

9

Climate Change Vulnerability Assessment Analysis: District Kullu

9 Climate Change Vulnerability Assessment Analysis : District Kullu

The process and methodology used in this study has been sub-divided into four phases for adopting a conceptual framework of vulnerability, generating spatial datasets of key factors, estimating the weights of various factors contributing to vulnerability and generating the vulnerability ranking maps of the districts in the study area. The novelty of this study is that it has considered climatic, physical and socio-economic factors together to arrive at the vulnerability rating. The methodology of vulnerability assessment is based on the integration of various climatic, environmental and socio-economic factors following the multi-criteria decision-making technique in a geographical information system (GIS). Various steps of methodology include (1) identification of indicators, (2) ranking of indicators, and (3) calculation of vulnerability index.

9.1 Identification of Indicators

Construction of vulnerability index consists of several steps. First is the selection of study area which consists of several regions. In our case three development block of district Kullu falling in Beas River Bain were indicated. In each region a set of indicators have been selected for each of the three component of vulnerability i.e. Exposure, Sensitivity, Adaptive Capacity. The indicators were selected based on the availability of data, personal judgment or previous research. Since vulnerability is dynamic over time, it is important that all the indicators relate to the particular year chosen. An attempt has been made to assess vulnerability assessment over the years, depending upon the availability of data for each year for all the indicators of each block. A list of indicators shown as under, it can be modified according to the availability of data and need in future as well, the process is dynamic and can be further expended based on data and time.

A brief description of these indicators along with their data source is given as follows:

Description of variables/indicators used for vulnerability assessment

Code	Exposure	Units	Years	Functional Relationship with Exposure	Data Source
E01	Average maximum air temperature	oC	1979-2013	↑	SWAT Model
E02	Average minimum air temperature	oC	1979-2013	↑	SWAT Model
E03	Total amount of precipitation	mm	1979-2013	↓	SWAT Model
E04	Water stress days	Days	1979-2013	↑	SWAT Model
E05	Temperature stress days	Days	1979-2013	↑	SWAT Model
Code	**Sensitivity**	**Units**	**Years**	**Functional Relationship with Sensitivity**	**Data Source**
S01	Average Hill Slope	Degree	-	↑	SWAT Model
S02	Annual Average Water Yield	mm	1979-2013	↓	SWAT Model
S03	Percentage of Net Sown Area to Geographical area	%age	2011	↓	Census 2011
S04	Human population density	Person/Ha.	2011	↑	Census 2011
S05	Percentage of Un-irrigated Land Area to Geographical area	%age	2011	↑	Census 2011
S06	Percentage of Barren & Un-	%age	2011	↑	Census 2011

	cultivable Land Area to Geographical area				
S07	Percentage of Cultivable Waste Land Area to Geographical Area	%age	2011	↑	Census 2011

Code	Adaptive Capacity	Units	Years	Functional Relationship with Adaptive Capacity	Data Source
A01	Educational Institutes	Number	2011	↑	Census 2011
A02	Health Institutes	Number	2011	↑	Census 2011
A03	Road Network	Yes/No	2011	↑	Census 2011
A04	Agricultural Credit Societies	Yes/No	2011	↑	Census 2011
A05	Self Help Group	Yes/No	2011	↑	Census 2011
A06	Mandis/Regular Market	Yes/No	2011	↑	Census 2011
A07	Agricultural Marketing Society	Yes/No	2011	↑	Census 2011
A08	Hand Pump	Yes/No	2011	↑	Census 2011
A09	Spring Source	Yes/No	2011	↑	Census 2011
A10	Tank/Pond/Lake	Yes/No	2011	↑	Census 2011
A11	Irrigated Area	Hectares	2011	↑	Census 2011

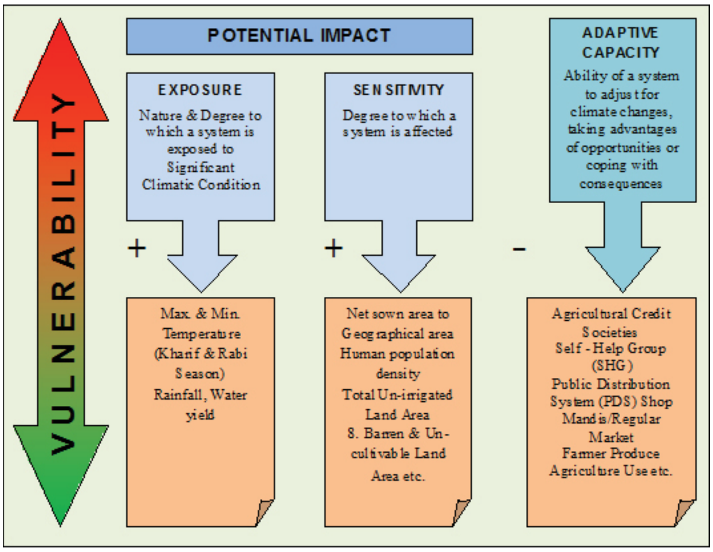


Figure 9.1 Frameworks for Calculation of Vulnerability

9.2 Exposure

The effects of climate change are different at different locations. Some regions are warmer than the others. Also, the precipitation patterns shift in different areas are varying resulting in uneven distribution of rainfall. Some regions observes prolonged dry periods and some experience both warm and intense rainfall. In correlations with the above statements reveals that exposure relates to the degree of climate stress at a particular location. The exposure can also be determined by the long-term climatic changes or the variation in climate including the magnitude and frequency of hazards.

The major constraints in studying and analysing the climate change is un-availability of long-term observed data at desired locations. The Global Climate Modelling (GCM) could act as solution to this problem, but it could provide climate information on a very broader scale, which sometime might not match or desirable/ fit to the local conditions. Local climate change is influenced significantly by local topographical features, such as mountains. GCMs are not able to account for these local topographies as they use a relatively coarse spatial resolution. On the other hand Regional Climate Models (RCM) have a comparatively higher resolution (approximately 25 km) and are influenced by a smaller scale of topographical features. It is much more computationally intensive to run an RCM. Therefore, in our case we have adopted/ used RCM technique to generate local climate data.

The Regional Climate Modelling technique consists of using initial conditions, time-dependent lateral meteorological conditions and surface boundary conditions to drive high-resolution RCMs. The driving data is derived from GCMs (or analyses of observations) and can include GHG and aerosol forcing. A variation of this technique is to also force the large-scale component of the RCM solution throughout the entire domain *(e.g., Kida et al., 1991; Cocke and LaRow, 2000; von Storch et al., 2000)*

The provision of a flexible RCM is part of an integrated package of methods, which would also include a range of GCM projections for assisting countries to generate climate change scenarios and hence to inform adaptation decisions. The Hadley Centre has developed such a flexible RCM a practical tool to make their own projections of national patterns of climate change and hence estimate the possible impacts and assess their vulnerability. It must be stressed that the RCM does not replace GCMs, but it is a powerful tool to be used together with the GCMs in order to add fine scale detail to their broad-scale projections.

Before inception of the climate change vulnerability assessment report, PRECIS (Providing Regional Climates for Impacts Studies) was proposed for generating regional climate data, but due to its requirement of long time for complex operating procedures and non-availability of desired inputs some other regional climate models and methods were used for analysing climate data.

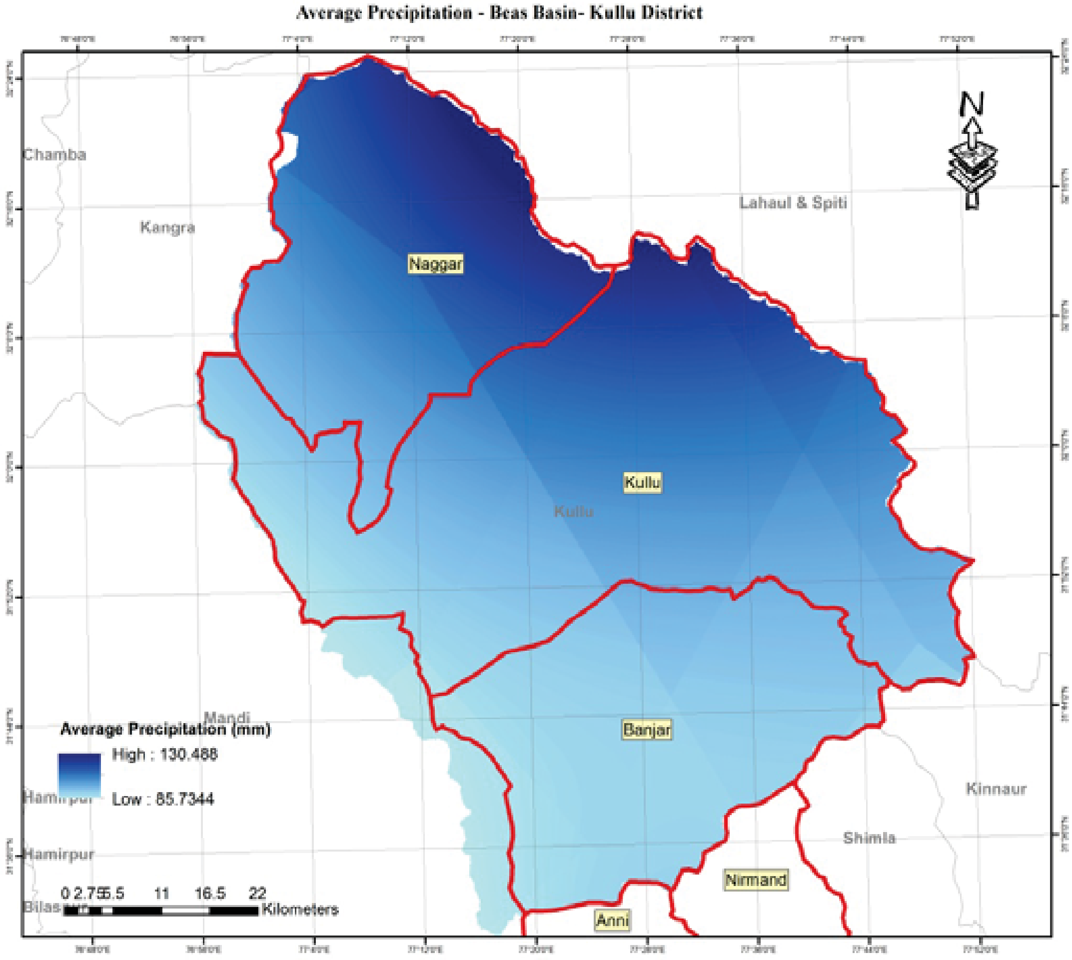
Modelling & Climate Change Projections

Two scenario RCP 4.5 & RCP 8.5 are used for climate projections. Representative Concentration Pathway (RCP) 4.5 is a scenario that stabilizes radiative forcing at 4.5 W m−2 in the year 2100 without ever exceeding that value. Simulated with the Global Change Assessment Model (GCAM), RCP4.5 includes longterm, global emissions of greenhouse gases, short-lived species, and land-use-land-cover in a global economic framework. RCP4.5 was updated from earlier GCAM scenarios to incorporate historical emissions and land cover information common to the RCP process and follows a cost-minimizing pathway to reach the target radiative forcing. The imperative to limit emissions in order to reach this target drives changes in the energy system, including shifts to electricity, to lower emissions energy technologies and to the deployment of carbon capture and geologic storage technology. In addition, the RCP4.5 emissions price also applies to land use emissions; as a result, forest lands expand from their present day extent. The simulated future emissions and land use were downscaled from the regional simulation to a grid to facilitate transfer to climate models. While there are many alternative pathways to achieve a radiative forcing level of 4.5 W m−2, the application of the RCP4.5 provides a common platform for climate models to explore the climate system response to stabilizing the anthropogenic components of radiative forcing.

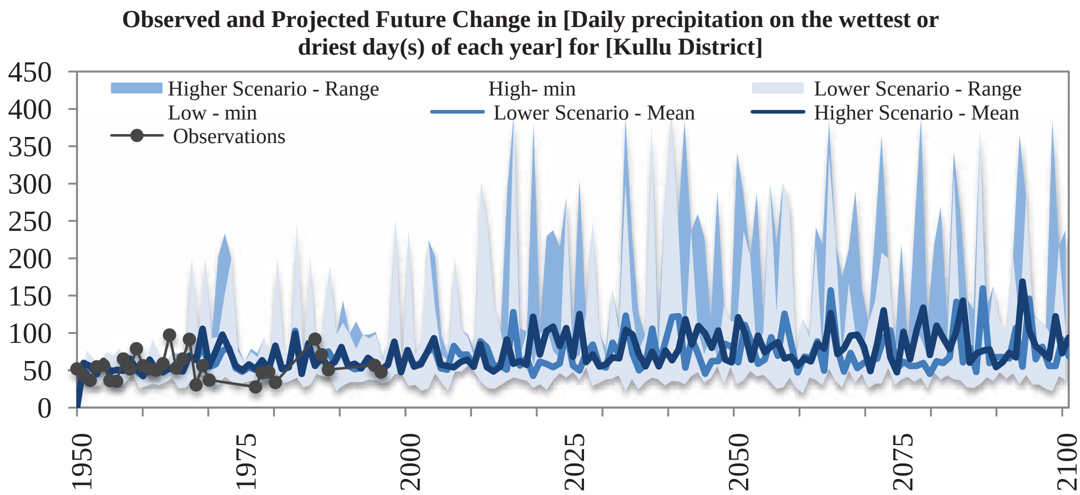
The RCP8.5 combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies. Compared to the total set of Representative Concentration Pathways (RCPs), RCP8.5 thus corresponds to the pathway with the highest greenhouse gas emissions. Using the IIASA Integrated Assessment Framework and the MESSAGE model for the development of the RCP8.5, we focus in this paper on two important extensions compared to earlier scenarios: 1) the development of spatially explicit air pollution projections, and 2) enhancements in the land-use and land-cover change projections. In addition, we explore scenario variants that use RCP8.5 as a baseline, and assume different degrees of greenhouse gas mitigation policies to reduce radiative forcing. Based on our modeling framework, we find it technically possible to limit forcing from RCP8.5 to lower levels comparable to the other RCPs (2.6 to 6 W/m2). Our scenario analysis further indicates that climate policyinduced changes of global energy supply and demand may lead to significant co-benefits for other policy priorities, such as local air pollution.

9.2.1 Precipitation & Temperature

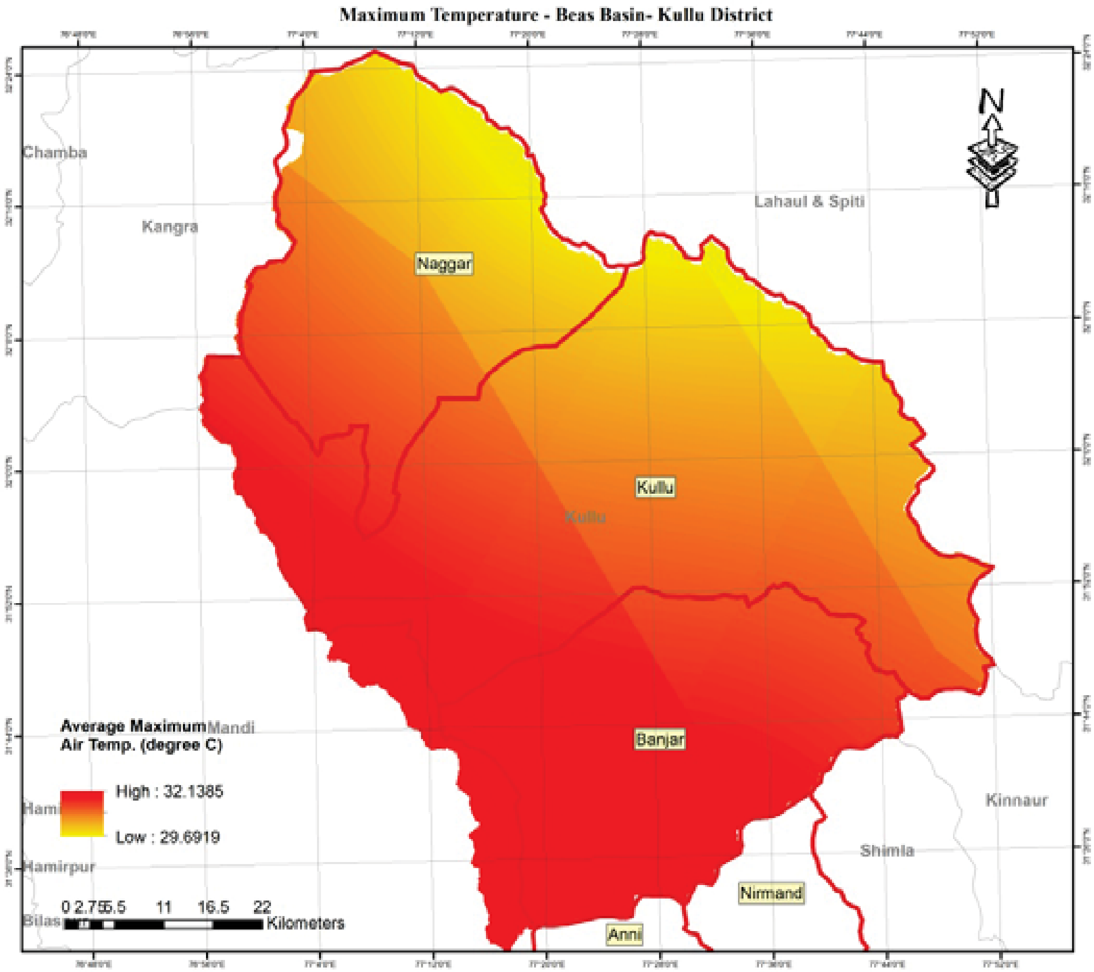
In order to analyse climate change global weather data available for 30 years (1979-2013) was analysed but since the scale of our study is panchayat/village level the precipitation was available for the few locations as depicted in Weather Station Location Map (Map 8.4).



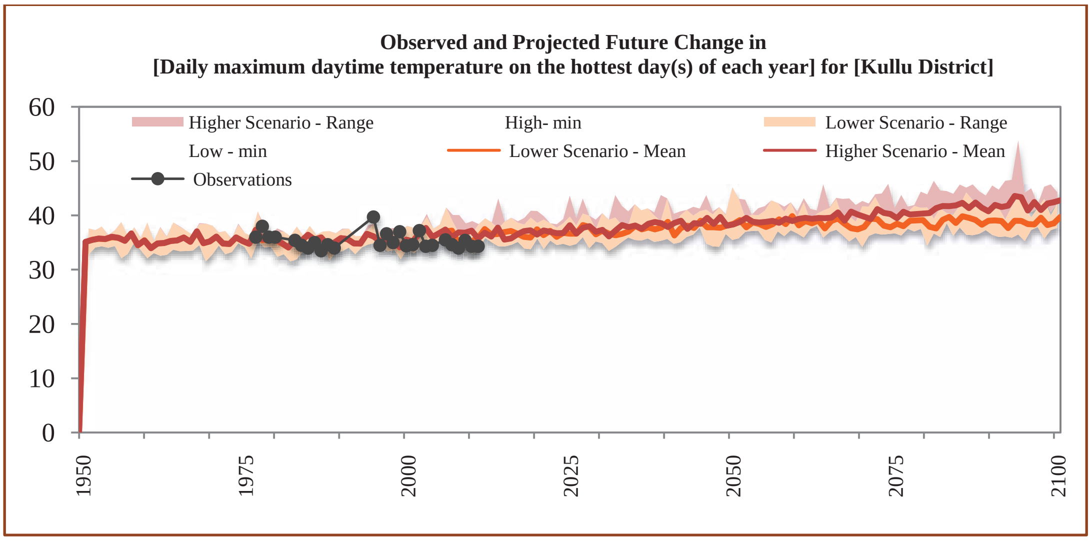
Map 9.1 Average Precipitation Map – Kullu District

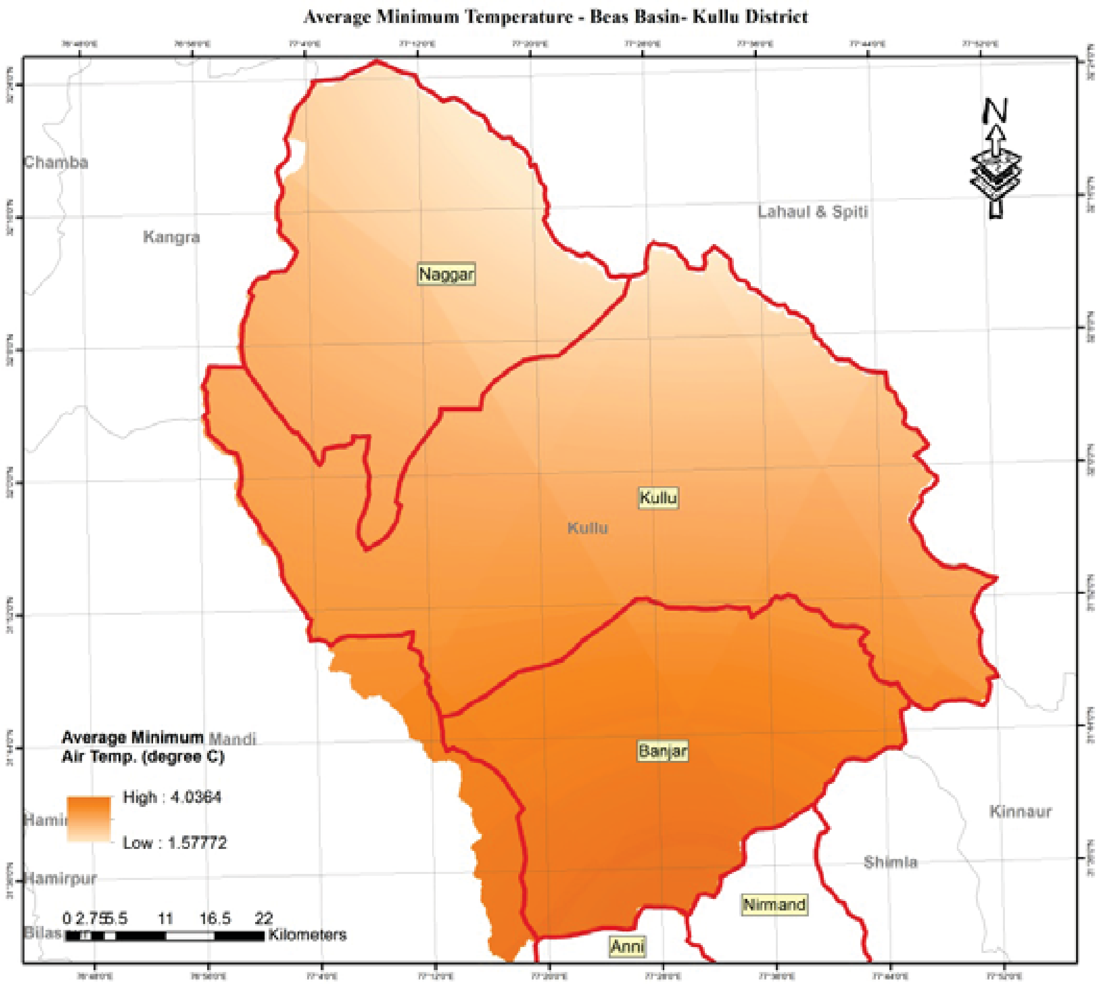


Since precipitation is one of the indicator used in analysing climate change vulnerability at village level, there is a requirement of precipitation values for each village, therefore, the available data is further extrapolated using IWD method (*Inverse Distance Weighting is a type of deterministic method for multivariate interpolation with a known scattered set of points. The assigned values to unknown points are calculated with a weighted average of the values available at the known points*).

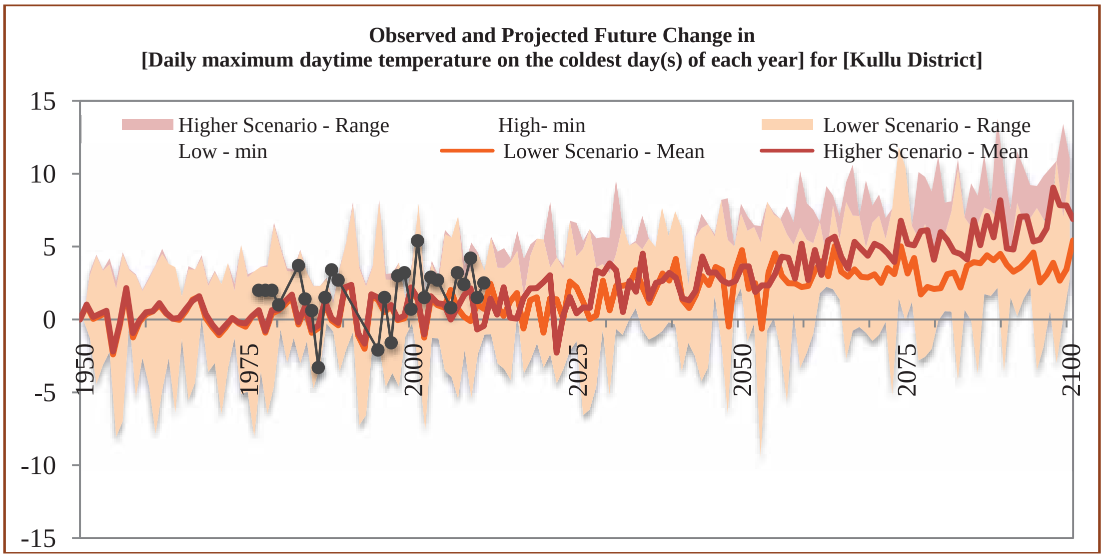


Map 9.2 Average Maximum Temperature Map – Kullu District





Map 9.3 Average Minimum Map – Kullu District



After downscaling the global climate data to the regional level the clear picture of climate change appeared. Also observed and projected future climate change w.r.t. Precipitation wettest & driest day, Maximum & Minimum day temperature on the hottest days(s) of each year (Year 1950-2100) analysed and depicted through graphs. After analysing an increase in minimum & maximum day temperature on the hottest day(s) has been observed over 150 years from observed and project climate change data.

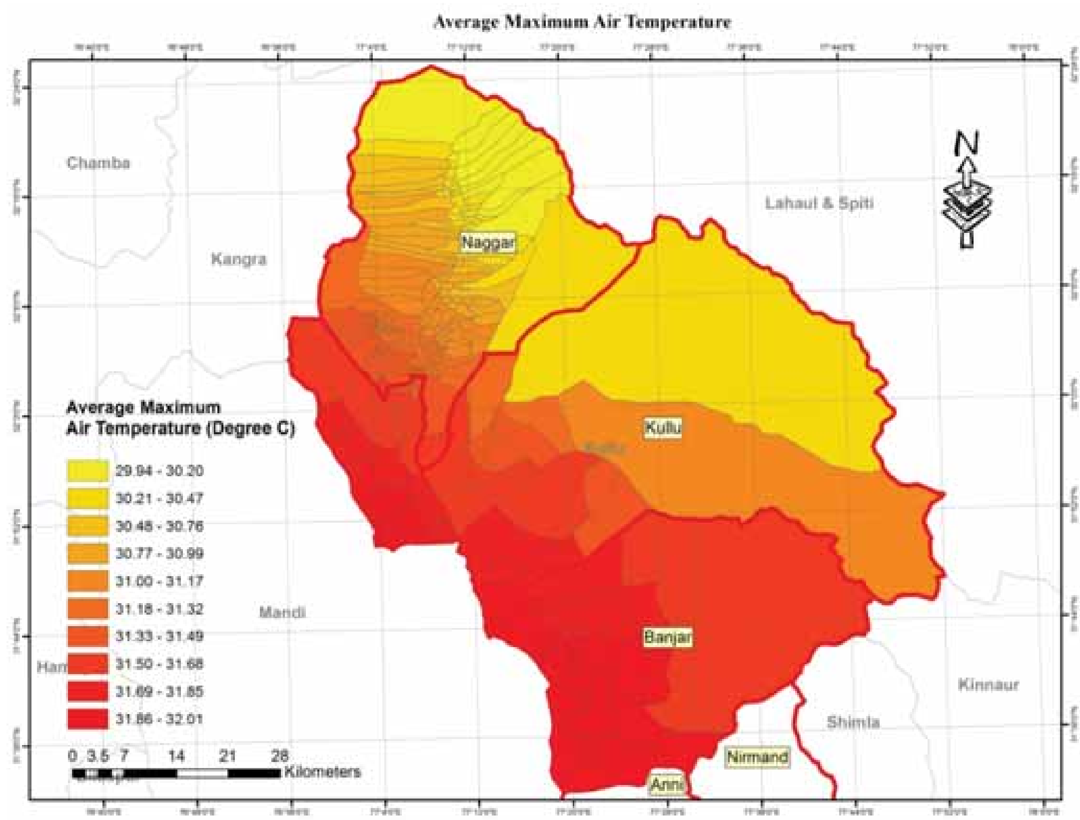
9.3 Exposure Indicators

Four indicators of exposure have been computed using meteorological data for a period of 34 years (1979-2013). The maps have been developed for each of these indicators of climatic exposure. The indicator-wise analysis is as under:

Code	Exposure	Units	Years	Functional Relationship with Exposure	Data Source
E01	Average maximum air temperature	°C	1979-2013	↑	SWAT Model
E02	Average minimum air temperature	°C	1979-2013	↑	SWAT Model
E03	Average precipitation	mm	1979-2013	↓	SWAT Model
E04	Water stress days	Days	1979-2013	↑	SWAT Model
E05	Temperature stress days	Days	1979-2013	↑	SWAT Model

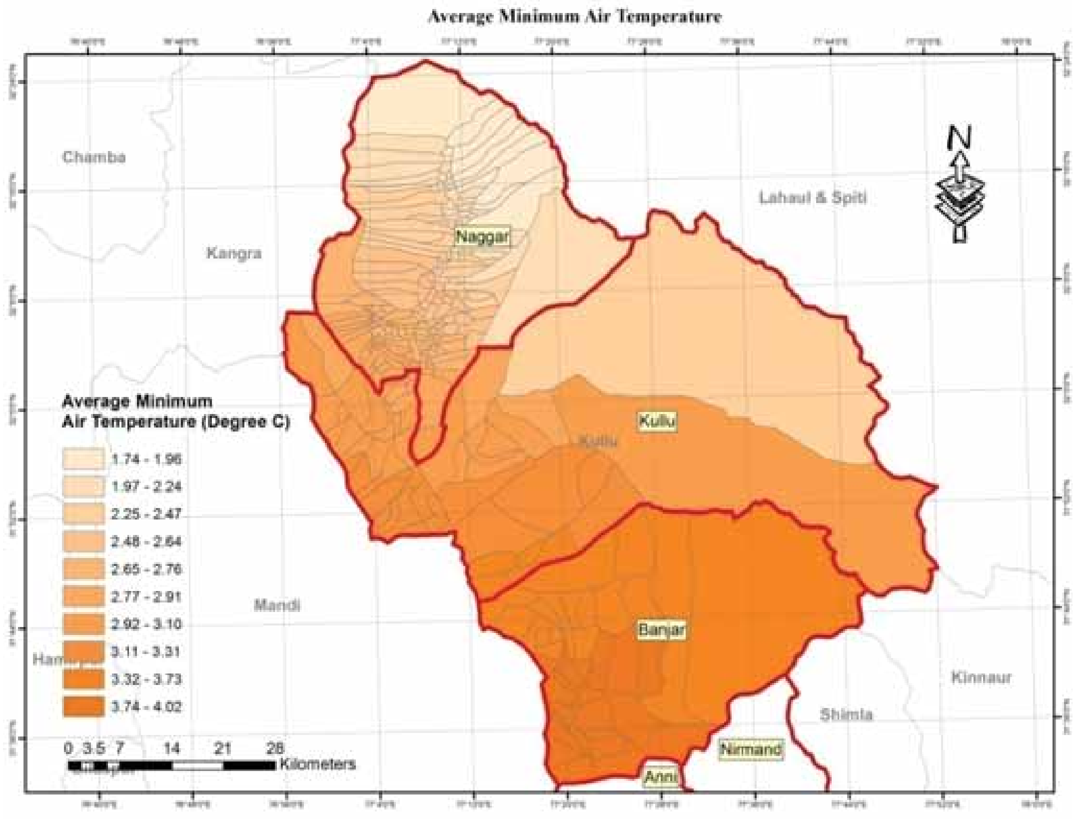
E01 Average maximum air temperature

Global Weather data have used to calculate temperature indicator. There were only three weather stations each at three developmental blocks. The data for the period of 34 years (1979-2013) is available. Temperature data is available on daily basis. A monthly average have been calculated for 34 years.



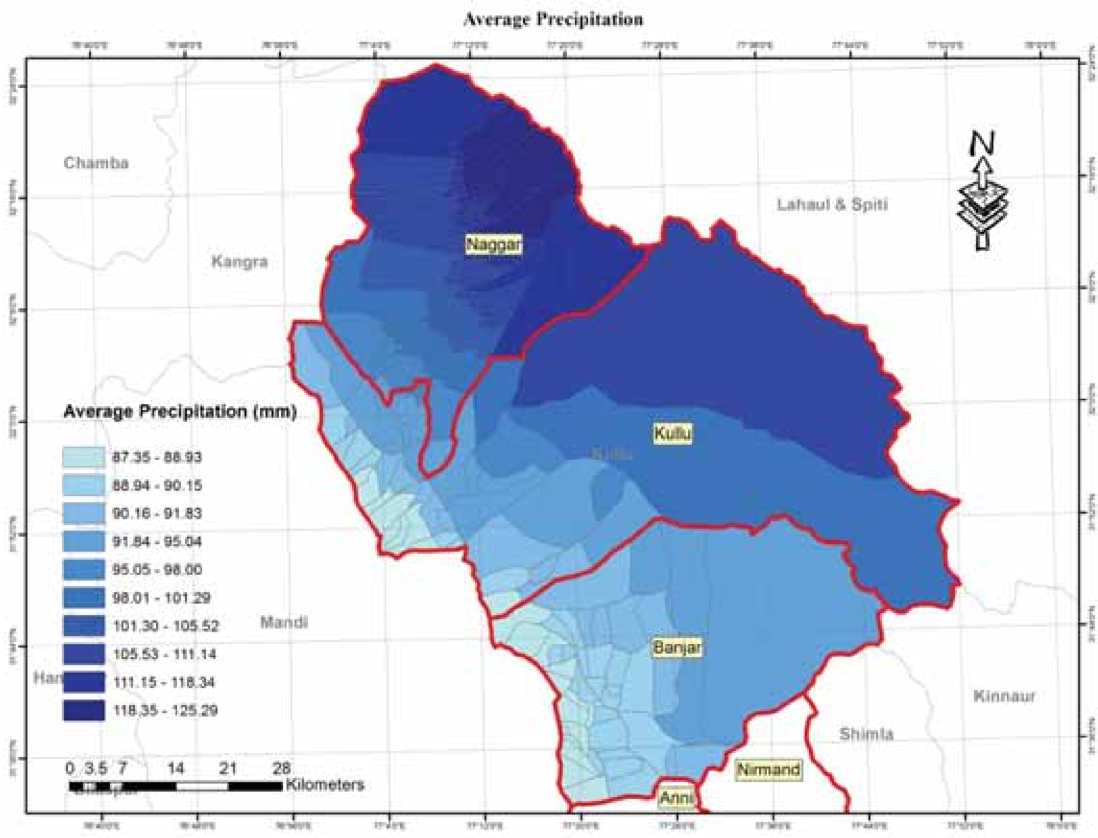
Map 9.4 Village wise Average maximum air temperature – Beas Basin - Kullu District

E02 Average minimum air temperature



Map 9.5 Village wise Average minimum air temperature – Beas Basin - Kullu District

E03 Average precipitation

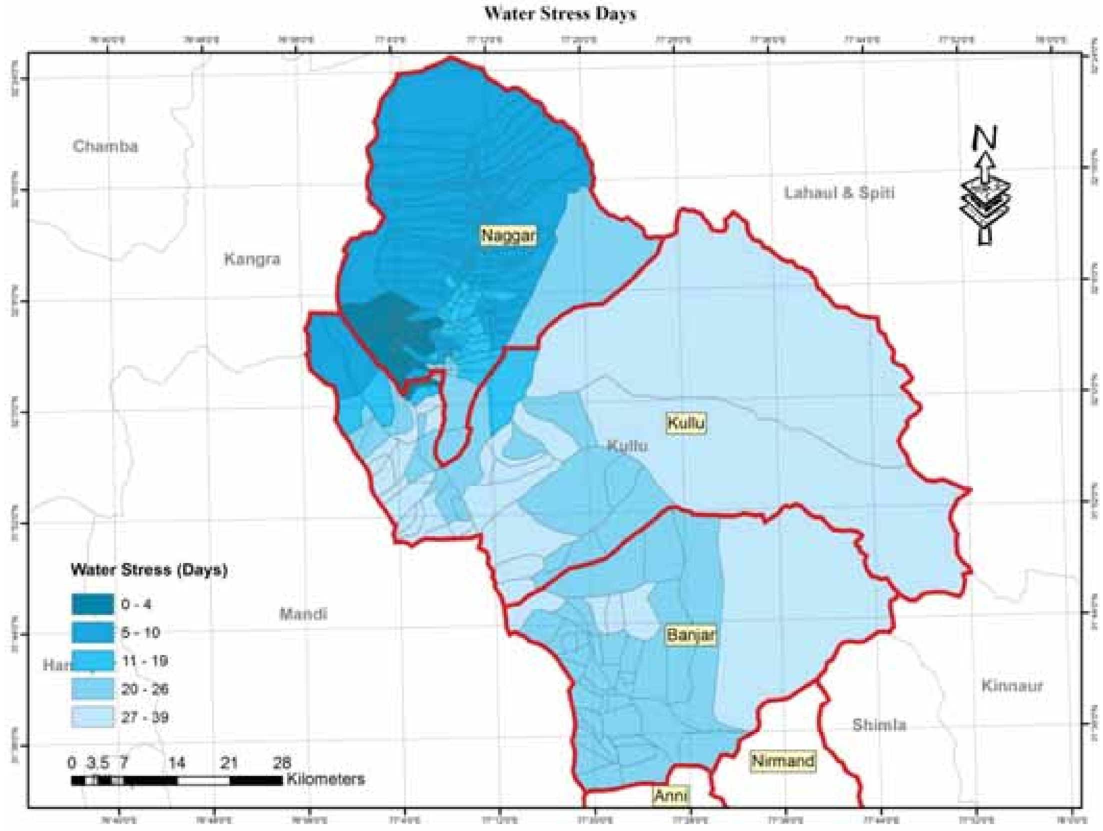


Map 9.6 Village wise Average Precipitation – Beas Basin - Kullu District

Global Weather data has been used to calculate precipitation indicator. As explained earlier, there were only three weather stations each at three developmental blocks and data for the period of 34 years (1979-2013) is available. Precipitation data is available on daily basis. A monthly average is calculated for 34 years.

E04 Water stress days

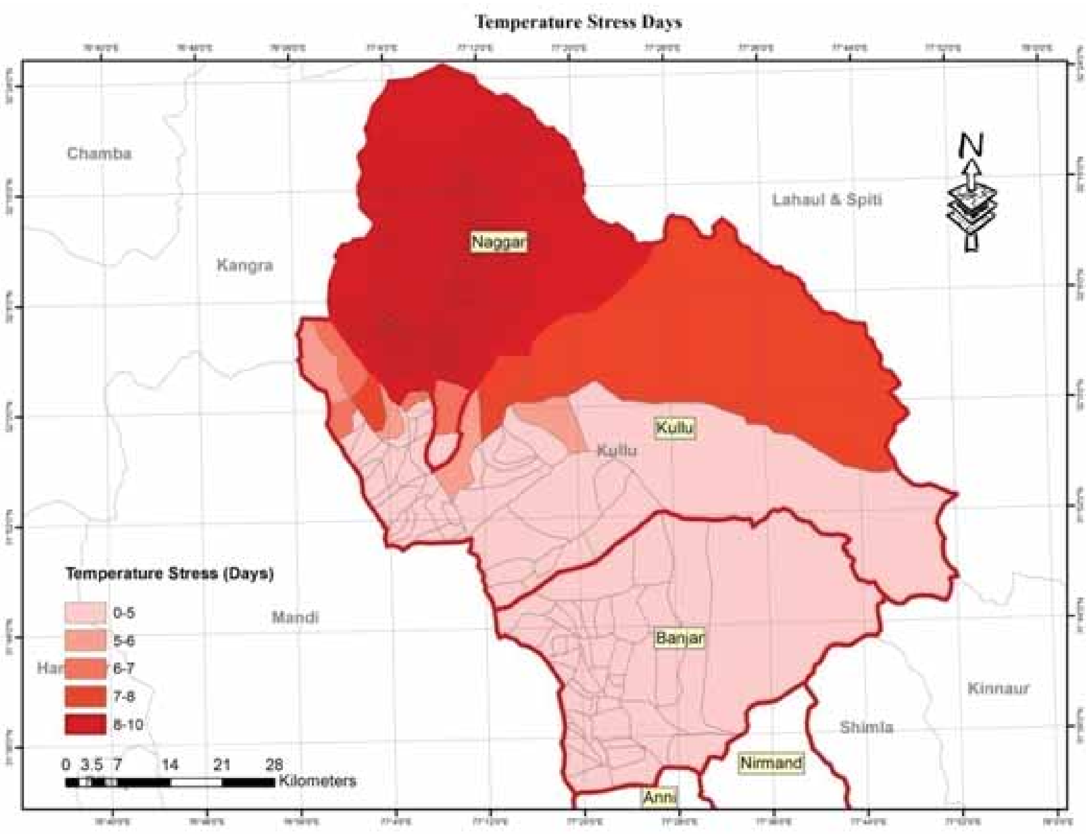
The water stress days are generated using SWAT model analysis. Water stress days for each Hydrological Response Unit (HRU) the smallest unit of micro shed are generated after running the SWAT model. These water stress days are further calculated for all the villages of the three developmental blocks of district Kullu falling in Beas River Basin. The following Map 9.7 depicts that villages of Kullu and Banjar Block encounter more water stress days as compare to the Naggar Block. More the water stress days will increase the exposure to the climate change vulnerability.



Map 9.7 Village wise Water Stress Days – Beas Basin - Kullu District

E05 Temperature stress days

The temperature stress days are also generated after SWAT model analysis and further depicted in Map 9.8. Temperature stress days for each Hydrological Response Unit (HRU) the smallest unit of micro shed are generated. These temperature stress days are further calculated for all the villages of the three developmental blocks of district Kullu falling in Beas River Basin. The Map 9.8 depicts that villages of Naggar and Kullu Blocks encounter more temperature stress days as compare to the Banjar Block. More the temperature stress days will increase the exposure to the climate change vulnerability.



Map 9.8 Village wise Temperature Stress Days – Beas Basin - Kullu District

9.3 Composite Exposure

Composite exposure has been calculated using normalization of values of four variables viz: Rain fall, temperature (E01,E02,E03,E04 & E05). Since the values are with different scale and units, the normalization of indicators using functional relationship has been done.

Variable Indicator E01 i.e. Average maximum temperature has ↑ functional relationship with exposure and the normalization is done using the formula, which means the increase in average maximum temperature will increase the exposure level that will further leads to high vulnerability:

$$x_{ij} = \frac{X_{ij}-Min_i\{X_{ij}\}}{Max_i\{X_{ij}\}-Min_i\{X_{ij}\}}$$

However, for indicator E03 i.e. Average precipitation the normalization is done using the formula:

$$y_{ij} = \frac{Max_i\{X_{ij}\}-X_{ij}}{Max_i\{X_{ij}\}-Min_i\{X_{ij}\}}$$

This is because the function relationship of indicator E03 with vulnerability is ↓, which means, the increase in precipitation will reduce exposure level and vulnerability.

After calculating the score of variables E01, E02, E03, E04 & E05 the average score is calculated and the Composite Exposure is calculated and mapped for all villages of three blocks of district Kullu falling in Beas River Basin.

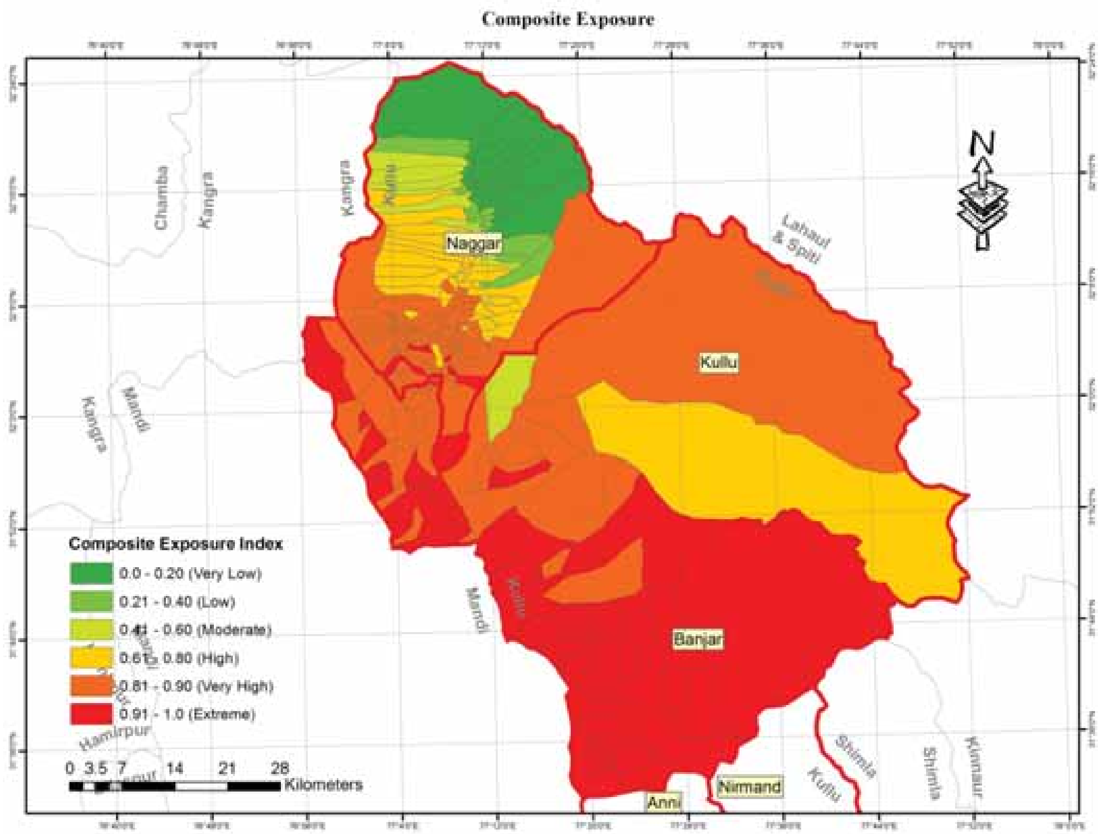
Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables					Composite Exposure
			E01	E02	E03	E04	E05	
800103	Banjar (NP)	Banjar	0.98	0.93	0.96	0.57	0.00	0.88
012900	Kotla (1/1)	Banjar	0.96	0.84	0.97	0.62	0.19	0.93
012901	Chakurtha (1/2)	Banjar	0.96	0.80	0.98	0.66	0.19	0.93
012902	Kanon (1/3)	Banjar	0.92	0.82	0.94	0.62	0.19	0.89
012903	Dhaugi (1/4)	Banjar	0.91	0.82	0.94	0.63	0.19	0.89
012904	Dusharh (2/5)	Banjar	0.91	0.82	0.93	0.69	0.19	0.91
012905	Manyashi (2/6)	Banjar	0.91	0.83	0.92	0.67	0.19	0.91
012906	Sachen (2/7)	Banjar	0.87	0.77	0.90	0.63	0.19	0.84
012907	Shanshar (41/104)	Banjar	0.79	0.74	0.85	0.64	0.19	0.78
012908	Gara Parli (41/103)	Banjar	0.90	0.84	0.92	0.70	0.19	0.92
012909	Shangarh (3/9)	Banjar	0.89	0.84	0.91	0.63	0.19	0.88
012910	Lapah (3/8)	Banjar	0.93	0.89	0.94	0.63	0.19	0.93
012911	Shapnil (4/11)	Banjar	0.95	0.92	0.94	0.63	0.19	0.94
012912	Siri Kot (4/10)	Banjar	0.95	0.92	0.94	0.63	0.19	0.95
012913	Kalwari (4/12)	Banjar	0.95	0.90	0.95	0.63	0.19	0.94
012914	Deotha (5/14)	Banjar	0.93	0.87	0.94	0.63	0.19	0.92
012915	Thani Char (5/15)	Banjar	0.94	0.87	0.95	0.63	0.19	0.92
012916	Chanon (5/19)	Banjar	0.96	0.89	0.96	0.63	0.19	0.94
012917	Palach (4/13)	Banjar	0.94	0.85	0.95	0.62	0.19	0.92
012918	Sehuli (5/16)	Banjar	0.94	0.85	0.96	0.62	0.19	0.92
012919	Jauri ((5/17	Banjar	0.96	0.87	0.96	0.62	0.19	0.94
012920	Thati Bir (5/18)	Banjar	0.98	0.89	0.98	0.63	0.19	0.96
012921	Ratwah (6/21)	Banjar	0.98	0.91	0.97	0.64	0.19	0.97
012922	Tarangali (6/20)	Banjar	0.99	0.92	0.98	0.63	0.19	0.98
012923	Bala Gad (7/23)	Banjar	0.99	0.94	0.97	0.62	0.19	0.98
012924	Bahu (9/27)	Banjar	1.00	0.93	0.98	0.62	0.19	0.98
012925	Chethar (7/22)	Banjar	0.99	0.94	0.98	0.62	0.19	0.98
012926	Khabal (8/24)	Banjar	0.99	0.95	0.97	0.62	0.19	0.99
012927	Mohni (8/25)	Banjar	1.00	0.96	0.98	0.62	0.19	0.99
012928	Seraj (8/26)	Banjar	1.00	0.98	0.97	0.62	0.19	0.99
012929	Karshai Gad-II (23/72)	Banjar	0.98	0.96	0.96	0.62	0.19	0.98
012930	Tandi (9/28)	Banjar	0.97	0.99	0.94	0.61	0.19	0.98
012931	Sajwar (10/29)	Banjar	0.98	0.98	0.95	0.61	0.19	0.98
012932	Ghiaghi (10/30)	Banjar	0.98	0.97	0.95	0.61	0.19	0.97
012933	Rashala (10/31)	Banjar	0.97	0.95	0.95	0.64	0.19	0.98
012934	Bini (11/32)	Banjar	0.96	0.93	0.95	0.63	0.19	0.96
012935	Bihar (11/33)	Banjar	0.96	0.98	0.93	0.64	0.19	0.97
012936	Sharchi (12/34)	Banjar	0.94	0.92	0.93	0.63	0.19	0.94
012937	Pakhari (12/37)	Banjar	0.93	0.93	0.93	0.63	0.19	0.94
012938	Tinder (13/36)	Banjar	0.84	0.84	0.87	0.64	0.19	0.85
012939	Chippni (14/38)	Banjar	0.96	1.00	0.92	0.62	0.19	0.97
012940	Shilhi (12/35)	Banjar	0.78	0.81	0.87	0.84	0.19	0.89
012941	Mashyar (14/39)	Banjar	0.99	1.00	0.95	0.64	0.19	1.00
800101	Kullu (M Cl)	Kullu	0.83	0.57	0.88	0.65	0.19	0.75
800102	Bhuntar (NP)	Kullu	0.89	0.64	0.92	0.62	0.19	0.80
012799	Biasar (27/55)	Kullu	0.76	0.51	0.81	0.09	0.91	0.74
012800	Up Muhal Thalli	Kullu	0.73	0.49	0.78	0.02	1.00	0.71
012801	Up Muhal Ropa sari	Kullu	0.72	0.49	0.78	0.02	1.00	0.71
012802	Up Muhal Mapak	Kullu	0.70	0.48	0.75	0.51	1.00	0.87
012803	Bandrol (27/56)	Kullu	0.69	0.47	0.75	0.57	1.00	0.89
012804	Up Muhal Nangabag	Kullu	0.73	0.50	0.78	0.38	0.55	0.68
012805	Up Muhal Harabag	Kullu	0.71	0.49	0.76	0.08	1.00	0.72
012806	Up Muhal Bagu Nalha	Kullu	0.71	0.49	0.77	0.02	1.00	0.70
012807	Up Muhal Maltibag	Kullu	0.72	0.48	0.78	0.02	1.00	0.70
012850	Jandor (26/54)	Kullu	0.76	0.52	0.81	0.67	0.19	0.68
012851	Banogi (26/53)	Kullu	0.78	0.53	0.83	0.67	0.19	0.70
012852	Sari (26/51)	Kullu	0.80	0.54	0.85	0.64	0.19	0.71
012853	Bastori (26/52)	Kullu	0.82	0.55	0.87	0.67	0.19	0.75
012854	Dughilag (30/67)	Kullu	0.81	0.54	0.86	0.54	0.34	0.74
012855	Majhat (30/68)	Kullu	0.81	0.53	0.87	0.26	0.70	0.77
012856	Phallan (30/66)	Kullu	0.77	0.50	0.84	0.14	0.54	0.62

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables					Composite Exposure
			E01	E02	E03	E04	E05	
012857	Dunkhri Gahar (30/65)	Kullu	0.81	0.52	0.89	0.16	0.40	0.62
012858	Pichhli (31/69)	Kullu	0.87	0.56	0.93	0.41	0.47	0.80
012859	Mashna (31/70)	Kullu	0.90	0.58	0.95	0.61	0.19	0.79
012860	Gahar (32/71)	Kullu	0.86	0.56	0.91	0.58	0.22	0.75
012861	Gramang (32/72)	Kullu	0.89	0.59	0.94	0.66	0.19	0.81
012862	Bhalyani (33/75)	Kullu	0.89	0.58	0.94	0.63	0.19	0.79
012863	Brahman (33/74)	Kullu	0.94	0.62	0.98	0.67	0.19	0.86
012864	Balh (33/73)	Kullu	0.92	0.61	0.97	0.66	0.19	0.84
012865	Bhumtir (33/76)	Kullu	0.88	0.59	0.92	0.67	0.19	0.80
012866	Peej (34/77)	Kullu	0.87	0.60	0.92	0.64	0.19	0.79
012867	Balh (34/79)	Kullu	0.88	0.61	0.92	0.67	0.19	0.81
012868	Kharihar (34/81)	Kullu	0.94	0.63	0.98	0.68	0.19	0.86
012869	Barahar (34/80)	Kullu	0.80	0.56	0.84	0.64	0.19	0.72
012871	Rajgiri (35/82)	Kullu	0.96	0.66	0.99	0.68	0.19	0.89
012872	Shillihar (35/83)	Kullu	0.87	0.61	0.91	0.61	0.19	0.78
012873	Mohal (35/84)	Kullu	0.94	0.64	0.98	0.71	0.19	0.88
012874	Bhullang (35/86)	Kullu	0.94	0.65	0.97	0.68	0.19	0.87
012875	Khokhan (35/87)	Kullu	0.94	0.67	0.97	0.72	0.19	0.90
012876	Neol (35/88)	Kullu	0.91	0.66	0.94	0.67	0.19	0.85
012877	Bajaura (36/89)	Kullu	0.91	0.67	0.94	0.66	0.19	0.85
012878	Hat (36/90)	Kullu	0.83	0.62	0.86	0.66	0.19	0.76
012879	Shillihar (37/91)	Kullu	0.78	0.55	0.82	0.58	0.30	0.72
012880	Kashawri (25/49)	Kullu	0.63	0.45	0.67	0.31	0.85	0.67
012881	Pini (25/48)	Kullu	0.17	0.15	0.22	0.53	1.00	0.34
012883	Manikarn (40/101)	Kullu	0.52	0.55	0.70	0.80	0.22	0.62
012884	Sosan (40/102)	Kullu	0.63	0.49	0.68	0.53	0.39	0.60
012885	Jari (39/100)	Kullu	0.69	0.53	0.73	0.66	0.19	0.62
012886	Bradha (39/99)	Kullu	0.74	0.55	0.79	0.66	0.19	0.68
012887	Shat (38/98)	Kullu	0.79	0.58	0.83	0.66	0.19	0.72
012888	Chong (38/96)	Kullu	0.73	0.55	0.77	0.65	0.19	0.66
012889	Jallu (38/97)	Kullu	0.77	0.58	0.81	0.67	0.19	0.71
012890	Ratocha (38/95)	Kullu	0.87	0.69	0.90	0.67	0.19	0.83
012891	Diar (37/92)	Kullu	0.91	0.74	0.94	0.67	0.19	0.88
012892	Rote-II (42/107)	Kullu	0.87	0.73	0.91	0.65	0.19	0.84
012893	Bhallan-I (42/106)	Kullu	0.76	0.64	0.81	0.63	0.19	0.72
012894	Manjhli (37/93)	Kullu	0.69	0.60	0.75	0.64	0.19	0.65
012895	Parli (37/94)	Kullu	0.74	0.67	0.80	0.63	0.19	0.71
012896	Shamshi (CT)	Kullu	0.89	0.63	0.93	0.16	1.00	0.94
012897	Raila (42/105)	Kullu	0.86	0.74	0.90	0.63	0.19	0.83
012898	Bhalan-II (42/106)	Kullu	0.95	0.77	0.97	0.69	0.19	0.93
012899	Rote-I (42/107)	Kullu	0.97	0.83	0.98	0.64	0.19	0.94
800100	Manali (M Cl)	Naggar	0.19	0.14	0.25	0.62	0.19	0.08
012658	Palchan (21/24)	Naggar	0.21	0.15	0.31	0.19	1.00	0.26
012659	UP Muhal Solang	Naggar	0.12	0.08	0.20	0.18	1.00	0.16
012660	UP Muhal Kothi	Naggar	0.03	0.02	0.05	0.15	1.00	0.02
012661	UP Muhal Kulang	Naggar	0.02	0.01	0.04	0.11	1.00	0.00
012662	Muhal Buruwa (21/25)	Naggar	0.28	0.19	0.38	0.16	1.00	0.32
012663	Up Muhal Buruwa Majhach	Naggar	0.14	0.10	0.20	0.10	1.00	0.14
012664	Up Muhal Vyas Tibba	Naggar	0.12	0.09	0.18	0.11	1.00	0.12
012665	Up Muhal Shanag	Naggar	0.16	0.11	0.22	0.14	1.00	0.17
012666	Up Muhal Gaushal	Naggar	0.16	0.12	0.23	0.14	1.00	0.18
012667	Up Muhal Bahang	Naggar	0.03	0.02	0.05	0.12	1.00	0.02
012668	Up Muhal Majhach	Naggar	0.31	0.21	0.40	0.18	1.00	0.35
012669	Bashisht (20/23)	Naggar	0.03	0.02	0.04	0.18	1.00	0.03
012670	Up Muhal Kaushala	Naggar	0.00	0.00	0.00	0.19	1.00	0.00
012671	Up Muhal Dharanu	Naggar	0.11	0.08	0.15	0.14	1.00	0.12
012672	Up Muhal Chachoga	Naggar	0.15	0.11	0.20	0.14	1.00	0.16
012673	Up Muhal Aleu	Naggar	0.18	0.14	0.25	0.14	1.00	0.20
012674	Jangal Mehduda Mehfuja Aleu Vihal	Naggar	0.17	0.13	0.23	0.14	1.00	0.19
012675	Muhal Manali (21/26)	Naggar	0.18	0.13	0.24	0.11	1.00	0.18

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables					Composite Exposure
			E01	E02	E03	E04	E05	
012676	Up Muhal Dhungri -2nd	Naggar	0.42	0.28	0.50	0.18	1.00	0.46
012677	Up Muhal Tyan Padhar	Naggar	0.18	0.13	0.25	0.13	1.00	0.19
012678	Up Muhal Manali Koot	Naggar	0.32	0.22	0.41	0.19	1.00	0.37
012679	Up Muhal Manu Nagar	Naggar	0.31	0.21	0.39	0.19	1.00	0.36
012680	Up Muhal Manali Ser	Naggar	0.17	0.12	0.24	0.11	1.00	0.18
012681	Up Muhal Kaliganch	Naggar	0.19	0.14	0.27	0.13	1.00	0.21
012682	Aarkshit Van R-I Dhungri	Naggar	0.21	0.15	0.29	0.16	1.00	0.24
012683	Muhal Nasogi (21/27)	Naggar	0.34	0.23	0.42	0.20	1.00	0.39
012684	Up Muhal Simsa	Naggar	0.22	0.17	0.30	0.12	1.00	0.24
012685	Up Muhal Syal	Naggar	0.21	0.15	0.28	0.14	1.00	0.23
012686	Up Muhal Chhiyal	Naggar	0.22	0.16	0.29	0.14	1.00	0.25
012687	Up Muhal Kanyal	Naggar	0.40	0.27	0.47	0.18	1.00	0.44
012688	Muhal Shallin (21/28)	Naggar	0.39	0.26	0.43	0.12	1.00	0.40
012689	Up Muhal Klath	Naggar	0.47	0.31	0.53	0.14	1.00	0.49
012690	Up Muhal Parsha	Naggar	0.43	0.28	0.49	0.15	1.00	0.46
012691	Up Muhal Klaont	Naggar	0.29	0.20	0.36	0.15	1.00	0.32
012692	Up Muhal Jhunjhari	Naggar	0.45	0.29	0.51	0.14	1.00	0.47
012693	Up Muhal Gadherani	Naggar	0.34	0.23	0.40	0.18	1.00	0.37
012694	Muhal Bran (22/29)	Naggar	0.42	0.28	0.46	0.14	1.00	0.43
012695	Up Muhal Chharogi	Naggar	0.43	0.28	0.47	0.15	1.00	0.44
012696	Up Muhal Mandhon	Naggar	0.49	0.32	0.55	0.15	1.00	0.52
012697	Up Muhal Shangchar	Naggar	0.52	0.34	0.58	0.15	1.00	0.54
012698	Up Muhal Dobha	Naggar	0.44	0.29	0.48	0.15	1.00	0.46
012699	Up Muhal Rampur	Naggar	0.44	0.30	0.49	0.15	1.00	0.46
012700	Muhal Pangan (22/38)	Naggar	0.47	0.31	0.52	0.15	1.00	0.49
012701	Up Muhal Gumidhar	Naggar	0.45	0.30	0.50	0.15	1.00	0.47
012702	Muhal Riyara (22/30)	Naggar	0.47	0.31	0.52	0.15	1.00	0.49
012703	Up Muhal Defri	Naggar	0.49	0.33	0.54	0.21	1.00	0.54
012704	Muhal Shigli (22/31)	Naggar	0.55	0.36	0.62	0.15	1.00	0.58
012705	Up Muhal Kasheri	Naggar	0.55	0.36	0.62	0.17	1.00	0.59
012706	Up Muhal Nayalag	Naggar	0.51	0.34	0.56	0.34	1.00	0.61
012707	Muhal Hallan-II (22/32)	Naggar	0.57	0.38	0.64	0.12	1.00	0.59
012708	Up Muhal Magana	Naggar	0.58	0.39	0.64	0.13	1.00	0.60
012709	Up Muhal Shilha	Naggar	0.53	0.36	0.59	0.10	1.00	0.54
012710	Muhal Bari (22/36)	Naggar	0.55	0.37	0.60	0.29	1.00	0.63
012711	Up Muhal Tarashi	Naggar	0.57	0.38	0.63	0.36	1.00	0.68
012712	Badgran (22/37)	Naggar	0.52	0.35	0.57	0.31	1.00	0.61
012713	Soil (23/41)	Naggar	0.26	0.20	0.32	0.18	1.00	0.30
012714	Up Muhal Haripur	Naggar	0.46	0.31	0.50	0.24	1.00	0.52
012715	Up Muhal Somvan	Naggar	0.48	0.32	0.52	0.19	1.00	0.52
012716	Karjan (23/40)	Naggar	0.42	0.29	0.46	0.15	1.00	0.44
012717	Sajla (23/39)	Naggar	0.32	0.23	0.37	0.16	1.00	0.35
012718	Up Muhal Sajal Vihal	Naggar	0.41	0.27	0.45	0.14	1.00	0.42
012719	Up Muhal Dhamasu Kalaun	Naggar	0.39	0.27	0.43	0.15	1.00	0.41
012720	Muhal Gojra (20/20)	Naggar	0.21	0.17	0.28	0.16	1.00	0.25
012721	Up Muhal Khakhanal	Naggar	0.37	0.25	0.41	0.13	1.00	0.38
012722	Up Muhal Barnar	Naggar	0.23	0.18	0.31	0.16	1.00	0.27
012723	Muhal Jagatsukh (20/21)	Naggar	0.23	0.17	0.30	0.12	1.00	0.25
012724	Up Muhal Bhanara	Naggar	0.08	0.07	0.11	0.22	1.00	0.11
012725	Up Muhal Chhalala	Naggar	0.29	0.20	0.35	0.12	1.00	0.30
012726	Up Muhal Bahanu	Naggar	0.22	0.17	0.30	0.11	1.00	0.24
012727	Muhal Prini (20/22)	Naggar	0.20	0.15	0.26	0.13	1.00	0.21
012728	Up Muhal Hamta	Naggar	0.16	0.13	0.22	0.12	1.00	0.17
012729	Up Muhal Hamta 2/17	Naggar	0.01	0.01	0.01	0.16	1.00	0.00
012730	Up Muhal Hamta 1/7	Naggar	0.10	0.08	0.15	0.12	1.00	0.10
012731	Up Muhal Shuru	Naggar	0.21	0.16	0.28	0.11	1.00	0.22
012732	Up Muhal Jamari	Naggar	0.19	0.14	0.25	0.12	1.00	0.20
012733	Hallan-I (24/42)	Naggar	0.49	0.33	0.54	0.38	1.00	0.61
012734	Up Muhal Rangri	Naggar	0.50	0.34	0.55	0.41	1.00	0.63
012735	Up Muhal chaki	Naggar	0.51	0.34	0.55	0.35	1.00	0.61
012736	Up Muhal Sarsai	Naggar	0.49	0.33	0.53	0.41	1.00	0.61

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables					Composite Exposure
			E01	E02	E03	E04	E05	
012737	Up Muhal Kumartee	Naggar	0.47	0.32	0.51	0.34	1.00	0.56
012738	Up Muhal Raman	Naggar	0.45	0.31	0.49	0.30	1.00	0.53
012739	Up Muhal Batahar Bihal	Naggar	0.35	0.26	0.41	0.22	1.00	0.41
012740	Nagar (24/43)	Naggar	0.54	0.37	0.58	0.29	1.00	0.62
012741	Up Muhal Pulag	Naggar	0.48	0.34	0.52	0.20	1.00	0.52
012742	Up Muhal Rumsu	Naggar	0.50	0.34	0.54	0.22	1.00	0.55
012743	Up Muhal chachogee	Naggar	0.52	0.36	0.57	0.23	1.00	0.58
012744	Up Muhal Madi	Naggar	0.46	0.32	0.50	0.23	1.00	0.52
012745	Up Muhal Mashda	Naggar	0.52	0.35	0.57	0.37	1.00	0.63
012746	Up Muhal Ghadopa	Naggar	0.56	0.38	0.61	0.35	1.00	0.66
012747	Katrain (22/35)	Naggar	0.58	0.39	0.64	0.36	1.00	0.69
012748	Up Muhal Jatehad	Naggar	0.57	0.38	0.62	0.36	1.00	0.68
012749	Dawara (22/34)	Naggar	0.61	0.41	0.67	0.07	1.00	0.61
012750	Up Muhal Dachnee	Naggar	0.61	0.41	0.67	0.10	1.00	0.62
012751	Meha (22/33)	Naggar	0.61	0.41	0.68	0.02	1.00	0.59
012752	Up Muhal Bhujnu	Naggar	0.63	0.42	0.70	0.03	1.00	0.62
012753	Pichlihar (29/64)	Naggar	0.62	0.40	0.71	0.14	0.92	0.63
012754	Up Muhal chukdee	Naggar	0.69	0.45	0.77	0.06	1.00	0.69
012755	Up Muhal Jalog	Naggar	0.63	0.41	0.70	0.07	1.00	0.63
012756	Up Muhal Jigling	Naggar	0.64	0.42	0.72	0.06	1.00	0.64
012757	Up Muhal Kabhi	Naggar	0.64	0.42	0.71	0.06	1.00	0.64
012758	Up Muhal Kaistha	Naggar	0.69	0.45	0.77	0.06	0.95	0.67
012759	Up Muhal Galang	Naggar	0.69	0.45	0.77	0.04	1.00	0.68
012760	Up Muhal Nari	Naggar	0.71	0.46	0.78	0.02	1.00	0.69
012761	Up Muhal Bagnee	Naggar	0.70	0.46	0.77	0.03	1.00	0.69
012762	Up Muhal Daral	Naggar	0.63	0.42	0.70	0.03	1.00	0.62
012763	Up Muhal Damchin	Naggar	0.65	0.43	0.71	0.03	1.00	0.63
012764	Up Muhal Pradee	Naggar	0.64	0.43	0.71	0.02	1.00	0.63
012765	Fojal (29/63)	Naggar	0.67	0.44	0.73	0.02	1.00	0.65
012766	Up Muhal Runga - Ist	Naggar	0.71	0.46	0.78	0.03	0.98	0.69
012767	Up Muhal Runga - II nd	Naggar	0.65	0.43	0.72	0.01	1.00	0.63
012768	Up Muhal Dhara	Naggar	0.65	0.43	0.72	0.03	1.00	0.63
012769	Up Muhal challogee	Naggar	0.64	0.42	0.70	0.00	1.00	0.61
012770	Up Muhal Bulang Jhakdi	Naggar	0.66	0.43	0.72	0.02	1.00	0.64
012771	Up Muhal Demarcated Reserve Forest fozal Badon	Naggar	0.65	0.44	0.71	0.00	1.00	0.63
012772	Mandalgarh (28/62)	Naggar	0.72	0.47	0.79	0.04	1.00	0.71
012773	Up Muhal Himri	Naggar	0.68	0.45	0.74	0.01	1.00	0.66
012774	Up Muhal Parvi	Naggar	0.68	0.45	0.74	0.00	1.00	0.66
012775	Up Muhal Kral	Naggar	0.65	0.43	0.71	0.00	1.00	0.63
012776	Up Muhal Grahan	Naggar	0.66	0.44	0.73	0.00	1.00	0.64
012777	Up Muhal Galchet	Naggar	0.64	0.43	0.71	0.00	1.00	0.62
012778	Up Muhal Trisdee	Naggar	0.64	0.43	0.70	0.02	1.00	0.62
012779	Up Muhal Khdihar	Naggar	0.63	0.42	0.70	0.00	1.00	0.61
012780	Up Muhal salingcha	Naggar	0.63	0.42	0.69	0.00	1.00	0.60
012781	Up Muhal Shaldee	Naggar	0.62	0.42	0.68	0.14	1.00	0.65
012782	Dobhi (28/61)	Naggar	0.63	0.43	0.69	0.19	1.00	0.68
012783	Up Muhal Dohlonallha	Naggar	0.65	0.44	0.70	0.24	1.00	0.72
012784	Up Muhal Mahiliser	Naggar	0.61	0.41	0.67	0.00	1.00	0.58
012785	Up Muhal Shim	Naggar	0.67	0.45	0.72	0.35	1.00	0.78
012786	Shirar (27/59)	Naggar	0.67	0.45	0.73	0.02	1.00	0.65
012787	Up Muhal Shirar - Ist	Naggar	0.66	0.44	0.72	0.08	1.00	0.66
012788	Up Muhal Shirar - II nd	Naggar	0.69	0.47	0.75	0.57	1.00	0.89
012789	Benchi (27/58)	Naggar	0.72	0.48	0.78	0.08	1.00	0.72
012790	Up Muhal Pangan	Naggar	0.69	0.47	0.74	0.57	1.00	0.88
012791	Up Muhal Chattanseri	Naggar	0.68	0.46	0.73	0.57	1.00	0.87
012792	Up Muhal Raison	Naggar	0.70	0.46	0.77	0.00	1.00	0.68
012793	Shillihar (27/60)	Naggar	0.69	0.46	0.75	0.19	1.00	0.74
012794	Up Muhal Jallohra	Naggar	0.69	0.46	0.76	0.00	1.00	0.67
012795	Up Muhal Kamarda	Naggar	0.69	0.46	0.75	0.00	1.00	0.66
012796	Up Muhal Janehda	Naggar	0.73	0.48	0.80	0.04	1.00	0.72

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables					Composite Exposure
			E01	E02	E03	E04	E05	
012797	Up Muhal Mathi shil	Naggar	0.71	0.47	0.77	0.02	1.00	0.69
012798	Up Muhal Kufri	Naggar	0.74	0.50	0.80	0.02	1.00	0.73
012808	Manjhlihar (27/57)	Naggar	0.76	0.50	0.81	0.02	1.00	0.74
012809	Up Muhal Kahudhar	Naggar	0.75	0.49	0.81	0.02	1.00	0.73
012810	Up Muhal Lohadi	Naggar	0.72	0.48	0.78	0.02	1.00	0.71
012811	Up Muhal Sajuni	Naggar	0.72	0.48	0.78	0.16	1.00	0.76
012812	Up Muhal Kharga	Naggar	0.57	0.40	0.62	0.43	1.00	0.71
012813	Nathan (24/45)	Naggar	0.59	0.40	0.65	0.36	1.00	0.70
012814	Up Muhal Dalashan	Naggar	0.57	0.39	0.62	0.39	1.00	0.69
012815	Up Muhal Nashalla	Naggar	0.54	0.37	0.59	0.34	1.00	0.65
012816	Up Muhal Laran Keloo	Naggar	0.56	0.38	0.61	0.36	1.00	0.67
012817	Up Muhal Ghod dor	Naggar	0.58	0.39	0.63	0.36	1.00	0.69
012818	Up Muhal Mahilee	Naggar	0.62	0.42	0.67	0.26	1.00	0.69
012819	Up Muhal Hirnee	Naggar	0.61	0.41	0.66	0.29	1.00	0.69
012820	Up Muhal Bhiyalee	Naggar	0.59	0.40	0.64	0.43	1.00	0.73
012821	Up Muhal Chatee	Naggar	0.60	0.41	0.66	0.34	1.00	0.71
012822	Up Muhal Nayanu sari	Naggar	0.58	0.40	0.63	0.43	1.00	0.72
012823	Up Muhal Paljot	Naggar	0.56	0.39	0.61	0.39	1.00	0.68
012824	Up Muhal Shanshr	Naggar	0.56	0.38	0.61	0.36	1.00	0.67
012825	Up Muhal Tilla Shadnee	Naggar	0.52	0.36	0.56	0.21	1.00	0.57
012826	Up Muhal Kharol	Naggar	0.52	0.36	0.56	0.19	1.00	0.56
012827	Up Muhal Dhanaseri	Naggar	0.55	0.39	0.59	0.20	1.00	0.60
012828	Up Muhal Thach	Naggar	0.62	0.42	0.67	0.19	1.00	0.66
012829	Up Muhal Ganesh Naggar	Naggar	0.61	0.42	0.65	0.42	1.00	0.75
012830	Jana (24/46)	Naggar	0.59	0.41	0.65	0.42	1.00	0.73
012831	Up Muhal Parsh	Naggar	0.61	0.42	0.66	0.31	1.00	0.70
012832	Up Muhal Sharan Gran	Naggar	0.60	0.41	0.65	0.42	1.00	0.74
012833	Up Muhal Shahadgran	Naggar	0.62	0.42	0.67	0.25	1.00	0.69
012834	Up Muhal Ladi Chanon - Ist	Naggar	0.63	0.43	0.68	0.29	1.00	0.72
012835	Up Muhal Ladi Chanon - II nd	Naggar	0.62	0.43	0.67	0.36	1.00	0.73
012836	Up Muhal Mehra Bag	Naggar	0.59	0.41	0.64	0.42	1.00	0.73
012837	Up Muhal Barnot	Naggar	0.63	0.43	0.68	0.19	1.00	0.67
012838	Up Muhal Deogra	Naggar	0.64	0.44	0.70	0.39	1.00	0.77
012839	Up Muhal Sharnee	Naggar	0.64	0.44	0.69	0.20	1.00	0.69
012840	Up Muhal Archandee Ist	Naggar	0.65	0.45	0.71	0.53	1.00	0.84
012841	Up Muhal Archandee IInd	Naggar	0.64	0.43	0.69	0.19	1.00	0.68
012842	Up Muhal Mahilee	Naggar	0.65	0.44	0.70	0.11	1.00	0.67
012843	Up Muhal Baga Mahilee	Naggar	0.66	0.45	0.71	0.57	1.00	0.85
012844	Up Muhal Dhama	Naggar	0.67	0.46	0.72	0.57	1.00	0.86
012845	Up Muhal Junkhra Dham	Naggar	0.62	0.44	0.67	0.41	1.00	0.75
012846	Up Muhal Phata Ban	Naggar	0.65	0.46	0.70	0.33	1.00	0.76
012847	Up Muhal Gohru	Naggar	0.67	0.46	0.73	0.57	1.00	0.87
012848	Up Muhal Kalmidhar	Naggar	0.72	0.50	0.77	0.55	0.48	0.71
012849	Kais (25/47)	Naggar	0.75	0.51	0.81	0.47	0.44	0.69
012870	Kharal (25/50)	Naggar	0.97	0.66	1.00	0.69	0.19	0.90
012882	Malana (24/44)	Naggar	0.23	0.27	0.38	1.00	0.86	0.61



Map 9.8 Village wise Composite Exposure Map – Beas Basin - Kullu District

The Composite Exposure Map (Map: 9.8) depicts that exposure level villages of Banjar & Kullu Block is higher than the Naggar Block. The village wise exposure level has been shown in the exposure table.

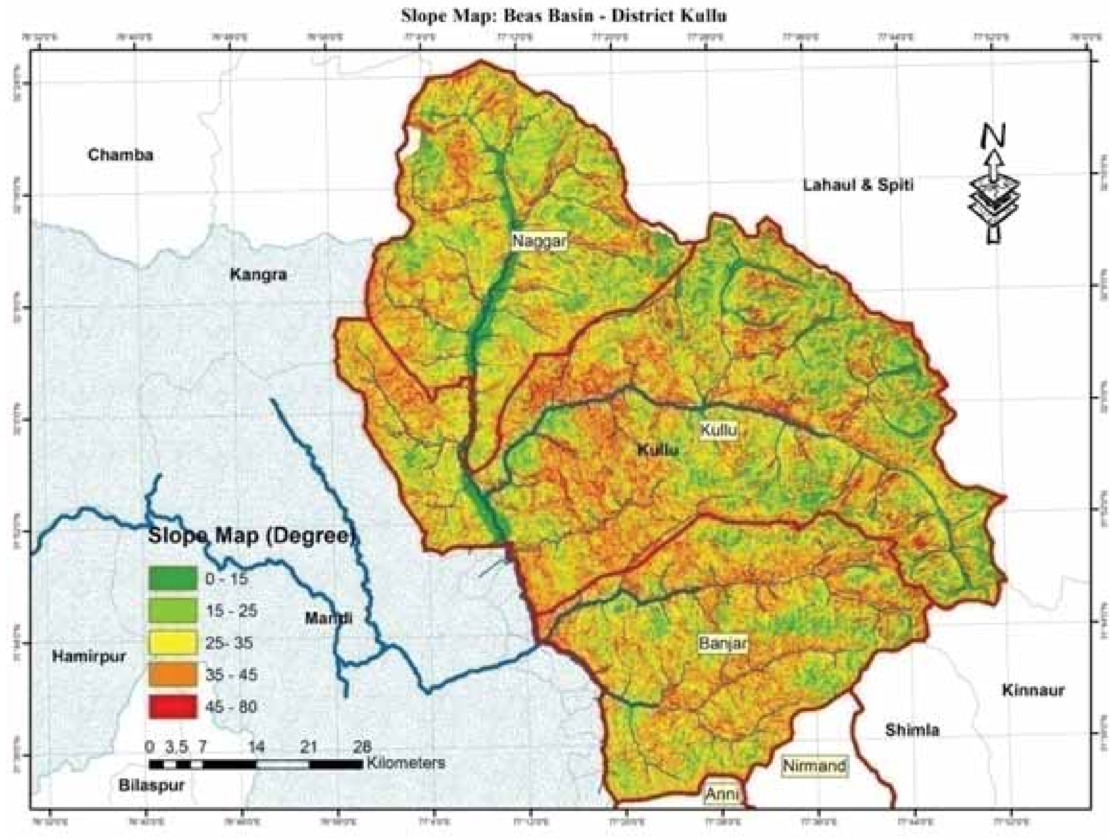
9.4 Sensitivity indicators

The relative importance of the effects of climate change varies with different regions, groups and sectors in society. For example, highly intense rainfall may lead to devastating results in some region, whereas the same may not be of much harm in some other region. The degree to which a system is modified or affected by internal, external, or sometimes with both disturbances is defined as sensitivity. The measure that reflects the responsiveness of a system to climatic influences determines the degree to which a group is affected by the environmental stress.

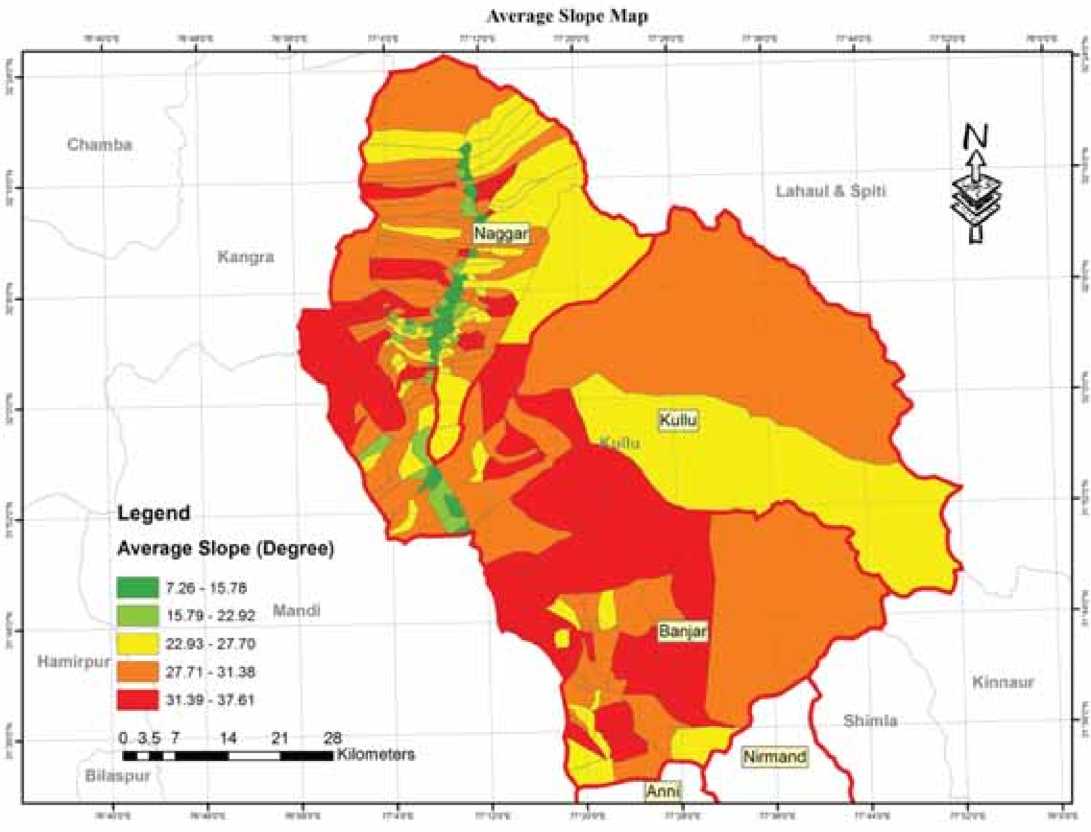
Hence in this analysis we have used eight indicators of sensitivity computation using values generated for Rate of Increase in Water Yield by SWAT model, Average Hill slope calculated using DEM, calculating Percentage of Net Sown area to the geographical area, Human population density per hectares, Percentage of Un-irrigated Land Area to Geographical area, Percentage of Barren & Un-cultivable Land Area to Geographical area, Percentage of Barren & Un-cultivable Land Area to Geographical area, Percentage of Forest Area to Geographical Area and Percentage of Cultivable Waste Land Area to Geographical Area. The maps have been developed for each of these indicators of Sensitivity. The indicator-wise functional relationship analysis is as under:

Code	Sensitivity	Units	Years	Functional Relationship with Sensitivity	Data Source
S01	Average Hill Slope	Degree	-	↑	Generated from SWAT Model
S02	Annual Average Water Yield	mm	1979-2013	↓	Generated from SWAT Model
S03	Percentage of Net Sown Area to Geographical area	%age	2011	↓	Census 2011
S04	Human population density	Person/Ha.	2011	↑	Census 2011
S05	Percentage of Un-irrigated Land Area to Geographical area	%age	2011	↑	Census 2011
S06	Percentage of Barren & Un-cultivable Land Area to Geographical area	%age	2011	↑	Census 2011
S07	Percentage of Cultivable Waste Land Area to Geographical Area	%age	2011	↑	Census 2011

S01 Average Hill Slope

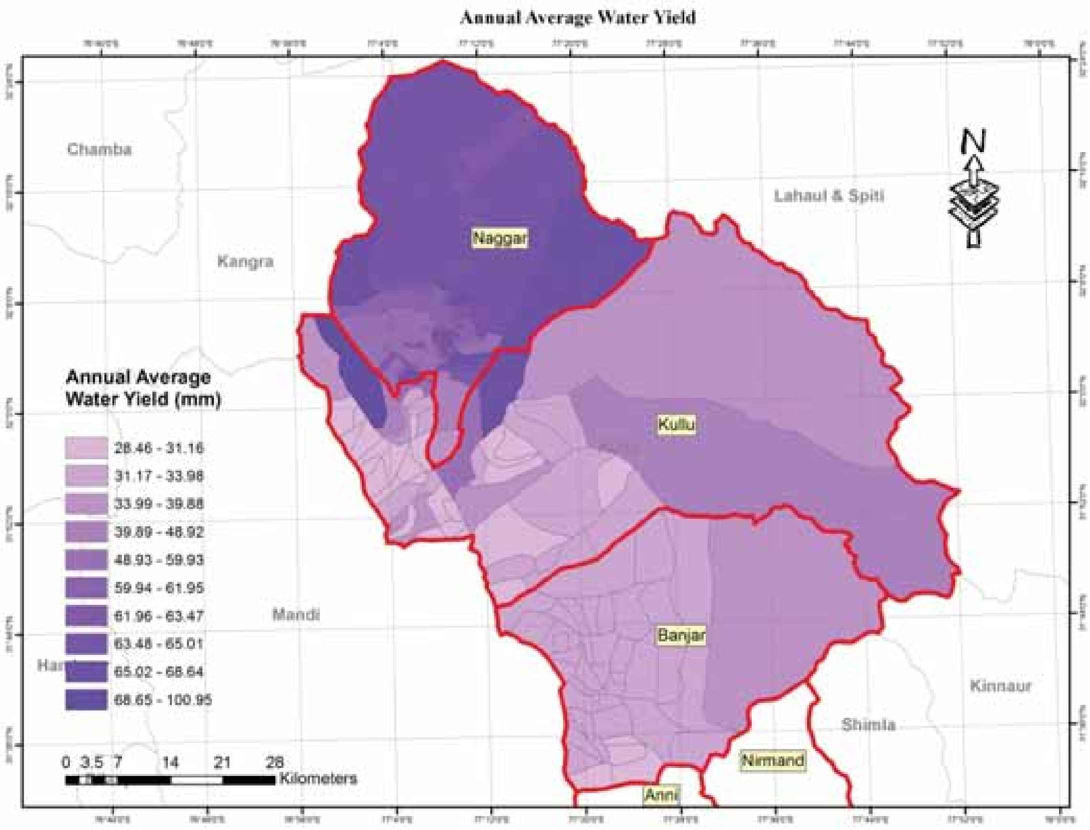


Map 9.10 (a) Slope Map of District Kullu



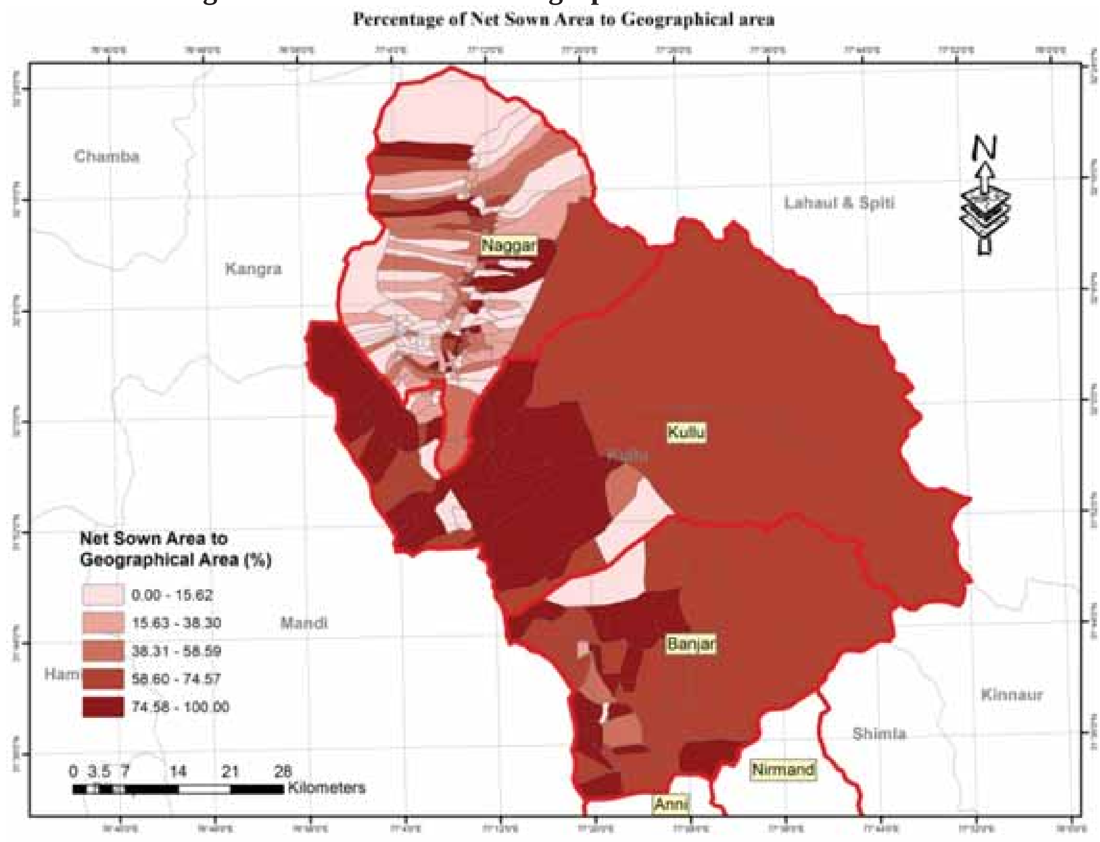
Map 9.10 (b) Villages wise Average Slope

S02 Average Water Yield



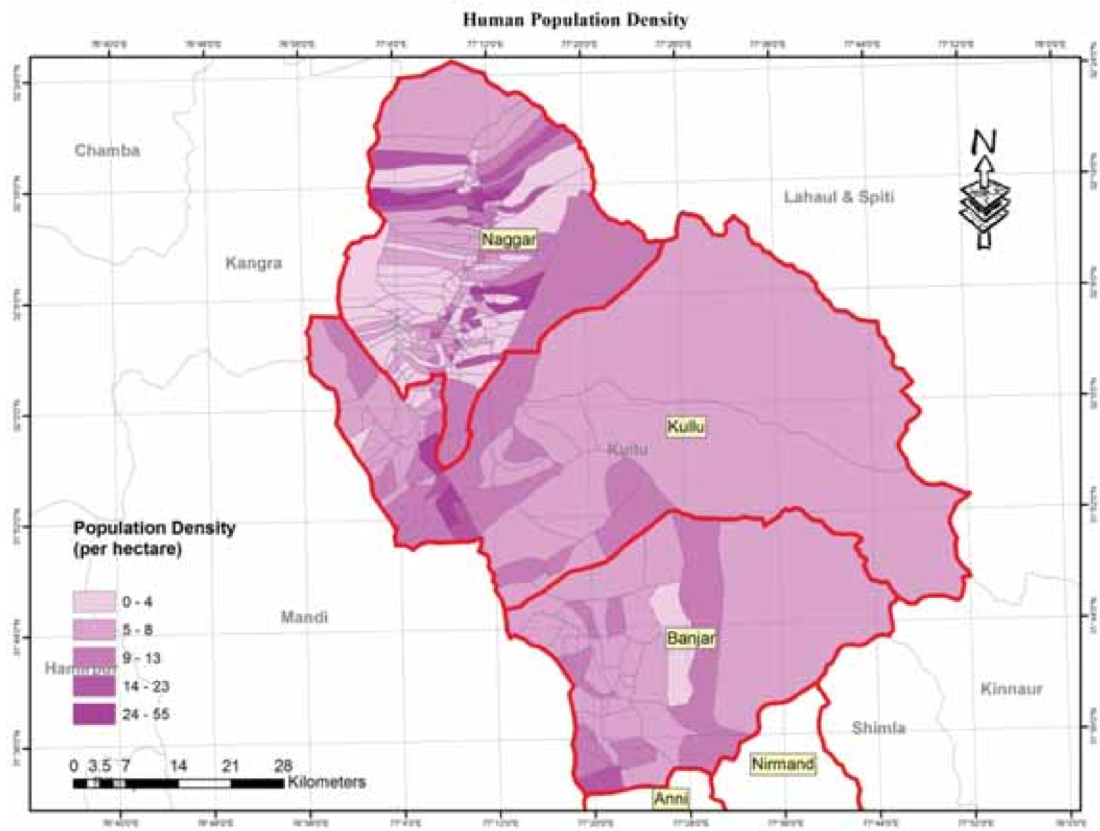
Map 9.9 Village wise Annual Average Water Yield (1979-2013)

S03 Percentage of Net Sown Area to Geographical area



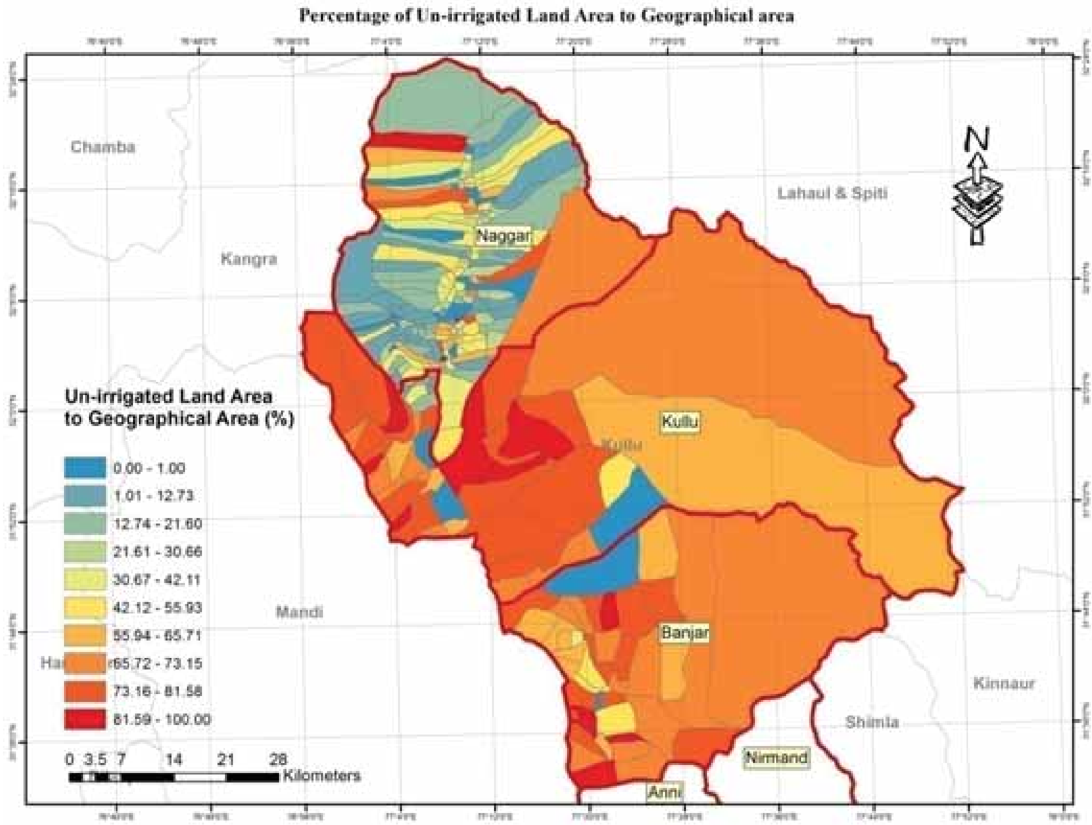
Map 9.11 Percentage of Net Sown Area to Geographical area

S04 Human Population Density



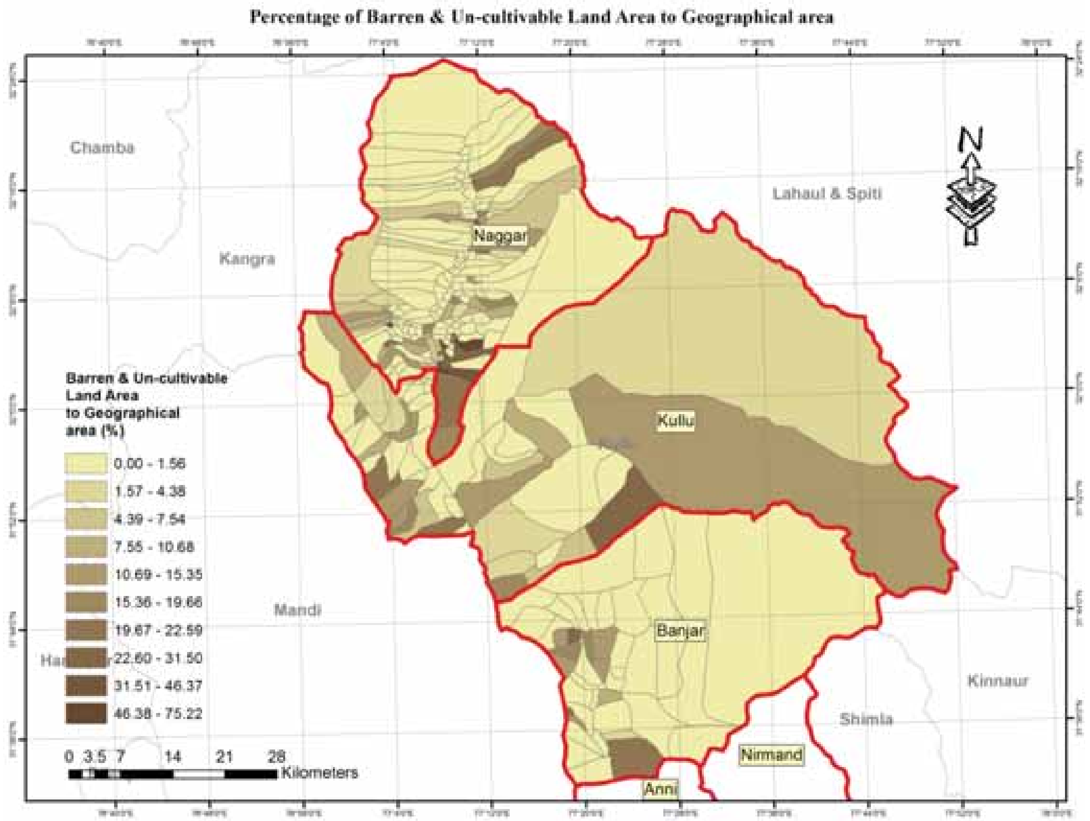
Map 9.12 Census Village Wise Human Population Density per Hectares

S05 Percentage of Un-irrigated Land Area to Geographical area



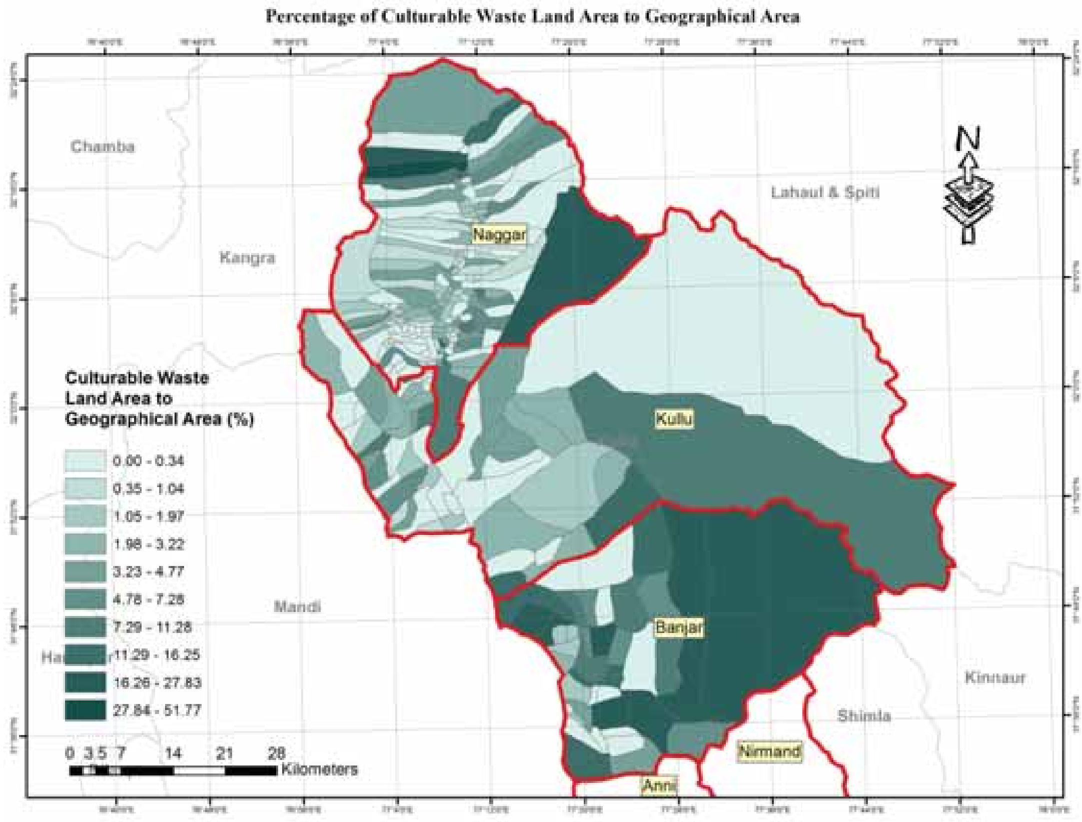
Map 9.13 Percentage of Un-irrigated Land Area to Geographical area

S06 Percentage of Barren & Un-cultivable Land Area to Geographical area



Map 9.14 Percentage of Barren & Un-cultivable Land Area to Geographical area

S07 Percentage of Cultivable Waste Land Area to Geographical Area



Map 9.15 Percentage of Cultivable Waste Land Area to Geographical Area

9.5 Composite Sensitivity

Sensitivity has been calculated by using normalized values of variables based upon Average Hill Slope, Annual Average Water Yield, Percentage of Net Sown Area to Geographical area Human population density, Percentage of Un-irrigated Land Area to Geographical area, Percentage of Barren & Un-cultivable Land Area to Geographical area, Percentage of Cultivable Waste Land Area to Geographical Area. Since the values are on different scale and units, the normalization of indicators using functional relationship has been done.

Variable Indicator S02 i.e. Average Water Yield has ↓ functional relationship with sensitivity and the normalization is done using the formula, which means the Increase in Water Yield will reduce the vulnerability:

$$y_{ij} = \frac{Max_i\{X_{ij}\}-X_{ij}}{Max_i\{X_{ij}\}-Min_i\{X_{ij}\}}$$

However, for indicator S01 i.e. Average Hill Slope the normalization is done using the formula:

$$x_{ij} = \frac{X_{ij}-Min_i\{X_{ij}\}}{Max_i\{X_{ij}\}-Min_i\{X_{ij}\}}$$

This has been done since the functional relationship of indicator S01 with vulnerability is ↑, which means, the increase in Average Hill Slope will indicate increase the vulnerability.

After calculating the score of variables S01 to S07 the average score is calculated and the Composite Sensitivity is calculated and mapped for all census villages:

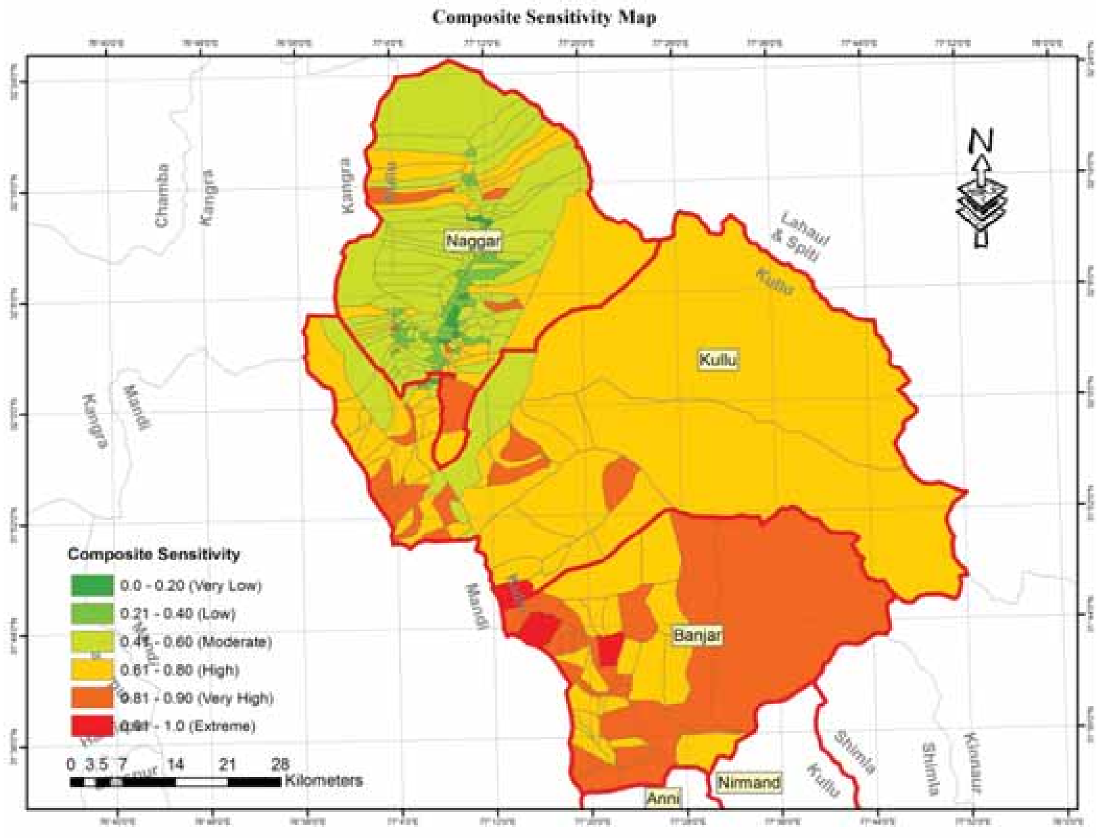
Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables							Composite Sensitivity
			S01	S02	S03	S04	S05	S06	S07	
800103	Banjar (NP)	Banjar	0.66	0.95	1.00	0.12	0.00	0.00	0.00	0.64
012900	Kotla (1/1)	Banjar	0.91	0.94	0.36	0.14	0.64	0.00	0.34	0.90
012901	Chakurtha (1/2)	Banjar	0.88	0.94	0.37	0.08	0.63	0.00	0.41	0.89
012902	Kanon (1/3)	Banjar	0.80	0.94	0.24	0.12	0.76	0.00	0.28	0.82
012903	Dhaugi (1/4)	Banjar	0.85	0.94	0.28	0.11	0.72	0.00	0.25	0.82
012904	Dusharh (2/5)	Banjar	0.67	0.95	0.31	0.21	0.69	0.00	0.17	0.76
012905	Manyashi (2/6)	Banjar	0.75	0.94	0.22	0.11	0.78	0.00	0.14	0.73
012906	Sachen (2/7)	Banjar	0.69	0.94	0.00	0.15	1.00	0.00	0.00	0.67
012907	Shanshar (41/104)	Banjar	0.66	0.94	1.00	0.13	0.00	0.00	0.00	0.65
012908	Gara Parli (41/103)	Banjar	0.82	0.94	0.38	0.09	0.62	0.00	0.25	0.80
012909	Shangarh (3/9)	Banjar	0.86	0.94	0.23	0.11	0.77	0.00	0.20	0.81
012910	Lapah (3/8)	Banjar	0.71	0.94	0.22	0.03	0.78	0.00	0.11	0.67
012911	Shapnil (4/11)	Banjar	0.78	0.94	0.21	0.12	0.79	0.00	0.10	0.74
012912	Siri Kot (4/10)	Banjar	0.85	0.94	0.24	0.08	0.76	0.00	0.23	0.81
012913	Kalwari (4/12)	Banjar	0.83	0.94	0.33	0.10	0.67	0.00	0.26	0.82
012914	Deotha (5/14)	Banjar	0.73	0.94	0.22	0.10	0.78	0.16	0.19	0.81
012915	Thani Char (5/15)	Banjar	0.79	0.94	0.32	0.08	0.68	0.15	0.40	0.91
012916	Chanon (5/19)	Banjar	0.78	0.94	0.25	0.12	0.75	0.26	0.11	0.85
012917	Palach (4/13)	Banjar	0.81	0.94	0.52	0.12	0.48	0.00	0.20	0.79
012918	Sehuli (5/16)	Banjar	0.70	0.94	0.67	0.13	0.33	0.35	0.03	0.82
012919	Jauri ((5/17	Banjar	0.85	0.94	0.40	0.11	0.60	0.18	0.03	0.81
012920	Thati Bir (5/18)	Banjar	0.63	0.94	0.40	0.18	0.60	0.26	0.02	0.77
012921	Ratwah (6/21)	Banjar	0.83	0.94	0.37	0.15	0.63	0.17	0.06	0.82
012922	Tarangali (6/20)	Banjar	0.82	0.94	0.46	0.15	0.54	0.00	0.29	0.84
012923	Bala Gad (7/23)	Banjar	0.74	0.94	0.20	0.12	0.80	0.00	0.03	0.69
012924	Bahu (9/27)	Banjar	0.71	0.95	0.16	0.11	0.84	0.00	0.08	0.70
012925	Chethar (7/22)	Banjar	0.67	0.94	0.23	0.14	0.77	0.29	0.01	0.78
012926	Khabal (8/24)	Banjar	0.76	0.94	0.17	0.16	0.83	0.20	0.02	0.80
012927	Mohni (8/25)	Banjar	0.75	0.95	0.18	0.15	0.82	0.00	0.00	0.69
012928	Seraj (8/26)	Banjar	0.81	0.96	0.29	0.15	0.71	0.00	0.24	0.82
012929	Karshai Gad-II (23/72)	Banjar	0.59	0.97	0.17	0.42	0.83	0.00	0.26	0.86
012930	Tandi (9/28)	Banjar	0.63	0.96	0.39	0.13	0.61	0.00	0.00	0.64
012931	Sajwar (10/29)	Banjar	0.64	0.99	0.30	0.13	0.70	0.30	0.07	0.82
012932	Ghiaghi (10/30)	Banjar	0.70	0.99	0.32	0.18	0.68	0.27	0.00	0.82
012933	Rashala (10/31)	Banjar	0.80	0.97	0.16	0.15	0.84	0.04	0.00	0.75
012934	Bini (11/32)	Banjar	0.84	0.94	0.47	0.11	0.53	0.00	0.38	0.87
012935	Bihar (11/33)	Banjar	0.86	0.94	0.23	0.13	0.77	0.12	0.00	0.78
012936	Sharchi (12/34)	Banjar	0.78	0.95	0.31	0.13	0.69	0.00	0.45	0.89
012937	Pakhari (12/37)	Banjar	0.75	0.94	0.29	0.08	0.71	0.00	0.00	0.66
012938	Tinder (13/36)	Banjar	0.85	0.94	0.39	0.06	0.61	0.00	0.16	0.77
012939	Chippni (14/38)	Banjar	0.80	0.94	0.30	0.15	0.70	0.00	0.39	0.88
012940	Shilhi (12/35)	Banjar	0.81	0.95	0.24	0.15	0.76	0.00	0.13	0.78
012941	Mashyar (14/39)	Banjar	0.67	0.88	0.28	0.12	0.72	0.00	0.45	0.81
800101	Kullu (M Cl)	Kullu	0.44	0.97	1.00	0.51	0.00	0.00	0.00	0.73
800102	Bhuntar (NP)	Kullu	0.01	0.99	1.00	0.41	0.00	0.00	0.00	0.51
012799	Biasar (27/55)	Kullu	0.64	0.62	0.75	0.09	0.25	0.00	0.26	0.60
012800	Up Muhal Thalli	Kullu	0.70	0.58	0.97	0.00	0.03	0.00	0.00	0.46
012801	Up Muhal Ropa sari	Kullu	0.49	0.58	0.83	0.06	0.17	0.00	0.00	0.39
012802	Up Muhal Mapak	Kullu	0.40	0.53	0.80	0.01	0.20	0.00	0.00	0.32
012803	Bandrol (27/56)	Kullu	0.39	0.53	0.30	0.21	0.05	0.00	0.00	0.12
012804	Up Muhal Nangabag	Kullu	0.69	0.78	0.36	0.08	0.61	0.00	0.00	0.56
012805	Up Muhal Harabag	Kullu	0.43	0.57	0.94	0.15	0.06	0.00	0.00	0.41
012806	Up Muhal Bagu Nalha	Kullu	0.79	0.58	0.90	0.07	0.09	0.00	0.00	0.52
012807	Up Muhal Maltibag	Kullu	0.61	0.58	0.61	0.12	0.21	0.00	0.00	0.40
012850	Jandor (26/54)	Kullu	0.68	0.95	0.66	0.06	0.33	0.00	0.05	0.65
012851	Banogi (26/53)	Kullu	0.60	0.95	0.81	0.12	0.18	0.00	0.05	0.63
012852	Sari (26/51)	Kullu	0.77	0.95	0.23	0.15	0.77	0.00	0.15	0.77

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables							Composite Sensitivity
			S01	S02	S03	S04	S05	S06	S07	
012853	Bastori (26/52)	Kullu	0.72	0.98	0.28	0.12	0.72	0.18	0.08	0.79
012854	Dughilag (30/67)	Kullu	0.87	0.91	0.22	0.14	0.78	0.17	0.06	0.83
012855	Majhat (30/68)	Kullu	0.93	0.72	0.17	0.14	0.83	0.04	0.06	0.71
012856	Phallan (30/66)	Kullu	0.93	0.13	0.22	0.11	0.78	0.04	0.08	0.46
012857	Dunkhri Gahar (30/65)	Kullu	0.89	0.00	0.17	0.17	0.81	0.12	0.00	0.41
012858	Pichhli (31/69)	Kullu	0.82	0.84	0.21	0.11	0.77	0.00	0.05	0.68
012859	Mashna (31/70)	Kullu	0.83	0.99	0.18	0.09	0.79	0.00	0.00	0.71
012860	Gahar (32/71)	Kullu	0.82	0.98	0.28	0.06	0.72	0.00	0.00	0.70
012861	Gramang (32/72)	Kullu	0.68	0.99	0.24	0.13	0.76	0.17	0.00	0.75
012862	Bhalyani (33/75)	Kullu	0.49	0.99	0.21	0.10	0.78	0.13	0.21	0.73
012863	Brahman (33/74)	Kullu	0.71	0.98	0.19	0.12	0.80	0.00	0.03	0.69
012864	Balh (33/73)	Kullu	0.72	0.99	0.28	0.15	0.69	0.28	0.13	0.86
012865	Bhumtir (33/76)	Kullu	0.57	0.97	0.15	0.11	0.85	0.00	0.08	0.65
012866	Peej (34/77)	Kullu	0.69	0.98	0.35	0.10	0.65	0.00	0.00	0.66
012867	Balh (34/79)	Kullu	0.67	0.98	0.29	0.23	0.68	0.00	0.04	0.71
012868	Kharihar (34/81)	Kullu	0.52	0.99	0.28	0.14	0.72	0.01	0.10	0.66
012869	Barahar (34/80)	Kullu	0.79	0.96	0.27	0.09	0.73	0.28	0.00	0.81
012871	Rajgiri (35/82)	Kullu	0.77	0.88	0.16	0.21	0.84	0.20	0.02	0.79
012872	Shillihar (35/83)	Kullu	0.64	1.00	0.22	0.19	0.78	0.25	0.07	0.82
012873	Mohal (35/84)	Kullu	0.23	0.95	0.12	0.36	0.64	0.00	0.02	0.47
012874	Bhullang (35/86)	Kullu	0.77	0.92	0.19	0.22	0.81	0.18	0.11	0.85
012875	Khokhan (35/87)	Kullu	0.75	0.90	0.25	0.24	0.75	0.07	0.00	0.74
012876	Neol (35/88)	Kullu	0.71	0.98	0.29	0.20	0.71	0.30	0.02	0.85
012877	Bajaura (36/89)	Kullu	0.33	0.99	0.26	0.25	0.61	0.28	0.03	0.66
012878	Hat (36/90)	Kullu	0.00	0.98	0.21	0.26	0.78	0.00	0.00	0.44
012879	Shillihar (37/91)	Kullu	0.78	0.91	0.18	0.18	0.78	0.17	0.00	0.76
012880	Kashawri (25/49)	Kullu	0.72	0.57	0.01	0.19	0.99	0.01	0.00	0.55
012881	Pini (25/48)	Kullu	0.91	0.46	0.15	0.16	0.81	0.00	0.07	0.58
012883	Manikarn (40/101)	Kullu	0.70	0.87	0.31	0.14	0.69	0.06	0.00	0.66
012884	Sosan (40/102)	Kullu	0.66	0.82	0.37	0.13	0.63	0.18	0.18	0.75
012885	Jari (39/100)	Kullu	0.87	0.94	0.17	0.13	0.79	0.00	0.06	0.74
012886	Bradha (39/99)	Kullu	0.73	0.96	0.13	0.14	0.83	0.14	0.05	0.75
012887	Shat (38/98)	Kullu	0.71	0.97	0.18	0.13	0.79	0.00	0.09	0.70
012888	Chong (38/96)	Kullu	0.60	0.94	0.09	0.11	0.88	0.00	0.07	0.63
012889	Jallu (38/97)	Kullu	0.97	0.97	0.11	0.15	0.86	0.00	0.08	0.81
012890	Ratocha (38/95)	Kullu	0.93	0.98	0.11	0.12	0.85	0.10	0.00	0.80
012891	Diar (37/92)	Kullu	0.74	0.97	0.16	0.13	0.81	0.04	0.05	0.72
012892	Rote-II (42/107)	Kullu	0.83	0.95	0.15	0.17	0.77	0.04	0.00	0.72
012893	Bhallan-I (42/106)	Kullu	0.89	0.95	0.17	0.15	0.79	0.00	0.00	0.74
012894	Manjhli (37/93)	Kullu	0.91	0.94	0.20	0.14	0.80	0.01	0.03	0.77
012895	Parli (37/94)	Kullu	0.91	0.99	0.45	0.18	0.53	0.00	0.06	0.81
012896	Shamshi (CT)	Kullu	0.74	0.98	1.00	0.50	0.00	0.00	0.00	0.85
012897	Raila (42/105)	Kullu	0.35	0.94	1.00	0.15	0.00	0.35	0.24	0.77
012898	Bhalan-II (42/106)	Kullu	0.85	0.94	0.31	0.13	0.69	0.09	0.04	0.78
012899	Rote-I (42/107)	Kullu	0.88	0.96	0.29	0.13	0.71	0.22	0.25	0.94
800100	Manali (M Cl)	Naggar	0.19	0.51	1.00	0.49	0.00	0.00	0.00	0.42
012658	Palchan (21/24)	Naggar	0.66	0.51	0.17	0.13	0.83	0.00	0.00	0.47
012659	UP Muhal Solang	Naggar	0.76	0.50	0.84	0.11	0.16	0.00	0.08	0.53
012660	UP Muhal Kothi	Naggar	0.62	0.51	0.86	0.08	0.14	0.00	0.31	0.56
012661	UP Muhal Kulang	Naggar	0.60	0.52	0.98	0.11	0.02	0.00	0.00	0.44
012662	Muhal Buruwa (21/25)	Naggar	0.66	0.51	0.37	0.27	0.63	0.00	0.37	0.68
012663	Up Muhal Buruwa Majhach	Naggar	0.16	0.53	0.64	0.04	0.36	0.00	0.54	0.45
012664	Up Muhal Vyas Tibba	Naggar	0.28	0.53	1.00	0.00	0.00	0.00	0.00	0.26
012665	Up Muhal Shanag	Naggar	0.23	0.51	0.64	0.10	0.36	0.00	1.00	0.70
012666	Up Muhal Gaushal	Naggar	0.21	0.52	0.73	0.14	0.27	0.00	0.19	0.37
012667	Up Muhal Bahang	Naggar	0.59	0.52	0.81	0.22	0.19	0.00	0.08	0.51
012668	Up Muhal Majhach	Naggar	0.75	0.50	0.68	0.06	0.32	0.00	0.76	0.79
012669	Bashisht (20/23)	Naggar	0.63	0.51	0.50	0.27	0.39	0.24	0.10	0.61
012670	Up Muhal Kaushala	Naggar	0.72	0.51	0.47	0.19	0.51	0.27	0.13	0.67
012671	Up Muhal Dharanu	Naggar	0.82	0.51	0.48	0.35	0.35	0.28	0.00	0.67
012672	Up Muhal Chachoga	Naggar	0.90	0.51	0.37	0.68	0.63	0.00	0.06	0.83

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables							Composite Sensitivity
			S01	S02	S03	S04	S05	S06	S07	
012673	Up Muhal Aleu	Naggar	0.77	0.51	0.38	0.24	0.44	0.00	0.05	0.51
012674	Jangal Mehduda Mehfuja Aleu Vihal	Naggar	0.89	0.51	1.00	0.07	0.00	0.00	0.00	0.54
012675	Muhal Manali (21/26)	Naggar	0.33	0.52	0.49	0.31	0.51	0.00	0.03	0.42
012676	Up Muhal Dhungri -2nd	Naggar	0.85	0.50	0.34	0.96	0.66	0.00	0.00	0.89
012677	Up Muhal Tyan Padhar	Naggar	0.31	0.52	0.77	0.00	0.23	0.00	0.24	0.37
012678	Up Muhal Manali Koot	Naggar	0.79	0.50	1.00	0.00	0.00	0.00	0.20	0.55
012679	Up Muhal Manu Nagar	Naggar	0.75	0.50	0.73	0.18	0.27	0.00	0.19	0.60
012680	Up Muhal Manali Ser	Naggar	0.26	0.52	0.45	0.01	0.55	0.00	0.00	0.25
012681	Up Muhal Kaliganch	Naggar	0.70	0.52	0.74	0.04	0.26	0.00	0.07	0.47
012682	Aarkshit Van R-I Dhungri	Naggar	0.87	0.51	1.00	0.00	0.00	0.00	0.00	0.50
012683	Muhal Nasogi (21/27)	Naggar	0.76	0.50	0.21	0.38	0.79	0.00	0.08	0.64
012684	Up Muhal Simsa	Naggar	0.38	0.52	0.26	0.15	0.28	0.00	0.03	0.18
012685	Up Muhal Syal	Naggar	0.29	0.52	0.24	1.00	0.59	0.00	0.04	0.62
012686	Up Muhal Chhiyal	Naggar	0.45	0.52	0.29	0.24	0.71	0.00	0.03	0.44
012687	Up Muhal Kanyal	Naggar	0.79	0.50	0.53	0.08	0.47	0.09	0.00	0.53
012688	Muhal Shallin (21/28)	Naggar	0.74	0.51	0.49	0.08	0.50	0.00	0.04	0.49
012689	Up Muhal Klath	Naggar	0.71	0.51	0.80	0.08	0.16	0.00	0.00	0.45
012690	Up Muhal Parsha	Naggar	0.68	0.51	0.51	0.13	0.36	0.00	0.02	0.43
012691	Up Muhal Klaont	Naggar	0.70	0.51	0.62	0.01	0.38	0.00	0.05	0.45
012692	Up Muhal Jhunjhari	Naggar	0.57	0.51	1.00	0.09	0.00	0.00	0.00	0.42
012693	Up Muhal Gadherani	Naggar	0.79	0.50	0.33	0.36	0.42	0.16	0.00	0.57
012694	Muhal Bran (22/29)	Naggar	0.84	0.51	0.76	0.05	0.16	0.00	0.01	0.48
012695	Up Muhal Chharogi	Naggar	0.93	0.51	0.87	0.00	0.13	0.00	0.02	0.54
012696	Up Muhal Mandhon	Naggar	0.72	0.51	0.98	0.00	0.02	0.04	0.02	0.47
012697	Up Muhal Shangchar	Naggar	0.69	0.51	0.55	0.11	0.45	0.00	0.02	0.47
012698	Up Muhal Dobha	Naggar	0.77	0.52	0.62	0.05	0.26	0.00	0.01	0.44
012699	Up Muhal Rampur	Naggar	0.33	0.52	0.31	0.10	0.52	0.00	0.00	0.25
012700	Muhal Pangan (22/38)	Naggar	0.44	0.52	0.41	0.09	0.53	0.00	0.03	0.34
012701	Up Muhal Gumidhar	Naggar	0.76	0.52	0.37	0.18	0.32	0.00	0.01	0.41
012702	Muhal Riyara (22/30)	Naggar	0.46	0.52	0.64	0.06	0.36	0.00	0.07	0.39
012703	Up Muhal Defri	Naggar	0.71	0.51	0.50	0.06	0.50	0.00	0.09	0.49
012704	Muhal Shigli (22/31)	Naggar	0.85	0.50	0.83	0.01	0.17	0.00	0.06	0.52
012705	Up Muhal Kasheri	Naggar	0.82	0.50	0.90	0.01	0.10	0.00	0.02	0.49
012706	Up Muhal Nayalag	Naggar	0.81	0.48	0.67	0.03	0.33	0.00	0.01	0.48
012707	Muhal Hallan-II (22/32)	Naggar	0.71	0.53	0.85	0.02	0.15	0.00	0.01	0.46
012708	Up Muhal Magana	Naggar	0.74	0.55	0.80	0.03	0.20	0.00	0.07	0.51
012709	Up Muhal Shilha	Naggar	0.76	0.55	0.66	0.03	0.32	0.00	0.03	0.48
012710	Muhal Bari (22/36)	Naggar	0.38	0.55	0.58	0.22	0.29	0.00	0.06	0.38
012711	Up Muhal Tarashi	Naggar	0.76	0.55	0.67	0.03	0.33	0.00	0.04	0.50
012712	Badgran (22/37)	Naggar	0.11	0.50	0.58	0.10	0.35	0.00	0.05	0.21
012713	Soil (23/41)	Naggar	0.78	0.51	0.20	0.15	0.79	0.00	0.01	0.53
012714	Up Muhal Haripur	Naggar	0.60	0.51	0.28	0.09	0.63	0.19	0.02	0.48
012715	Up Muhal Somvan	Naggar	0.26	0.51	0.99	0.03	0.01	0.00	0.00	0.26
012716	Karjan (23/40)	Naggar	0.54	0.51	0.20	0.14	0.30	0.00	0.01	0.22
012717	Sajla (23/39)	Naggar	0.75	0.50	0.17	0.11	0.22	0.00	0.01	0.24
012718	Up Muhal Sajal Vihal	Naggar	0.17	0.51	0.48	0.15	0.47	0.00	0.00	0.25
012719	Up Muhal Dhamasu Kalaun	Naggar	0.59	0.51	0.99	0.03	0.01	0.00	0.07	0.42
012720	Muhal Gojra (20/20)	Naggar	0.75	0.50	0.15	0.18	0.42	0.17	0.00	0.42
012721	Up Muhal Khakhanal	Naggar	0.61	0.51	0.39	0.11	0.15	0.27	0.00	0.36
012722	Up Muhal Barnar	Naggar	0.66	0.51	0.97	0.00	0.03	0.05	0.00	0.43
012723	Muhal Jagatsukh (20/21)	Naggar	0.49	0.52	0.26	0.18	0.30	0.27	0.00	0.35
012724	Up Muhal Bhanara	Naggar	0.65	0.51	0.81	0.04	0.19	0.08	0.00	0.45
012725	Up Muhal Chhalala	Naggar	0.12	0.52	0.44	0.03	0.25	0.18	0.00	0.14
012726	Up Muhal Bahanu	Naggar	0.16	0.52	0.43	0.09	0.33	0.46	0.00	0.33
012727	Muhal Prini (20/22)	Naggar	0.69	0.51	0.33	0.19	0.18	0.24	0.02	0.41
012728	Up Muhal Hamta	Naggar	0.57	0.51	0.75	0.02	0.25	0.04	0.13	0.46
012729	Up Muhal Hamta 2/17	Naggar	0.65	0.51	0.94	0.00	0.06	0.01	0.00	0.41
012730	Up Muhal Hamta 1/7	Naggar	0.57	0.51	0.96	0.26	0.04	0.03	0.11	0.54
012731	Up Muhal Shuru	Naggar	0.17	0.52	0.28	0.16	0.27	0.15	0.04	0.17
012732	Up Muhal Jamari	Naggar	0.87	0.51	0.66	0.00	0.34	0.02	0.11	0.56

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables							Composite Sensitivity
			S01	S02	S03	S04	S05	S06	S07	
012733	Hallan-I (24/42)	Naggar	0.04	0.49	0.44	0.11	0.56	0.00	0.07	0.22
012734	Up Muhal Rangri	Naggar	0.08	0.48	0.33	0.04	0.26	0.00	0.01	0.00
012735	Up Muhal chaki	Naggar	0.70	0.49	0.23	0.12	0.27	0.00	0.02	0.27
012736	Up Muhal Sarsai	Naggar	0.69	0.48	0.20	0.34	0.72	0.00	0.05	0.54
012737	Up Muhal Kumartee	Naggar	0.54	0.50	0.71	0.05	0.29	0.00	0.16	0.45
012738	Up Muhal Raman	Naggar	0.72	0.50	0.74	0.06	0.26	0.00	0.06	0.48
012739	Up Muhal Batahar Bihal	Naggar	0.62	0.51	1.00	0.52	0.00	0.00	0.00	0.62
012740	Nagar (24/43)	Naggar	0.41	0.53	1.00	0.32	0.00	0.04	0.00	0.46
012741	Up Muhal Pulag	Naggar	0.91	0.50	0.88	0.02	0.12	0.13	0.00	0.58
012742	Up Muhal Rumsu	Naggar	0.69	0.50	0.96	0.09	0.04	0.14	0.07	0.55
012743	Up Muhal chachogee	Naggar	0.53	0.51	0.99	0.04	0.01	0.08	0.12	0.46
012744	Up Muhal Madi	Naggar	0.92	0.50	0.94	0.49	0.06	0.26	0.10	0.88
012745	Up Muhal Mashda	Naggar	0.17	0.48	0.82	0.04	0.18	0.26	0.02	0.33
012746	Up Muhal Ghadopa	Naggar	0.09	0.55	0.68	0.02	0.00	0.11	0.03	0.12
012747	Katrain (22/35)	Naggar	0.41	0.55	0.98	0.19	0.00	0.00	0.06	0.42
012748	Up Muhal Jatehad	Naggar	0.07	0.55	0.89	0.34	0.06	0.00	0.08	0.33
012749	Dawara (22/34)	Naggar	0.70	0.58	0.93	0.20	0.02	0.00	0.03	0.54
012750	Up Muhal Dachnee	Naggar	0.82	0.57	0.99	0.01	0.01	0.00	0.04	0.52
012751	Meha (22/33)	Naggar	1.00	0.57	0.92	0.03	0.08	0.00	0.04	0.61
012752	Up Muhal Bhujnu	Naggar	0.72	0.57	0.95	0.02	0.02	0.00	0.03	0.47
012753	Pichlihar (29/64)	Naggar	0.79	0.45	0.97	0.06	0.03	0.05	0.01	0.49
012754	Up Muhal chukdee	Naggar	0.98	0.56	0.83	0.03	0.17	0.08	0.03	0.63
012755	Up Muhal Jalog	Naggar	0.89	0.56	0.99	0.00	0.01	0.05	0.00	0.55
012756	Up Muhal Jigling	Naggar	0.83	0.57	0.87	0.00	0.13	0.05	0.00	0.53
012757	Up Muhal Kabhi	Naggar	0.78	0.57	0.85	0.03	0.15	0.05	0.02	0.53
012758	Up Muhal Kaistha	Naggar	0.83	0.52	0.88	0.02	0.12	0.09	0.00	0.54
012759	Up Muhal Galang	Naggar	0.82	0.57	0.97	0.03	0.03	0.15	0.01	0.59
012760	Up Muhal Nari	Naggar	0.68	0.57	0.95	0.10	0.05	0.12	0.07	0.57
012761	Up Muhal Bagnee	Naggar	0.76	0.57	0.95	0.07	0.05	0.05	0.01	0.54
012762	Up Muhal Daral	Naggar	0.89	0.57	0.89	0.05	0.00	0.12	0.12	0.61
012763	Up Muhal Damchin	Naggar	0.46	0.57	0.94	0.02	0.04	0.01	0.01	0.36
012764	Up Muhal Pradee	Naggar	0.60	0.57	0.96	0.02	0.00	0.11	0.03	0.46
012765	Fojal (29/63)	Naggar	0.61	0.57	0.53	0.12	0.30	0.00	0.02	0.41
012766	Up Muhal Runga - Ist	Naggar	0.75	0.55	0.64	0.04	0.36	0.76	0.00	0.80
012767	Up Muhal Runga - II nd	Naggar	0.66	0.58	0.50	0.01	0.50	0.00	0.04	0.46
012768	Up Muhal Dhara	Naggar	0.51	0.57	0.68	0.07	0.28	0.00	0.02	0.40
012769	Up Muhal challogee	Naggar	0.25	0.58	0.98	0.03	0.02	0.00	0.02	0.29
012770	Up Muhal Bulang Jhakdi	Naggar	0.68	0.57	0.54	0.12	0.33	0.00	0.02	0.45
012771	Up Muhal Demarcated Reserve Forest fozal Badon	Naggar	0.56	0.58	1.00	0.00	0.00	0.00	0.00	0.40
012772	Mandalgarh (28/62)	Naggar	0.92	0.57	0.96	0.03	0.04	0.00	0.00	0.56
012773	Up Muhal Himri	Naggar	0.76	0.58	0.98	0.03	0.02	0.00	0.00	0.50
012774	Up Muhal Parvi	Naggar	0.49	0.58	0.93	0.02	0.07	0.00	0.00	0.38
012775	Up Muhal Kral	Naggar	0.34	0.58	0.97	0.04	0.03	0.00	0.00	0.32
012776	Up Muhal Grahan	Naggar	0.57	0.58	0.96	0.02	0.04	0.00	0.00	0.41
012777	Up Muhal Galchet	Naggar	0.47	0.58	0.91	0.05	0.09	0.00	0.00	0.38
012778	Up Muhal Trisdee	Naggar	0.56	0.58	0.85	0.10	0.15	0.00	0.00	0.44
012779	Up Muhal Khdihar	Naggar	0.28	0.58	0.86	0.11	0.14	0.00	0.00	0.33
012780	Up Muhal salingcha	Naggar	0.47	0.58	0.93	0.06	0.07	0.00	0.00	0.39
012781	Up Muhal Shaldee	Naggar	0.46	0.58	0.95	0.12	0.05	0.00	0.00	0.40
012782	Dobhi (28/61)	Naggar	0.60	0.58	0.73	0.25	0.20	0.25	0.00	0.60
012783	Up Muhal Dohlonallha	Naggar	0.08	0.57	0.69	0.11	0.25	0.13	0.00	0.26
012784	Up Muhal Mahiliser	Naggar	0.17	0.58	0.77	0.06	0.12	0.08	0.00	0.25
012785	Up Muhal Shim	Naggar	0.63	0.55	0.66	0.15	0.21	0.22	0.00	0.52
012786	Shirar (27/59)	Naggar	0.71	0.58	0.16	0.15	0.09	0.01	0.00	0.22
012787	Up Muhal Shirar - Ist	Naggar	0.74	0.58	0.81	0.07	0.16	0.12	0.00	0.54
012788	Up Muhal Shirar - II nd	Naggar	0.77	0.53	0.88	0.12	0.08	0.19	0.00	0.58
012789	Benchi (27/58)	Naggar	0.74	0.57	0.51	0.22	0.46	0.10	0.01	0.60
012790	Up Muhal Pangan	Naggar	0.31	0.53	0.53	0.13	0.35	0.19	0.13	0.41
012791	Up Muhal Chattanseri	Naggar	0.21	0.53	0.35	0.10	0.51	0.00	0.10	0.26
012792	Up Muhal Raison	Naggar	0.58	0.58	0.41	0.16	0.25	0.08	0.02	0.38

Village/ Town Code	Village/ Town Name	Block	Indicators/ Variables							Composite Sensitivity
			S01	S02	S03	S04	S05	S06	S07	
012793	Shillihar (27/60)	Naggar	0.65	0.56	0.69	0.09	0.31	0.41	0.00	0.64
012794	Up Muhal Jallohra	Naggar	0.65	0.58	0.38	0.06	0.62	0.00	0.00	0.46
012795	Up Muhal Kamarda	Naggar	0.62	0.58	0.75	0.03	0.15	0.30	0.00	0.53
012796	Up Muhal Janehda	Naggar	0.76	0.57	0.65	0.02	0.35	0.30	0.01	0.61
012797	Up Muhal Mathi shil	Naggar	0.74	0.58	0.73	0.04	0.27	0.11	0.00	0.53
012798	Up Muhal Kufri	Naggar	0.45	0.58	1.00	0.00	0.00	0.11	0.00	0.40
012808	Manjhlihar (27/57)	Naggar	0.79	0.58	0.82	0.04	0.18	0.00	0.00	0.51
012809	Up Muhal Kahudhar	Naggar	0.68	0.58	0.90	0.03	0.10	0.00	0.00	0.46
012810	Up Muhal Lohadi	Naggar	0.58	0.58	0.80	0.04	0.20	0.00	0.00	0.43
012811	Up Muhal Sajuni	Naggar	0.81	0.56	0.71	0.05	0.29	0.00	0.00	0.52
012812	Up Muhal Kharga	Naggar	0.87	0.49	0.68	0.05	0.32	0.00	0.00	0.51
012813	Nathan (24/45)	Naggar	0.06	0.55	0.45	0.11	0.55	0.00	0.09	0.26
012814	Up Muhal Dalashan	Naggar	0.58	0.53	0.17	0.10	0.57	0.00	0.05	0.34
012815	Up Muhal Nashalla	Naggar	0.60	0.55	0.34	0.36	0.39	0.00	0.08	0.48
012816	Up Muhal Laran Keloo	Naggar	0.51	0.55	0.18	0.29	0.82	0.00	0.00	0.49
012817	Up Muhal Ghod dor	Naggar	0.07	0.55	0.08	0.08	0.92	0.00	0.02	0.22
012818	Up Muhal Mahilee	Naggar	0.09	0.54	0.93	0.02	0.07	0.00	0.00	0.19
012819	Up Muhal Hirnee	Naggar	0.04	0.53	0.25	0.11	0.49	0.00	0.06	0.12
012820	Up Muhal Bhiyalee	Naggar	0.18	0.49	0.34	0.07	0.66	0.00	0.06	0.26
012821	Up Muhal Chatee	Naggar	0.48	0.50	0.15	0.04	0.23	0.00	0.03	0.10
012822	Up Muhal Nayanu sari	Naggar	0.59	0.49	0.18	0.32	0.61	0.00	0.01	0.43
012823	Up Muhal Paljot	Naggar	0.77	0.51	0.29	0.01	0.23	0.00	0.04	0.27
012824	Up Muhal Shanshr	Naggar	0.64	0.55	0.49	0.01	0.51	0.00	0.20	0.51
012825	Up Muhal Tilla Shadnee	Naggar	0.57	0.50	0.59	0.02	0.41	0.00	0.08	0.41
012826	Up Muhal Kharol	Naggar	0.69	0.50	0.78	0.00	0.22	0.00	0.12	0.47
012827	Up Muhal Dhanaseri	Naggar	0.70	0.51	0.79	0.00	0.21	0.00	0.14	0.49
012828	Up Muhal Thach	Naggar	0.65	0.58	0.77	0.00	0.23	0.00	0.00	0.43
012829	Up Muhal Ganesh Naggar	Naggar	0.73	0.50	0.21	0.24	0.64	0.00	0.07	0.50
012830	Jana (24/46)	Naggar	0.61	0.46	0.42	0.30	0.58	0.42	0.00	0.67
012831	Up Muhal Parsh	Naggar	0.45	0.52	0.36	0.12	0.64	0.29	0.00	0.50
012832	Up Muhal Sharan Gran	Naggar	0.51	0.46	0.38	0.17	0.62	0.30	0.00	0.53
012833	Up Muhal Shahadgran	Naggar	0.69	0.55	0.65	0.01	0.35	0.77	0.00	0.76
012834	Up Muhal Ladi Chanon - Ist	Naggar	0.60	0.54	1.00	0.00	0.00	0.00	0.00	0.40
012835	Up Muhal Ladi Chanon - II nd	Naggar	0.69	0.51	1.00	0.02	0.00	0.00	0.00	0.43
012836	Up Muhal Mehra Bag	Naggar	0.83	0.48	0.62	0.00	0.38	0.36	0.08	0.66
012837	Up Muhal Barnot	Naggar	0.46	0.58	0.64	0.06	0.36	0.70	0.13	0.73
012838	Up Muhal Deogra	Naggar	0.67	0.50	0.70	0.07	0.30	0.62	0.31	0.83
012839	Up Muhal Sharnee	Naggar	0.62	0.56	0.78	0.04	0.22	0.47	0.11	0.68
012840	Up Muhal Archandee Ist	Naggar	0.66	0.52	0.66	0.31	0.34	0.34	0.05	0.71
012841	Up Muhal Archandee IInd	Naggar	0.18	0.58	0.17	0.10	0.83	0.09	0.02	0.33
012842	Up Muhal Mahilee	Naggar	0.67	0.54	0.23	0.23	0.77	0.07	0.01	0.56
012843	Up Muhal Baga Mahilee	Naggar	0.73	0.53	0.94	0.07	0.02	0.49	0.13	0.72
012844	Up Muhal Dhama	Naggar	0.60	0.53	0.63	0.02	0.37	0.38	0.19	0.64
012845	Up Muhal Junkhra Dham	Naggar	0.73	0.50	0.85	0.02	0.15	0.51	0.08	0.69
012846	Up Muhal Phata Ban	Naggar	0.70	0.51	0.98	0.01	0.02	0.00	0.05	0.45
012847	Up Muhal Gohru	Naggar	0.66	0.53	0.85	0.01	0.15	0.55	0.05	0.67
012848	Up Muhal Kalmidhar	Naggar	0.64	0.79	0.85	0.00	0.15	1.00	0.16	1.01
012849	Kais (25/47)	Naggar	0.76	0.83	0.47	0.15	0.39	0.28	0.22	0.81
012870	Kharal (25/50)	Naggar	0.59	0.89	0.45	0.16	0.52	0.23	0.18	0.77
012882	Malana (24/44)	Naggar	0.65	0.45	0.27	0.18	0.73	0.00	0.38	0.61



Map 9.16 Census Village wise Composite Sensitivity Map

Map 9.16 above shows that the Sensitivity level Banjar & Kullu Blocks are high as compare to the Naggar Block because of indicators Average Hill Slope, Percentage of Net Sown Area to Geographical area, Human population density, Percentage of Un-irrigated Land Area to Geographical area, Percentage of Barren & Un-cultivable Land Area to Geographical area, Percentage of Cultivable Waste Land Area to Geographical Area & decrease in Annual Average Water Yield.

9.6 Adaptive Capacity Indicators

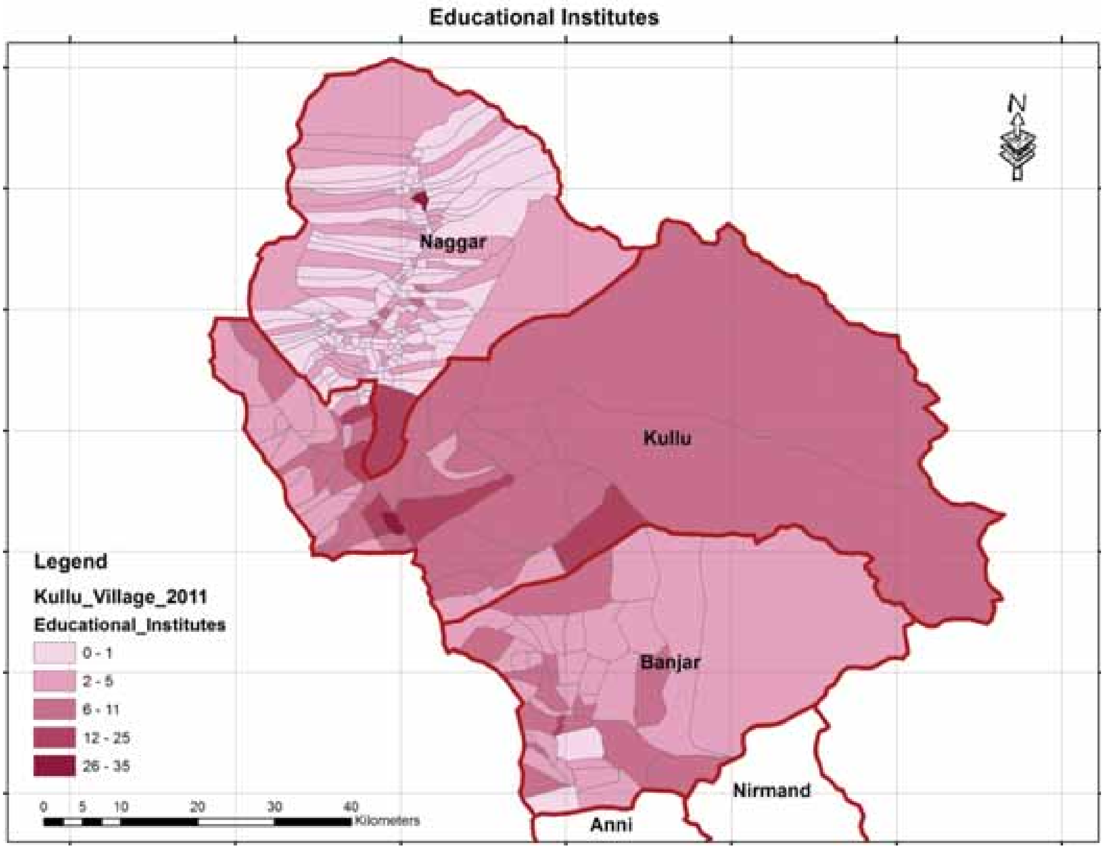
Based upon sensitivity and exposure, the extent of response to the effects of climate change differs across different regions. For example, frequent drought like conditions could be addressed by one by using appropriate irrigation technology, whereas other one may not be able to afford such technology or may lack the skills to operate it. Therefore, the ability to adapt to certain changes in conditions is very important to determine the vulnerability of a system towards the change. Adaptability, coping ability, stability, management capacity, flexibility, robustness and resilience, all together form the ability of a system to adapt to the changes effectively. Therefore, 'Adaptive capacity' is a significant factor that characterize vulnerability. Adaptive capacity is also defined as the potential or ability of a system, region or community to adjust to the effects or impacts of climate change (IPCC). The adaptive capacity of a system or society is to deal with the changes in conditions to modify its own characteristics and behaviour.

The increase in literacy rate levels enhances the capability of people to access information and cope up with adversities, resulting into reduced vulnerability. The farms with larger agricultural income, land area, farm value assets and latest technology are able to prepare and respond better as compared to the farms with lower, less technology. Also, the farms with traditional technologies are assumed to be less economically diversified and more vulnerable to climatic events. The availability of facilities like electricity, education, health care, etc. determines the state of poverty in a region. When two different agricultural regions having the same crops and similar climate are compared with each other, the exposure to climate changes might be similar, but the adaptive capacity and vulnerability could be very different based on the socio-economic factors. In addition to identification of threat, the analysis of vulnerability also involves resilience or responsiveness of the system and its ability to exploit opportunities and recover from the environmental and climatic changes. Therefore, asset ownership goes hand in hand with vulnerability. The people having more assets are less vulnerable to climate change and on the other hand the people with less areas are more prone to climate change vulnerability.

In present case we have used eleven variables/ indicators to calculate adaptive capacity. The indicators for adaptive capacity are computed using 2011 census data. The maps have been developed for each of these indicators under adaptive capacity. The indicator-wise analysis with functional relationship is as under:

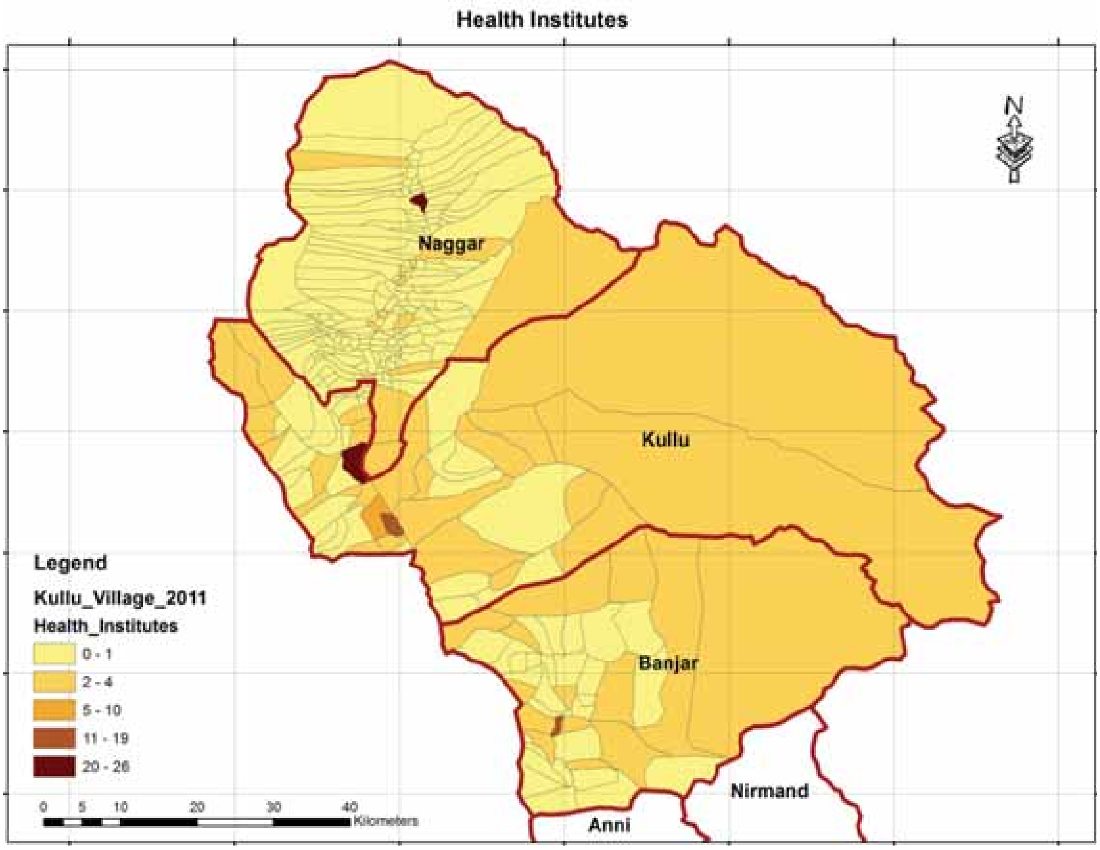
Code	Adaptive Capacity	Units	Years	Functional Relationship with Adaptive Capacity	Data Source
A01	Educational Institutes	Number	2011	↑	Census 2011
A02	Health Institutes	Number	2011	↑	Census 2011
A03	Road Network	Yes/No	2011	↑	Census 2011
A04	Agricultural Credit Societies	Yes/No	2011	↑	Census 2011
A05	Self Help Group	Yes/No	2011	↑	Census 2011
A06	Mandis/Regular Market	Yes/No	2011	↑	Census 2011
A07	Agricultural Marketing Society	Yes/No	2011	↑	Census 2011
A08	Hand Pump	Yes/No	2011	↑	Census 2011
A09	Spring Source	Yes/No	2011	↑	Census 2011
A10	Tank/Pond/Lake	Yes/No	2011	↑	Census 2011
A11	Irrigated Area	Hectares	2011	↑	Census 2011

A01 Educational Institutes



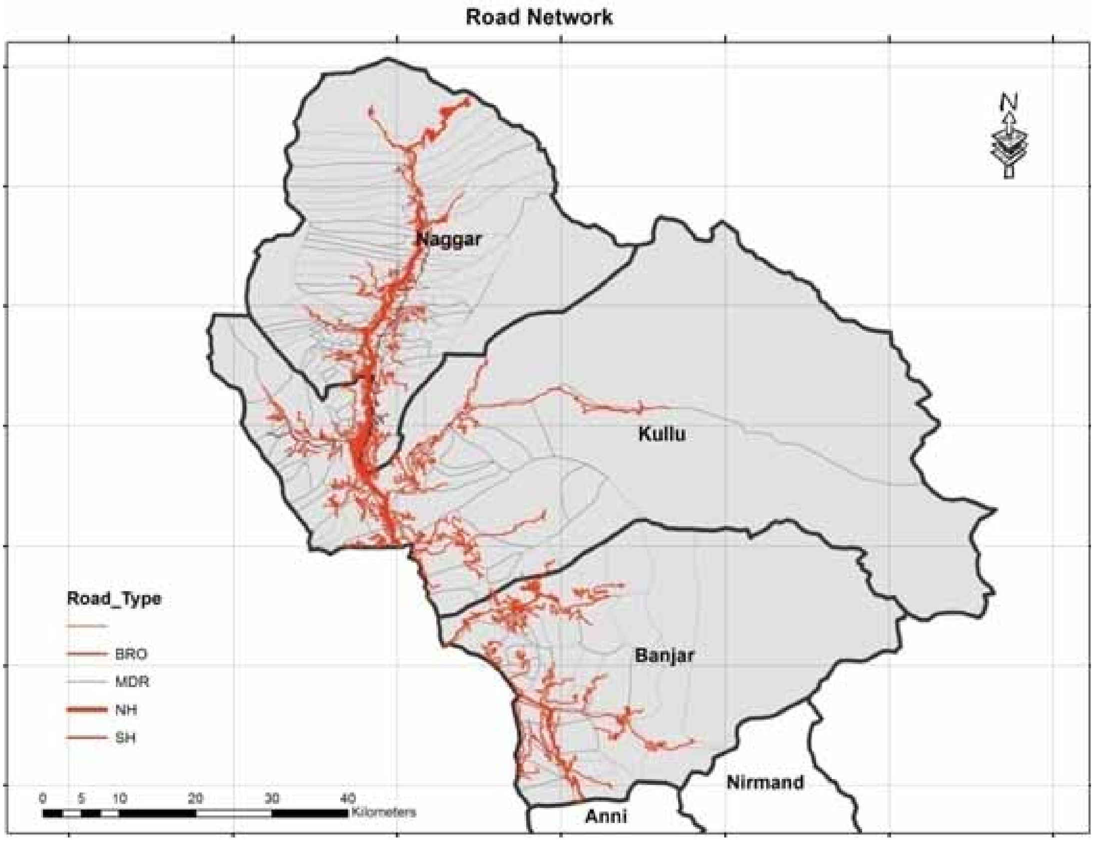
Map 9.17 Educational Institutes

A02 Health Institutes

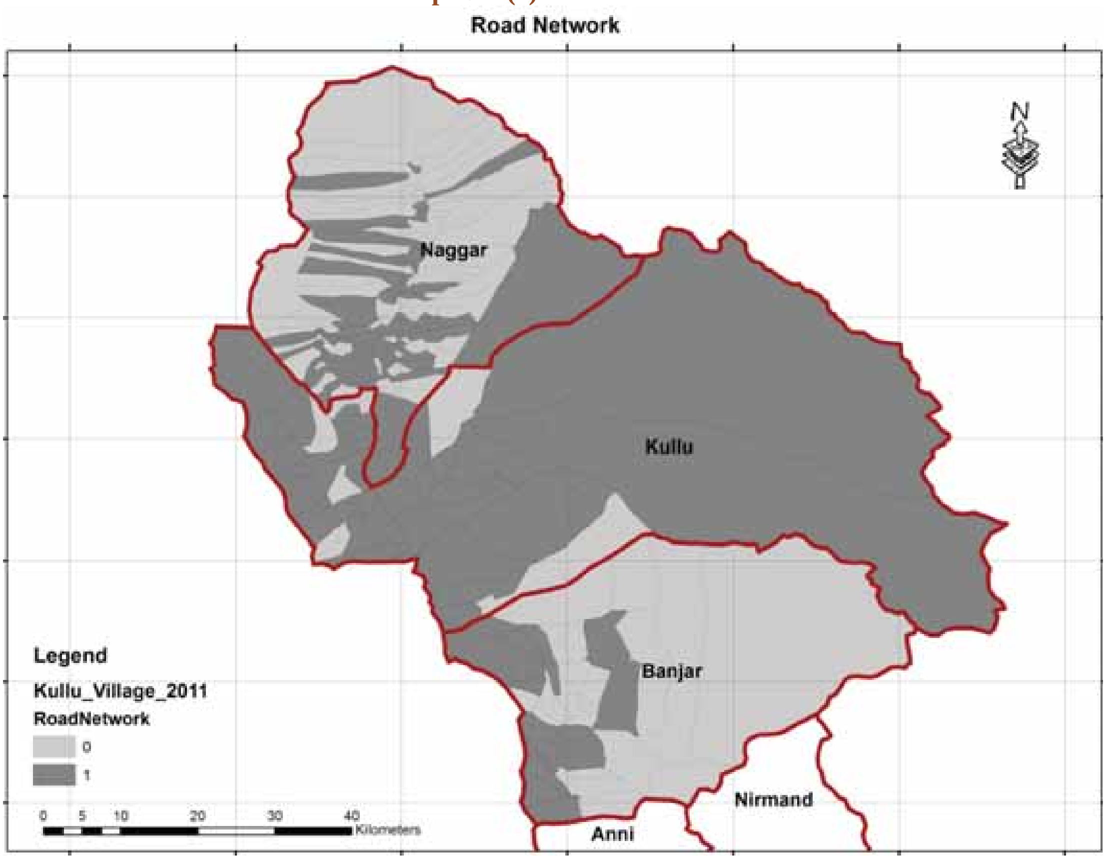


Map 9.18 Health Institutes

A03 Road Network

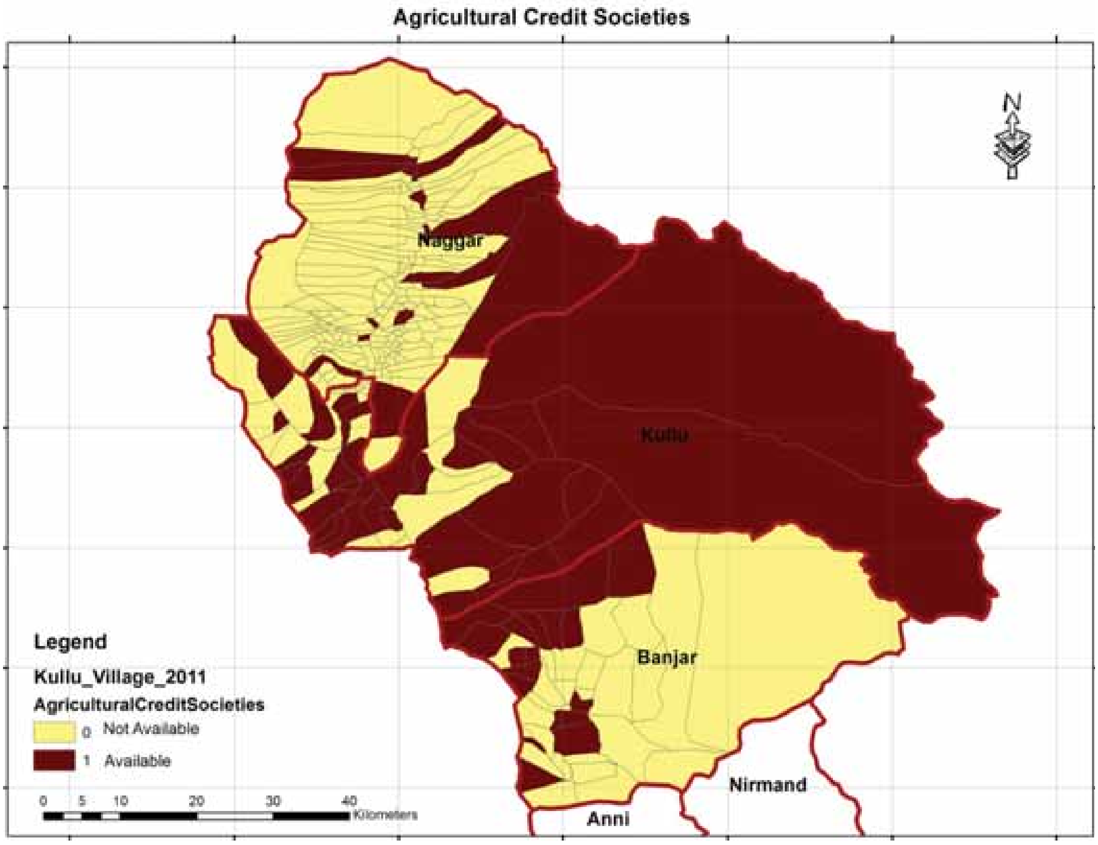


Map 9.19 (a) Road Network



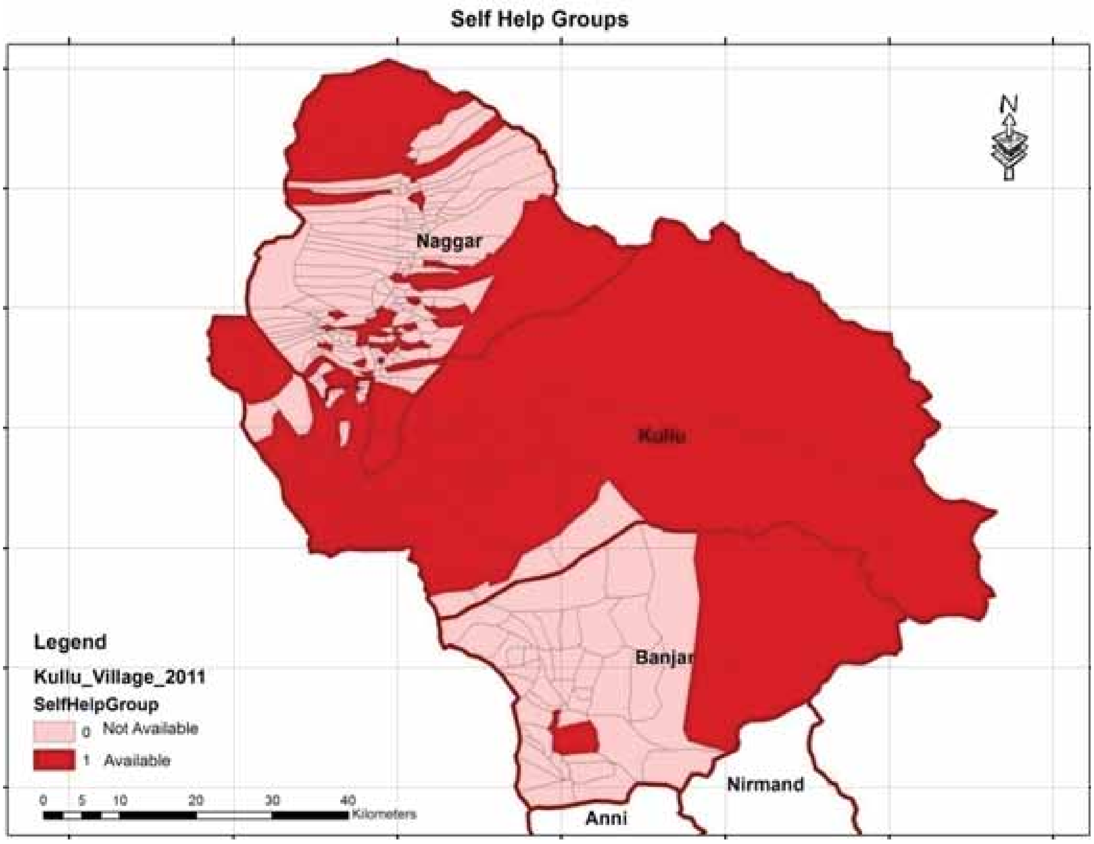
Map 9.19 (b) Road Network

A04 Agricultural Credit Societies



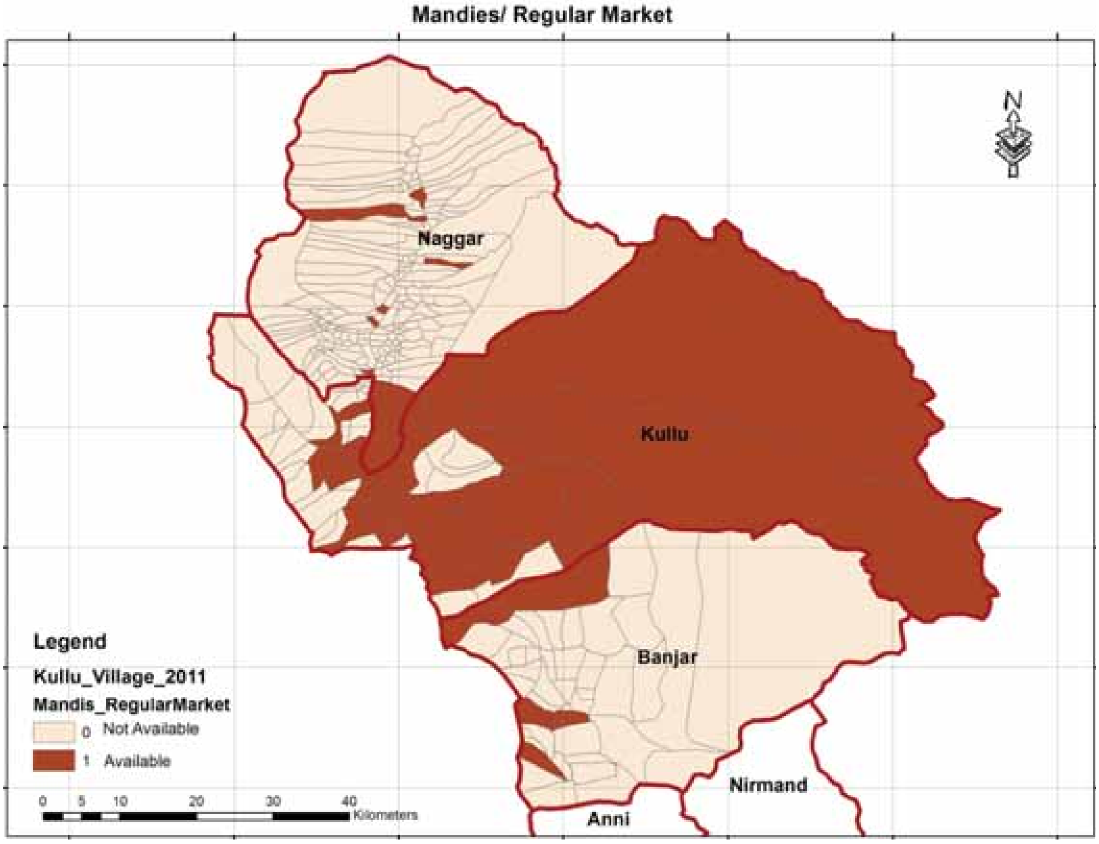
Map 9.20 Agricultural Credit Societies

A05 Self Help Group



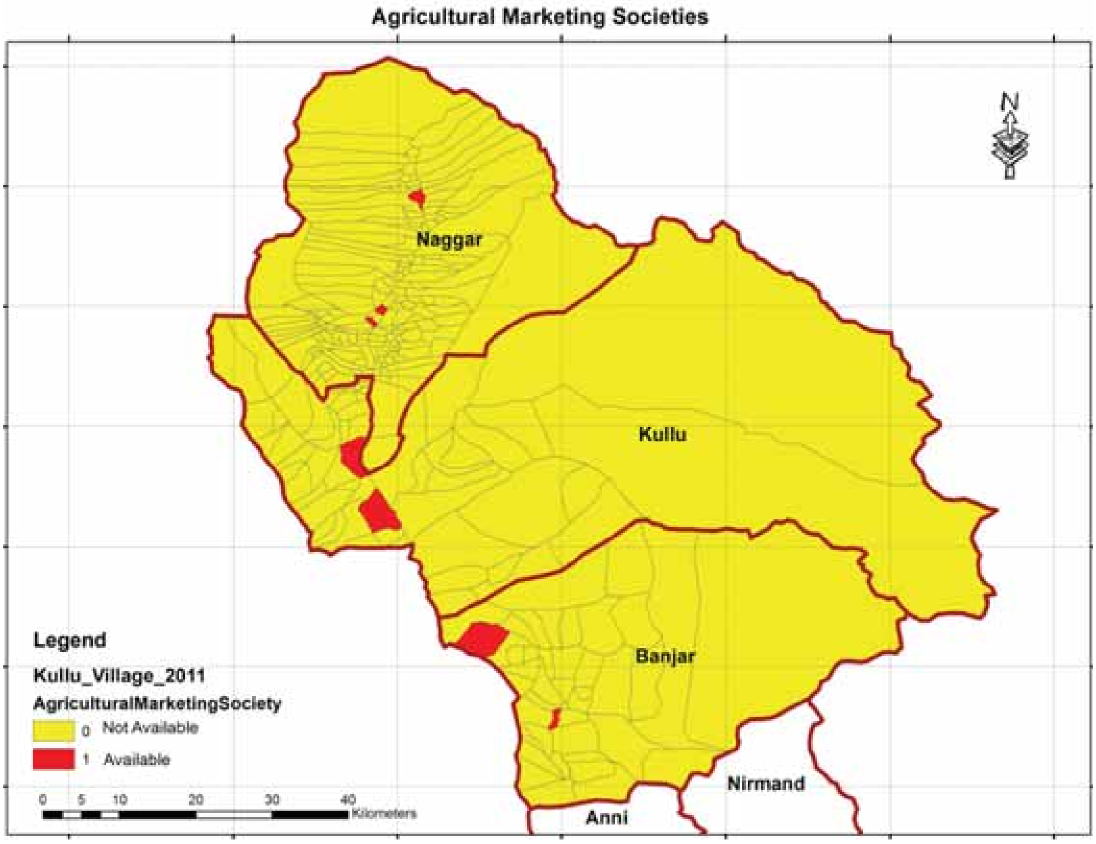
Map 9.21 Self Help Group

A06 Mandis/Regular Market



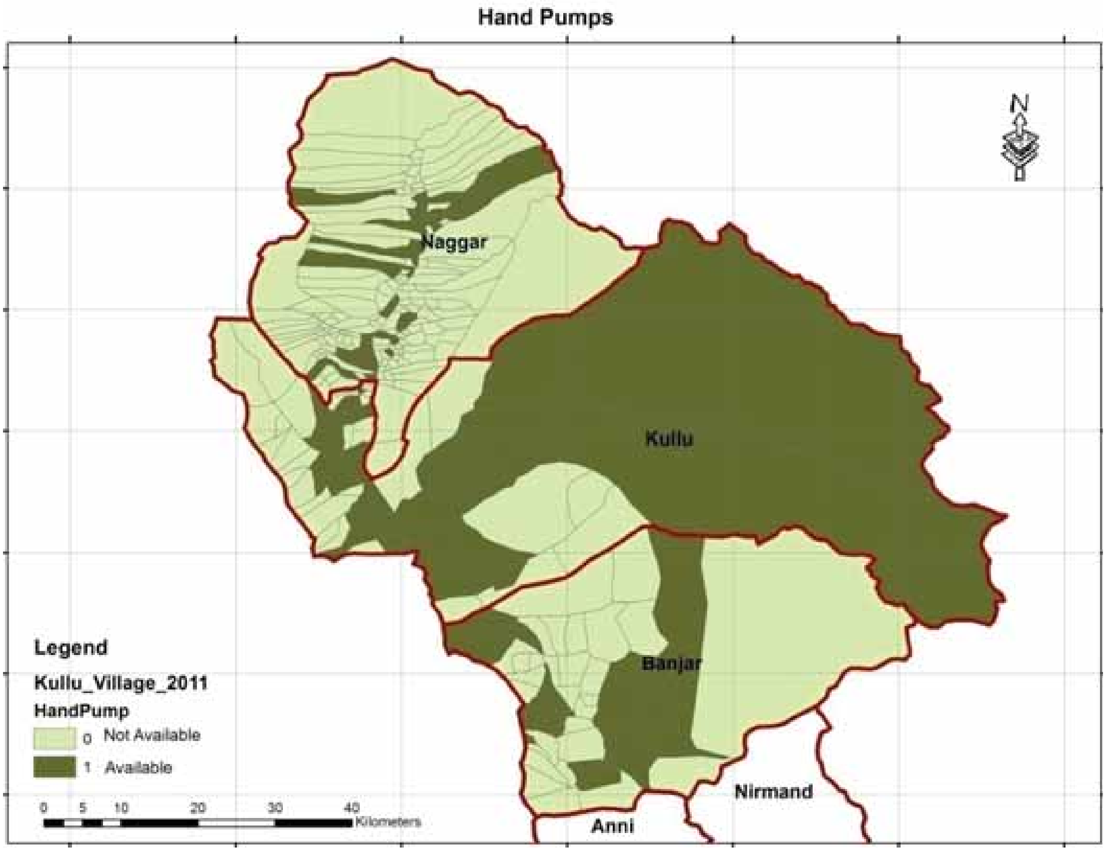
Map 9.22 Mandis/Regular Market

A07 Agricultural Marketing Society



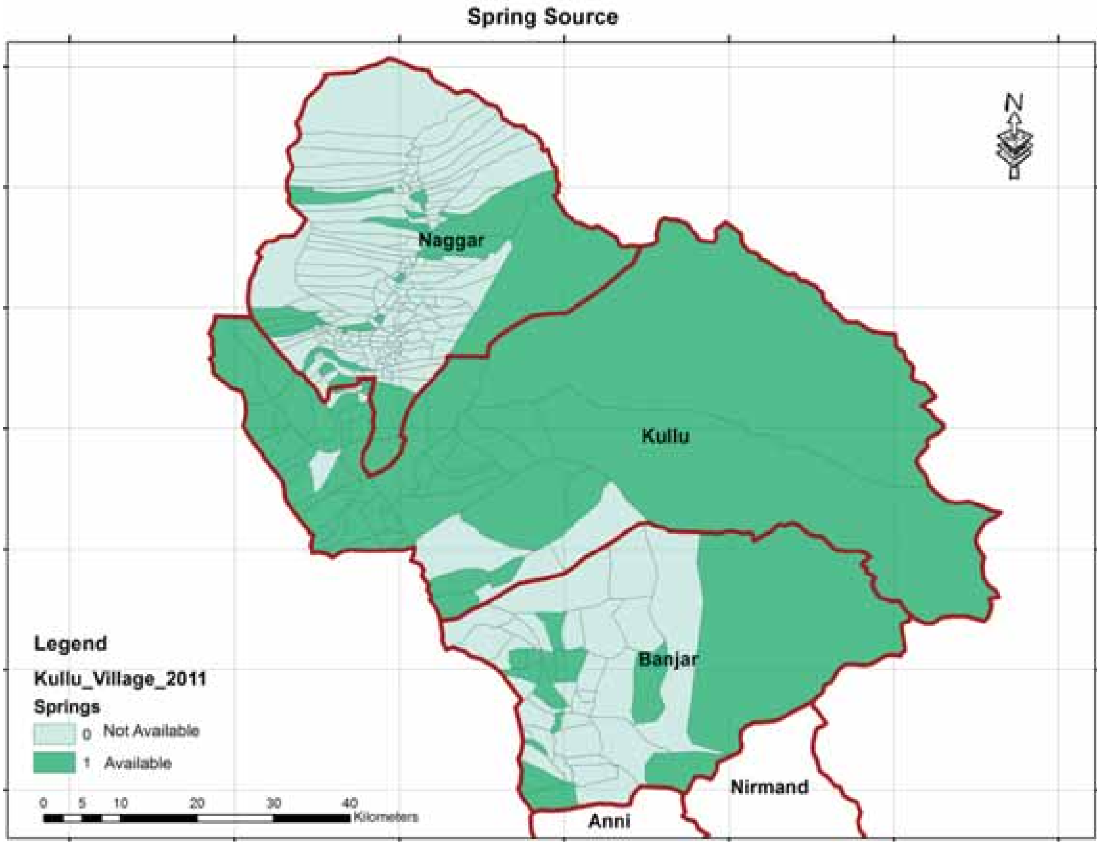
Map 9.23 Agricultural Marketing Society

A08 Hand Pump



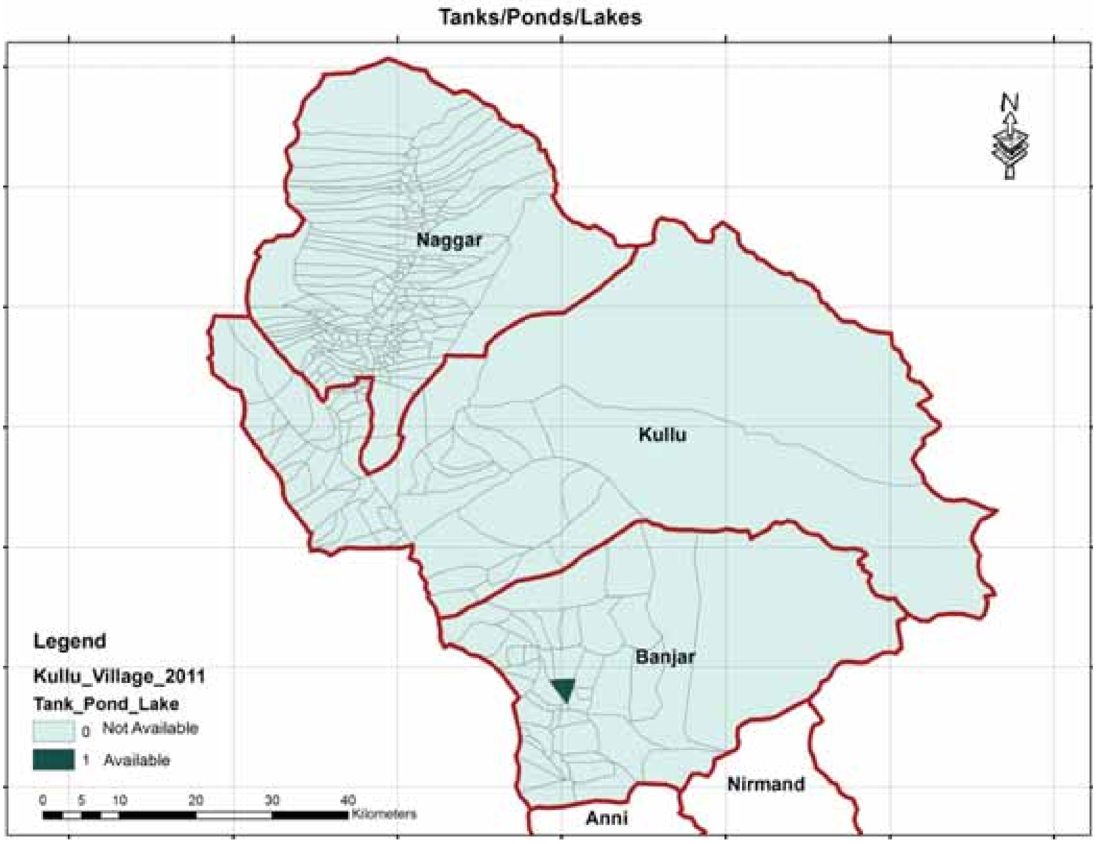
Map 9.24 Hand Pump

A09 Spring Source



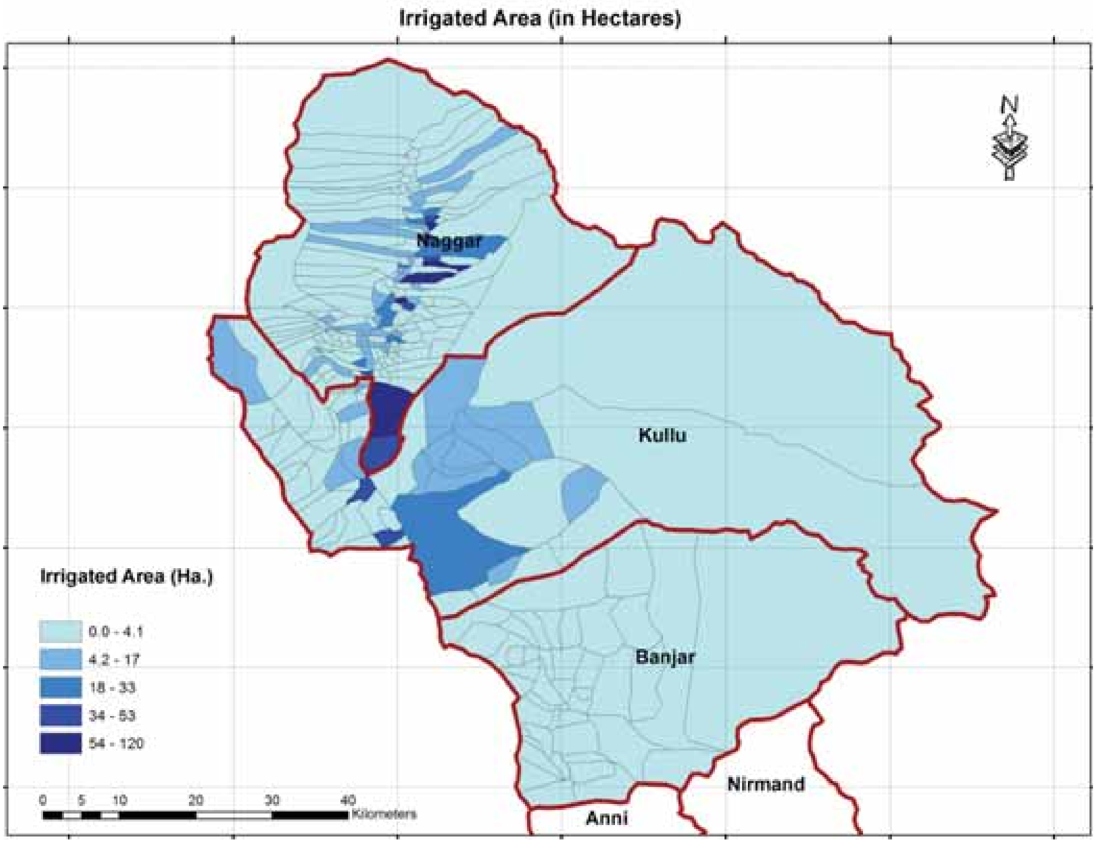
Map 9.25 Spring Source

A10 Tank/Pond/Lake



Map 9.26 Tanks/Ponds/Lakes

A11 Irrigated Area



Map 9.27 Irrigated Area

9.7 Composite Adaptive Capacity

Adaptive Capacity has been calculated using normalization of values of 11 variables viz. Educational Institutes, Health Institutes, Road Network, Agricultural Credit Societies, Self Help Group, Mandis/Regular Market, Agricultural Marketing Society, Hand Pump, Spring Source, Tank/Pond/Lake, Irrigated Area. Since the values are of different scale and units the normalization of indicators using functional relationship is done.

Variable Indicator A11 i.e. Irrigated Area has ↑ functional relationship with adaptive capacity and the normalization is done using the formula, which means the increase in Irrigated Area will increase the Adaptive Capacity resulting reduction in climate change vulnerability:

$$x_{ij} = \frac{X_{ij}-Min_i\{X_{ij}\}}{Max_i\{X_{ij}\}-Min_i\{X_{ij}\}}$$

After calculating the score of variables A01 to A11 the average score is calculated and the Composite Adaptive Capacity is calculated and mapped for all census villages:

Village Code	Village/ Town Name	Block	Indicators/ Variables											Composite Adaptive Capacity
			A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	
800103	Banjar (NP)	Banjar	0.54	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.02	0.91
012900	Kotla (1/1)	Banjar	0.20	0.04	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.47
012901	Chakurtha (1/2)	Banjar	0.11	0.04	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
012902	Kanon (1/3)	Banjar	0.11	0.12	1.00	1.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.47
012903	Dhaugi (1/4)	Banjar	0.11	0.12	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.36
012904	Dusharh (2/5)	Banjar	0.09	0.04	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
012905	Manyashi (2/6)	Banjar	0.11	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.23
012906	Sachen (2/7)	Banjar	0.14	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
012907	Shanshar (41/104)	Banjar	0.20	0.08	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.25
012908	Gara Parli (41/103)	Banjar	0.09	0.08	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
012909	Shangarh (3/9)	Banjar	0.09	0.04	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012910	Lapah (3/8)	Banjar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012911	Shapnil (4/11)	Banjar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012912	Siri Kot (4/10)	Banjar	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012913	Kalwari (4/12)	Banjar	0.23	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
012914	Deotha (5/14)	Banjar	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.13
012915	Thani Char (5/15)	Banjar	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.12
012916	Chanon (5/19)	Banjar	0.17	0.04	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.24
012917	Palach (4/13)	Banjar	0.17	0.04	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.24
012918	Sehuli (5/16)	Banjar	0.06	0.04	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.34
012919	Jauri ((5/17	Banjar	0.11	0.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.35
012920	Thati Bir (5/18)	Banjar	0.17	0.04	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.36
012921	Ratwah (6/21)	Banjar	0.11	0.08	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
012922	Tarangali (6/20)	Banjar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.12
012923	Bala Gad (7/23)	Banjar	0.20	0.12	1.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.37
012924	Bahu (9/27)	Banjar	0.09	0.12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
012925	Chethar (7/22)	Banjar	0.09	0.04	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.24
012926	Khabal (8/24)	Banjar	0.17	0.04	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.36
012927	Mohni (8/25)	Banjar	0.14	0.04	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.24
012928	Seraj (8/26)	Banjar	0.17	0.00	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.35
012929	Karshai Gad-II (23/72)	Banjar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.22
012930	Tandi (9/28)	Banjar	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012931	Sajwar (10/29)	Banjar	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012932	Ghiaghi (10/30)	Banjar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.12
012933	Rashala (10/31)	Banjar	0.14	0.12	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.14
012934	Bini (11/32)	Banjar	0.03	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
012935	Bihar (11/33)	Banjar	0.31	0.12	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.38
012936	Sharchi (12/34)	Banjar	0.20	0.08	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.14
012937	Pakhari (12/37)	Banjar	0.11	0.08	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.24

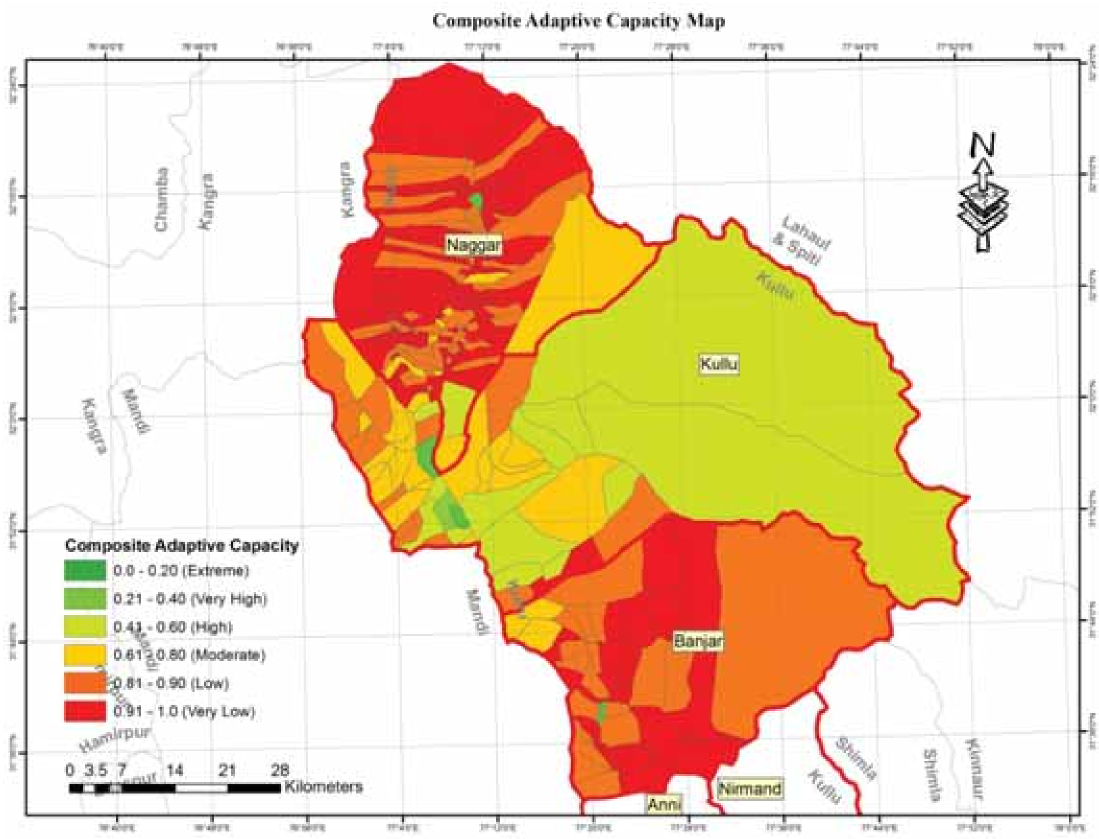
Village Code	Village/ Town Name	Block	Indicators/ Variables											Composite Adaptive Capacity
			A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	
012938	Tinder (13/36)	Banjar	0.17	0.04	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.24
012939	Chippni (14/38)	Banjar	0.14	0.08	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.14
012940	Shilhi (12/35)	Banjar	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.13
012941	Mashyar (14/39)	Banjar	0.14	0.08	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.25
800101	Kullu (M Cl)	Kullu	0.71	0.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.06	0.96
800102	Bhuntar (NP)	Kullu	0.97	0.73	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.02	0.97
012799	Biasar (27/55)	Kullu	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.12
012800	Up Muhal Thalli	Kullu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012801	Up Muhal Ropa sari	Kullu	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012802	Up Muhal Mapak	Kullu	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012803	Bandrol (27/56)	Kullu	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.13	0.13
012804	Up Muhal Nangabag	Kullu	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.01	0.12
012805	Up Muhal Harabag	Kullu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012806	Up Muhal Bagu Nalha	Kullu	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.01	0.11
012807	Up Muhal Maltibag	Kullu	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.07	0.23
012850	Jandor (26/54)	Kullu	0.14	0.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.02	0.57
012851	Banogi (26/53)	Kullu	0.40	0.08	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.07	0.73
012852	Sari (26/51)	Kullu	0.17	0.08	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.36
012853	Bastori (26/52)	Kullu	0.14	0.04	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.35
012854	Dughilag (30/67)	Kullu	0.23	0.04	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.58
012855	Majhat (30/68)	Kullu	0.09	0.04	0.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.46
012856	Phallan (30/66)	Kullu	0.09	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.23
012857	Dunkhri Gahar (30/65)	Kullu	0.20	0.08	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.03	0.48
012858	Pichhli (31/69)	Kullu	0.11	0.08	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.04	0.36
012859	Mashna (31/70)	Kullu	0.09	0.08	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.03	0.24
012860	Gahar (32/71)	Kullu	0.06	0.08	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.35
012861	Gramang (32/72)	Kullu	0.11	0.04	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.46
012862	Bhalyani (33/75)	Kullu	0.17	0.04	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.02	0.47
012863	Brahman (33/74)	Kullu	0.09	0.04	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.01	0.35
012864	Balh (33/73)	Kullu	0.14	0.04	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.03	0.47
012865	Bhumtir (33/76)	Kullu	0.11	0.04	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.46
012866	Peej (34/77)	Kullu	0.20	0.08	1.00	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.47
012867	Balh (34/79)	Kullu	0.17	0.04	0.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.09	0.59
012868	Kharihar (34/81)	Kullu	0.14	0.08	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.47
012869	Barahar (34/80)	Kullu	0.14	0.08	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.36
012871	Rajgiri (35/82)	Kullu	0.06	0.00	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.34
012872	Shillihar (35/83)	Kullu	0.17	0.04	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.36
012873	Mohal (35/84)	Kullu	0.26	0.12	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.31	0.74
012874	Bhullang (35/86)	Kullu	0.11	0.04	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.46
012875	Khokhan (35/87)	Kullu	0.17	0.04	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.69
012876	Neol (35/88)	Kullu	0.06	0.08	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.35
012877	Bajaura (36/89)	Kullu	0.26	0.08	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.43	0.64
012878	Hat (36/90)	Kullu	0.23	0.04	1.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.01	0.47
012879	Shillihar (37/91)	Kullu	0.40	0.08	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.26	0.64
012880	Kashawri (25/49)	Kullu	0.17	0.12	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.59
012881	Pini (25/48)	Kullu	0.20	0.04	0.00	0.00	1.00	1.00	0.00	0.00	1.00	0.00	0.09	0.37
012883	Manikarn (40/101)	Kullu	0.54	0.15	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.74
012884	Sosan (40/102)	Kullu	0.20	0.08	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.70
012885	Jari (39/100)	Kullu	0.20	0.12	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.13	0.71
012886	Bradha (39/99)	Kullu	0.20	0.08	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.10	0.71
012887	Shat (38/98)	Kullu	0.09	0.04	1.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.06	0.46
012888	Chong (38/96)	Kullu	0.20	0.08	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.06	0.59
012889	Jallu (38/97)	Kullu	0.17	0.04	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.06	0.58
012890	Ratocha (38/95)	Kullu	0.17	0.04	1.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.06	0.47
012891	Diar (37/92)	Kullu	0.23	0.08	1.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00	0.20	0.61
012892	Rote-II (42/107)	Kullu	0.20	0.04	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.24	0.61
012893	Bhallan-I (42/106)	Kullu	0.23	0.08	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.09	0.71
012894	Manjhli (37/93)	Kullu	0.29	0.04	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.59
012895	Parli (37/94)	Kullu	0.17	0.15	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.09	0.60
012896	Shamshi (CT)	Kullu	0.63	0.38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.03	0.89
012897	Raila (42/105)	Kullu	0.40	0.12	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.28

Village Code	Village/ Town Name	Block	Indicators/ Variables											Composite Adaptive Capacity
			A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	
012898	Bhalan-II (42/106)	Kullu	0.11	0.04	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
012899	Rote-I (42/107)	Kullu	0.11	0.04	1.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.35
800100	Manali (M Cl)	Naggar	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.05	1.00
012658	Palchan (21/24)	Naggar	0.09	0.04	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012659	UP Muhal Solang	Naggar	0.06	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012660	UP Muhal Kothi	Naggar	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012661	UP Muhal Kulang	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012662	Muhal Buruwa (21/25)	Naggar	0.09	0.08	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
012663	Up Muhal Buruwa Majhach	Naggar	0.06	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
012664	Up Muhal Vyas Tibba	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012665	Up Muhal Shanag	Naggar	0.03	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012666	Up Muhal Gaushal	Naggar	0.03	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012667	Up Muhal Bahang	Naggar	0.11	0.04	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
012668	Up Muhal Majhach	Naggar	0.03	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
012669	Bashisht (20/23)	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01
012670	Up Muhal Kaushala	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11
012671	Up Muhal Dharanu	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01
012672	Up Muhal Chachoga	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.11
012673	Up Muhal Aleu	Naggar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.17	0.14
012674	Jangal Mehduda Mehfuja Aleu Vihal	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012675	Muhal Manali (21/26)	Naggar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012676	Up Muhal Dhungri -2nd	Naggar	0.06	0.00	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.34
012677	Up Muhal Tyan Padhar	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012678	Up Muhal Manali Koot	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012679	Up Muhal Manu Nagar	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012680	Up Muhal Manali Ser	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012681	Up Muhal Kaliganch	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012682	Aarkshit Van R-I Dhungri	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012683	Muhal Nasogi (21/27)	Naggar	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012684	Up Muhal Simsa	Naggar	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.25	0.25
012685	Up Muhal Syal	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.05	0.23
012686	Up Muhal Chhiyal	Naggar	0.03	0.04	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.23
012687	Up Muhal Kanyal	Naggar	0.03	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.22
012688	Muhal Shallin (21/28)	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.01	0.23
012689	Up Muhal Klath	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.05	0.23
012690	Up Muhal Parsha	Naggar	0.09	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.13
012691	Up Muhal Klaont	Naggar	0.11	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.23
012692	Up Muhal Jhunjhari	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012693	Up Muhal Gadherani	Naggar	0.11	0.04	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.11	0.25
012694	Muhal Bran (22/29)	Naggar	0.09	0.12	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.12	0.26
012695	Up Muhal Chharogi	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012696	Up Muhal Mandhon	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012697	Up Muhal Shangchar	Naggar	0.06	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.23
012698	Up Muhal Dobha	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.15	0.24
012699	Up Muhal Rampur	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.10	0.12
012700	Muhal Pangan (22/38)	Naggar	0.11	0.12	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.06	0.36
012701	Up Muhal Gumidhar	Naggar	0.00	0.12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.14
012702	Muhal Riyara (22/30)	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012703	Up Muhal Defri	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012704	Muhal Shigli (22/31)	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012705	Up Muhal Kasheri	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012706	Up Muhal Nayalag	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012707	Muhal Hallan-II (22/32)	Naggar	0.06	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012708	Up Muhal Magana	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012709	Up Muhal Shilha	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01
012710	Muhal Bari (22/36)	Naggar	0.20	0.08	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.18	0.49
012711	Up Muhal Tarashi	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012712	Badgran (22/37)	Naggar	0.09	0.04	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.21	0.15
012713	Soil (23/41)	Naggar	0.06	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23

Village Code	Village/ Town Name	Block	Indicators/ Variables											Composite Adaptive Capacity
			A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	
012714	Up Muhal Haripur	Naggar	0.29	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.11	0.27
012715	Up Muhal Somvan	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012716	Karjan (23/40)	Naggar	0.03	0.04	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.61	0.41
012717	Sajla (23/39)	Naggar	0.09	0.04	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.54	0.29
012718	Up Muhal Sajal Vihal	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
012719	Up Muhal Dhamasu Kalaun	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012720	Muhal Gojra (20/20)	Naggar	0.11	0.08	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.17	0.15
012721	Up Muhal Khakhanal	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.38	0.16
012722	Up Muhal Barnar	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012723	Muhal Jagatsukh (20/21)	Naggar	0.03	0.12	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.61	0.31
012724	Up Muhal Bhanara	Naggar	0.03	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.22
012725	Up Muhal Chhalala	Naggar	0.09	0.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.32	0.38
012726	Up Muhal Bahanu	Naggar	0.03	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.07	0.23
012727	Muhal Prini (20/22)	Naggar	0.09	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.37	0.16
012728	Up Muhal Hamta	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.22
012729	Up Muhal Hamta 2/17	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.11
012730	Up Muhal Hamta 1/7	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.11
012731	Up Muhal Shuru	Naggar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.51	0.17
012732	Up Muhal Jamari	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012733	Hallan-I (24/42)	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012734	Up Muhal Rangri	Naggar	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.08
012735	Up Muhal chaki	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.04
012736	Up Muhal Sarsai	Naggar	0.20	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14
012737	Up Muhal Kumartee	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012738	Up Muhal Raman	Naggar	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012739	Up Muhal Batahar Bihal	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012740	Nagar (24/43)	Naggar	0.11	0.08	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.35
012741	Up Muhal Pulag	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012742	Up Muhal Rumsu	Naggar	0.06	0.04	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012743	Up Muhal chachogee	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012744	Up Muhal Madi	Naggar	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012745	Up Muhal Mashda	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012746	Up Muhal Ghadopa	Naggar	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.22	0.25
012747	Katrain (22/35)	Naggar	0.20	0.15	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.03	0.60
012748	Up Muhal Jatehad	Naggar	0.09	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.04	0.35
012749	Dawara (22/34)	Naggar	0.06	0.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.05	0.34
012750	Up Muhal Dachnee	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012751	Meha (22/33)	Naggar	0.06	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
012752	Up Muhal Bhujnu	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01
012753	Pichlihar (29/64)	Naggar	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012754	Up Muhal chukdee	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.11
012755	Up Muhal Jalog	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012756	Up Muhal Jigling	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012757	Up Muhal Kabhi	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.11
012758	Up Muhal Kaistha	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.11
012759	Up Muhal Galang	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.11
012760	Up Muhal Nari	Naggar	0.09	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.23
012761	Up Muhal Bagnee	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012762	Up Muhal Daral	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.03	0.23
012763	Up Muhal Damchin	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01
012764	Up Muhal Pradee	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.03	0.23
012765	Fojal (29/63)	Naggar	0.06	0.04	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.10	0.24
012766	Up Muhal Runga - I	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012767	Up Muhal Runga - II	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012768	Up Muhal Dhara	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11
012769	Up Muhal challogee	Naggar	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012770	Up Muhal Bulang Jhakdi	Naggar	0.06	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.12
012771	Up Muhal Demarcated Reserve Forest fozal Badon	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Village Code	Village/ Town Name	Block	Indicators/ Variables											Composite Adaptive Capacity
			A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	
012772	Mandalgarh (28/62)	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012773	Up Muhal Himri	Naggar	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012774	Up Muhal Parvi	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012775	Up Muhal Kral	Naggar	0.06	0.04	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
012776	Up Muhal Grahan	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012777	Up Muhal Galchet	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012778	Up Muhal Trisdee	Naggar	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
012779	Up Muhal Khdihar	Naggar	0.03	0.04	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012780	Up Muhal salingcha	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.22
012781	Up Muhal Shaldee	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012782	Dobhi (28/61)	Naggar	0.03	0.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.04	0.45
012783	Up Muhal Dohlonallha	Naggar	0.03	0.04	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.06	0.35
012784	Up Muhal Mahiliser	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.07	0.23
012785	Up Muhal Shim	Naggar	0.06	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.06	0.35
012786	Shirar (27/59)	Naggar	0.06	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.27	0.37
012787	Up Muhal Shirar - Ist	Naggar	0.06	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	0.23
012788	Up Muhal Shirar - II nd	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.02	0.22
012789	Benchi (27/58)	Naggar	0.09	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.23
012790	Up Muhal Pangan	Naggar	0.11	0.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.00	0.08	0.47
012791	Up Muhal Chattanseri	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.08	0.23
012792	Up Muhal Raison	Naggar	0.03	0.08	1.00	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.33	0.49
012793	Shillihar (27/60)	Naggar	0.03	0.04	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.23
012794	Up Muhal Jallohra	Naggar	0.06	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.23
012795	Up Muhal Kamarda	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.05	0.23
012796	Up Muhal Janehda	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.22
012797	Up Muhal Mathi shil	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.22
012798	Up Muhal Kufri	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012808	Manjhlihar (27/57)	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.11
012809	Up Muhal Kahudhar	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012810	Up Muhal Lohadi	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012811	Up Muhal Sajuni	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012812	Up Muhal Kharga	Naggar	0.03	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.22
012813	Nathan (24/45)	Naggar	0.06	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
012814	Up Muhal Dalashan	Naggar	0.06	0.04	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.13	0.36
012815	Up Muhal Nashalla	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.06	0.23
012816	Up Muhal Laran Keloo	Naggar	0.11	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
012817	Up Muhal Ghod dor	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.34
012818	Up Muhal Mahilee	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012819	Up Muhal Hirnee	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.09	0.23
012820	Up Muhal Bhiyalee	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012821	Up Muhal Chatee	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.19	0.24
012822	Up Muhal Nayanu sari	Naggar	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.04	0.23
012823	Up Muhal Paljot	Naggar	0.00	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.21	0.24
012824	Up Muhal Shanshr	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012825	Up Muhal Tilla Shadnee	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012826	Up Muhal Kharol	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012827	Up Muhal Dhanaseri	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012828	Up Muhal Thach	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012829	Up Muhal Ganesh Naggar	Naggar	0.03	0.04	1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.05	0.35
012830	Jana (24/46)	Naggar	0.06	0.08	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
012831	Up Muhal Parsh	Naggar	0.03	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012832	Up Muhal Sharan Gran	Naggar	0.03	0.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
012833	Up Muhal Shahadgran	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012834	Up Muhal Ladi Chanon - I	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012835	Up Muhal Ladi Chanon - II	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012836	Up Muhal Mehra Bag	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012837	Up Muhal Barnot	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012838	Up Muhal Deogra	Naggar	0.06	0.04	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
012839	Up Muhal Sharnee	Naggar	0.03	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012840	Up Muhal Archandee I	Naggar	0.06	0.04	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23

Village Code	Village/ Town Name	Block	Indicators/ Variables											Composite Adaptive Capacity
			A01	A02	A03	A04	A05	A06	A07	A08	A09	A10	A11	
012841	Up Muhal Archandee II	Naggar	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
012842	Up Muhal Mahilee	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012843	Up Muhal Baga Mahilee	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
012844	Up Muhal Dhama	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012845	Up Muhal Junkhra Dham	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012846	Up Muhal Phata Ban	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012847	Up Muhal Gohru	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012848	Up Muhal Kalmidhar	Naggar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
012849	Kais (25/47)	Naggar	0.37	0.12	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	0.72
012870	Kharal (25/50)	Naggar	0.60	0.12	1.00	0.00	1.00	1.00	0.00	0.00	1.00	0.00	0.31	0.56
012882	Malana (24/44)	Naggar	0.06	0.08	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.46



Map 9.28 Village wise Composite Adaptive Capacity

Map 9.28 depicts that the adaptive capacity of most of the villages of Naggar & Banjar Block is very low as compare to Kullu block. The main reason of the low adaptive capacity are that the less number of Irrigation facilities, less number of Educational Institutes, Health Institutes, Road Network, Agricultural Credit Societies, Self Help Group, Mandis/Regular Market, Agricultural Marketing Society, Hand Pump, Spring Source, Tank/Pond/Lake etc.

9.8 Composite Vulnerability

Once the weight of each indicator is determined, exposure, sensitivity and adaptive capacity maps have been prepared by taking weighted some of the rank of all relevant indicators. These three components and maps along with their functional relationship with vulnerability resulted in the final calculation of vulnerability map varying from 1 to 6 (very low, low, moderate, high, very high and extreme). The composite vulnerability rating maps have been generated using quantum GIS software.

The composite vulnerability rating is arrived at by combining the exposure, sensitivity and adaptive capacity using their respective weights using following formula:

Composite Vulnerability= (Exposure + Sensitivity- Adaptive Capacity)

The study is taken one step ahead towards determining vulnerability for all the villages separately. The vulnerability index was normalized on 0 to 1 scale for all the villages of each Block in study area and then the maps were prepared showing normalized vulnerability for each census village. The normalized vulnerability index has been computed using following formula:

Normalized Vulnerability = $(X-X_{min})/(X_{max}-X_{min})$

where, X is the value of vulnerability index of the villages, X_{min} is the minimum vulnerability of the villages, X_{max} is the maximum vulnerability index of the villages. The following table shows the vulnerability calculated for each census village of the three developmental blocks of the the district Kullu falling in Beas River Basin:

Village/ Town Code	Village/ Town Name	Block	Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)	Vulnerability V=(E+S)/AC
800103	Banjar (NP)	Banjar	0.88	0.64	0.91	0.48
012900	Kotla (1/1)	Banjar	0.93	0.90	0.47	0.81
012901	Chakurtha (1/2)	Banjar	0.93	0.89	0.13	0.96
012902	Kanon (1/3)	Banjar	0.89	0.82	0.47	0.76
012903	Dhaugi (1/4)	Banjar	0.89	0.82	0.36	0.81
012904	Dusharh (2/5)	Banjar	0.91	0.76	0.24	0.84
012905	Manyashi (2/6)	Banjar	0.91	0.73	0.23	0.83
012906	Sachen (2/7)	Banjar	0.84	0.67	0.13	0.82
012907	Shanshar (41/104)	Banjar	0.78	0.65	0.25	0.73
012908	Gara Parli (41/103)	Banjar	0.92	0.80	0.13	0.91
012909	Shangarh (3/9)	Banjar	0.88	0.81	0.12	0.90
012910	Lapah (3/8)	Banjar	0.93	0.67	0.01	0.91
012911	Shapnil (4/11)	Banjar	0.94	0.74	0.01	0.95
012912	Siri Kot (4/10)	Banjar	0.95	0.81	0.01	0.98
012913	Kalwari (4/12)	Banjar	0.94	0.82	0.14	0.93
012914	Deotha (5/14)	Banjar	0.92	0.81	0.13	0.92
012915	Thani Char (5/15)	Banjar	0.92	0.91	0.12	0.97
012916	Chanon (5/19)	Banjar	0.94	0.85	0.24	0.90
012917	Palach (4/13)	Banjar	0.92	0.79	0.24	0.86
012918	Sehuli (5/16)	Banjar	0.92	0.82	0.34	0.83
012919	Jauri ((5/17	Banjar	0.94	0.81	0.35	0.83
012920	Thati Bir (5/18)	Banjar	0.96	0.77	0.36	0.82
012921	Ratwah (6/21)	Banjar	0.97	0.82	0.13	0.94
012922	Tarangali (6/20)	Banjar	0.98	0.84	0.12	0.96
012923	Bala Gad (7/23)	Banjar	0.98	0.69	0.37	0.79
012924	Bahu (9/27)	Banjar	0.98	0.70	0.13	0.90
012925	Chethar (7/22)	Banjar	0.98	0.78	0.24	0.88
012926	Khabal (8/24)	Banjar	0.99	0.80	0.36	0.84
012927	Mohni (8/25)	Banjar	0.99	0.69	0.24	0.85
012928	Seraj (8/26)	Banjar	0.99	0.82	0.35	0.86
012929	Karshai Gad-II (23/72)	Banjar	0.98	0.86	0.22	0.93
012930	Tandi (9/28)	Banjar	0.98	0.64	0.01	0.92
012931	Sajwar (10/29)	Banjar	0.98	0.82	0.01	1.00
012932	Ghiaghi (10/30)	Banjar	0.97	0.82	0.12	0.95
012933	Rashala (10/31)	Banjar	0.98	0.75	0.14	0.91
012934	Bini (11/32)	Banjar	0.96	0.87	0.34	0.87
012935	Bihar (11/33)	Banjar	0.97	0.78	0.38	0.82
012936	Sharchi (12/34)	Banjar	0.94	0.89	0.14	0.96

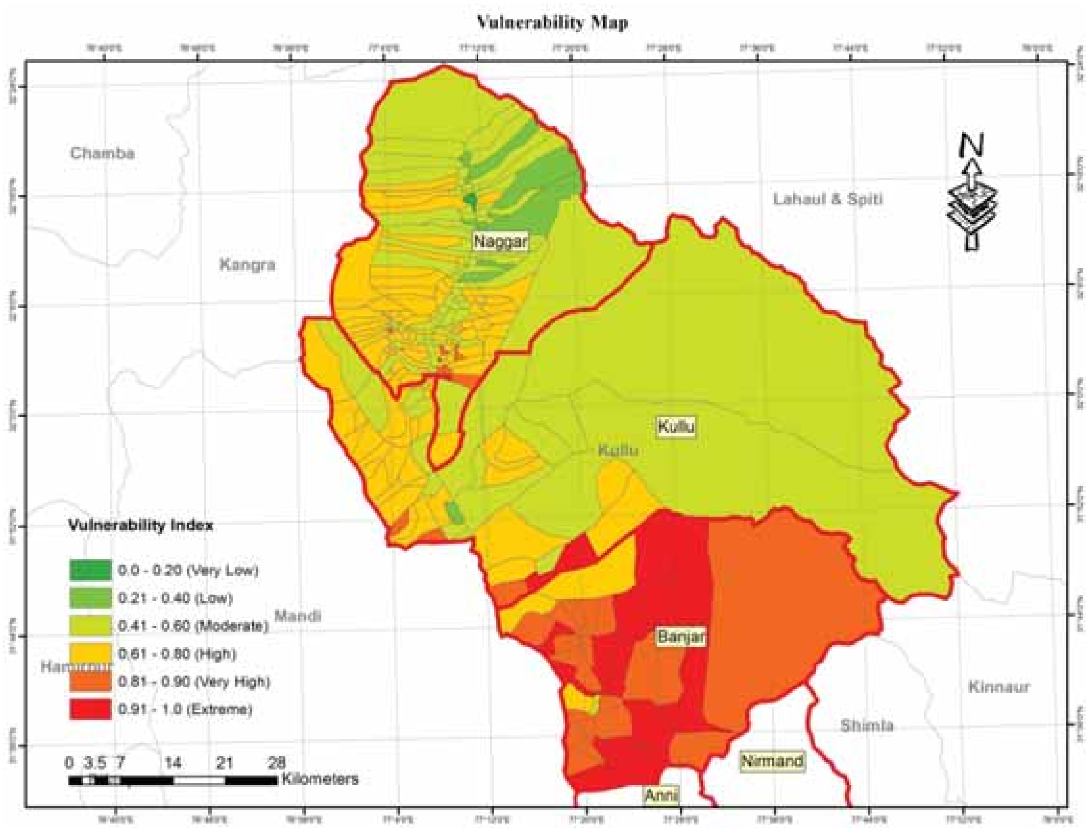
Village/ Town Code	Village/ Town Name	Block	Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)	Vulnerability V=(E+S)/AC
012937	Pakhari (12/37)	Banjar	0.94	0.66	0.24	0.81
012938	Tinder (13/36)	Banjar	0.85	0.77	0.24	0.82
012939	Chippni (14/38)	Banjar	0.97	0.88	0.14	0.97
012940	Shilhi (12/35)	Banjar	0.89	0.78	0.13	0.89
012941	Mashyar (14/39)	Banjar	1.00	0.81	0.25	0.90
800101	Kullu (M Cl)	Kullu	0.75	0.73	0.96	0.45
800102	Bhuntar (NP)	Kullu	0.80	0.51	0.97	0.37
012799	Biasar (27/55)	Kullu	0.74	0.60	0.12	0.75
012800	Up Muhal Thalli	Kullu	0.71	0.46	0.00	0.73
012801	Up Muhal Ropa sari	Kullu	0.71	0.39	0.11	0.65
012802	Up Muhal Mapak	Kullu	0.87	0.32	0.11	0.69
012803	Bandrol (27/56)	Kullu	0.89	0.12	0.13	0.60
012804	Up Muhal Nangabag	Kullu	0.68	0.56	0.12	0.71
012805	Up Muhal Harabag	Kullu	0.72	0.41	0.00	0.71
012806	Up Muhal Bagu Nalha	Kullu	0.70	0.52	0.11	0.70
012807	Up Muhal Maltibag	Kullu	0.70	0.40	0.23	0.60
012850	Jandor (26/54)	Kullu	0.68	0.65	0.57	0.55
012851	Banogi (26/53)	Kullu	0.70	0.63	0.73	0.48
012852	Sari (26/51)	Kullu	0.71	0.77	0.36	0.71
012853	Bastori (26/52)	Kullu	0.75	0.79	0.35	0.74
012854	Dughilag (30/67)	Kullu	0.74	0.83	0.58	0.65
012855	Majhat (30/68)	Kullu	0.77	0.71	0.46	0.66
012856	Phallan (30/66)	Kullu	0.62	0.46	0.23	0.59
012857	Dunkhri Gahar (30/65)	Kullu	0.62	0.41	0.48	0.46
012858	Pichhli (31/69)	Kullu	0.80	0.68	0.36	0.71
012859	Mashna (31/70)	Kullu	0.79	0.71	0.24	0.77
012860	Gahar (32/71)	Kullu	0.75	0.70	0.35	0.70
012861	Gramang (32/72)	Kullu	0.81	0.75	0.46	0.70
012862	Bhalyani (33/75)	Kullu	0.79	0.73	0.47	0.68
012863	Brahman (33/74)	Kullu	0.86	0.69	0.35	0.74
012864	Balh (33/73)	Kullu	0.84	0.86	0.47	0.76
012865	Bhumtir (33/76)	Kullu	0.80	0.65	0.46	0.65
012866	Peej (34/77)	Kullu	0.79	0.66	0.47	0.65
012867	Balh (34/79)	Kullu	0.81	0.71	0.59	0.62
012868	Kharihar (34/81)	Kullu	0.86	0.66	0.47	0.68
012869	Barahar (34/80)	Kullu	0.72	0.81	0.36	0.73
012871	Rajgiri (35/82)	Kullu	0.89	0.79	0.34	0.80
012872	Shillihar (35/83)	Kullu	0.78	0.82	0.36	0.76
012873	Mohal (35/84)	Kullu	0.88	0.47	0.74	0.48
012874	Bhullang (35/86)	Kullu	0.87	0.85	0.46	0.77
012875	Khokhan (35/87)	Kullu	0.90	0.74	0.69	0.63
012876	Neol (35/88)	Kullu	0.85	0.85	0.35	0.81
012877	Bajaura (36/89)	Kullu	0.85	0.66	0.64	0.60
012878	Hat (36/90)	Kullu	0.76	0.44	0.47	0.54
012879	Shillihar (37/91)	Kullu	0.72	0.76	0.64	0.59
012880	Kashawri (25/49)	Kullu	0.67	0.55	0.59	0.49
012881	Pini (25/48)	Kullu	0.34	0.58	0.37	0.46
012883	Manikarn (40/101)	Kullu	0.62	0.66	0.74	0.45
012884	Sosan (40/102)	Kullu	0.60	0.75	0.70	0.50
012885	Jari (39/100)	Kullu	0.62	0.74	0.71	0.50
012886	Bradha (39/99)	Kullu	0.68	0.75	0.71	0.53
012887	Shat (38/98)	Kullu	0.72	0.70	0.46	0.64
012888	Chong (38/96)	Kullu	0.66	0.63	0.59	0.52
012889	Jallu (38/97)	Kullu	0.71	0.81	0.58	0.63
012890	Ratocha (38/95)	Kullu	0.83	0.80	0.47	0.72
012891	Diar (37/92)	Kullu	0.88	0.72	0.61	0.65
012892	Rote-II (42/107)	Kullu	0.84	0.72	0.61	0.63
012893	Bhallan-I (42/106)	Kullu	0.72	0.74	0.71	0.55

Village/ Town Code	Village/ Town Name	Block	Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)	Vulnerability V=(E+S)/AC
012894	Manjhli (37/93)	Kullu	0.65	0.77	0.59	0.58
012895	Parli (37/94)	Kullu	0.71	0.81	0.60	0.62
012896	Shamshi (CT)	Kullu	0.94	0.85	0.89	0.61
012897	Raila (42/105)	Kullu	0.83	0.77	0.28	0.79
012898	Bhalan-II (42/106)	Kullu	0.93	0.78	0.13	0.91
012899	Rote-I (42/107)	Kullu	0.94	0.94	0.35	0.89
800100	Manali (M Cl)	Naggar	0.08	0.42	1.00	0.00
012658	Palchan (21/24)	Naggar	0.26	0.47	0.12	0.48
012659	UP Muhal Solang	Naggar	0.16	0.53	0.12	0.47
012660	UP Muhal Kothi	Naggar	0.02	0.56	0.01	0.47
012661	UP Muhal Kulang	Naggar	0.00	0.44	0.00	0.41
012662	Muhal Buruwa (21/25)	Naggar	0.32	0.68	0.24	0.55
012663	Up Muhal Buruwa Majhach	Naggar	0.14	0.45	0.34	0.33
012664	Up Muhal Vyas Tibba	Naggar	0.12	0.26	0.00	0.38
012665	Up Muhal Shanag	Naggar	0.17	0.70	0.22	0.50
012666	Up Muhal Gaushal	Naggar	0.18	0.37	0.22	0.36
012667	Up Muhal Bahang	Naggar	0.02	0.51	0.24	0.34
012668	Up Muhal Majhach	Naggar	0.35	0.79	0.34	0.57
012669	Bashisht (20/23)	Naggar	0.03	0.61	0.01	0.49
012670	Up Muhal Kaushala	Naggar	0.00	0.67	0.11	0.46
012671	Up Muhal Dharanu	Naggar	0.12	0.67	0.01	0.56
012672	Up Muhal Chachoga	Naggar	0.16	0.83	0.11	0.60
012673	Up Muhal Aleu	Naggar	0.20	0.51	0.14	0.47
012674	Jangal Mehduda Mehfuja Aleu Vihal	Naggar	0.19	0.54	0.00	0.54
012675	Muhal Manali (21/26)	Naggar	0.18	0.42	0.01	0.48
012676	Up Muhal Dhungri -2nd	Naggar	0.46	0.89	0.34	0.66
012677	Up Muhal Tyan Padhar	Naggar	0.19	0.37	0.00	0.46
012678	Up Muhal Manali Koot	Naggar	0.37	0.55	0.00	0.62
012679	Up Muhal Manu Nagar	Naggar	0.36	0.60	0.00	0.64
012680	Up Muhal Manali Ser	Naggar	0.18	0.25	0.00	0.41
012681	Up Muhal Kaliganch	Naggar	0.21	0.47	0.00	0.52
012682	Aarkshit Van R-I Dhungri	Naggar	0.24	0.50	0.00	0.54
012683	Muhal Nasogi (21/27)	Naggar	0.39	0.64	0.01	0.66
012684	Up Muhal Simsa	Naggar	0.24	0.18	0.25	0.29
012685	Up Muhal Syal	Naggar	0.23	0.62	0.23	0.49
012686	Up Muhal Chhiyal	Naggar	0.25	0.44	0.23	0.42
012687	Up Muhal Kanyal	Naggar	0.44	0.53	0.22	0.55
012688	Muhal Shallin (21/28)	Naggar	0.40	0.49	0.23	0.51
012689	Up Muhal Klath	Naggar	0.49	0.45	0.23	0.53
012690	Up Muhal Parsha	Naggar	0.46	0.43	0.13	0.55
012691	Up Muhal Klaont	Naggar	0.32	0.45	0.23	0.45
012692	Up Muhal Jhunjhari	Naggar	0.47	0.42	0.00	0.61
012693	Up Muhal Gadherani	Naggar	0.37	0.57	0.25	0.52
012694	Muhal Bran (22/29)	Naggar	0.43	0.48	0.26	0.50
012695	Up Muhal Chharogi	Naggar	0.44	0.54	0.00	0.65
012696	Up Muhal Mandhon	Naggar	0.52	0.47	0.00	0.65
012697	Up Muhal Shangchar	Naggar	0.54	0.47	0.23	0.56
012698	Up Muhal Dobha	Naggar	0.46	0.44	0.24	0.51
012699	Up Muhal Rampur	Naggar	0.46	0.25	0.12	0.48
012700	Muhal Pangan (22/38)	Naggar	0.49	0.34	0.36	0.42
012701	Up Muhal Gumidhar	Naggar	0.47	0.41	0.14	0.54
012702	Muhal Riyara (22/30)	Naggar	0.49	0.39	0.22	0.51
012703	Up Muhal Defri	Naggar	0.54	0.49	0.11	0.62
012704	Muhal Shigli (22/31)	Naggar	0.58	0.52	0.00	0.70
012705	Up Muhal Kasheri	Naggar	0.59	0.49	0.00	0.69
012706	Up Muhal Nayalag	Naggar	0.61	0.48	0.11	0.65
012707	Muhal Hallan-II (22/32)	Naggar	0.59	0.46	0.12	0.62
012708	Up Muhal Magana	Naggar	0.60	0.51	0.11	0.66

Village/ Town Code	Village/ Town Name	Block	Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)	Vulnerability V=(E+S)/AC
012709	Up Muhal Shilha	Naggar	0.54	0.48	0.01	0.66
012710	Muhal Bari (22/36)	Naggar	0.63	0.38	0.49	0.45
012711	Up Muhal Tarashi	Naggar	0.68	0.50	0.00	0.73
012712	Badgran (22/37)	Naggar	0.61	0.21	0.15	0.51
012713	Soil (23/41)	Naggar	0.30	0.53	0.23	0.48
012714	Up Muhal Haripur	Naggar	0.52	0.48	0.27	0.54
012715	Up Muhal Somvan	Naggar	0.52	0.26	0.11	0.51
012716	Karjan (23/40)	Naggar	0.44	0.22	0.41	0.33
012717	Sajla (23/39)	Naggar	0.35	0.24	0.29	0.35
012718	Up Muhal Sajal Vihal	Naggar	0.42	0.25	0.00	0.51
012719	Up Muhal Dhamasu Kalaun	Naggar	0.41	0.42	0.00	0.58
012720	Muhal Gojra (20/20)	Naggar	0.25	0.42	0.15	0.45
012721	Up Muhal Khakhanal	Naggar	0.38	0.36	0.16	0.47
012722	Up Muhal Barnar	Naggar	0.27	0.43	0.00	0.52
012723	Muhal Jagatsukh (20/21)	Naggar	0.25	0.35	0.31	0.34
012724	Up Muhal Bhanara	Naggar	0.11	0.45	0.22	0.37
012725	Up Muhal Chhalala	Naggar	0.30	0.14	0.38	0.24
012726	Up Muhal Bahanu	Naggar	0.24	0.33	0.23	0.37
012727	Muhal Prini (20/22)	Naggar	0.21	0.41	0.16	0.42
012728	Up Muhal Hamta	Naggar	0.17	0.46	0.22	0.40
012729	Up Muhal Hamta 2/17	Naggar	0.00	0.41	0.11	0.35
012730	Up Muhal Hamta 1/7	Naggar	0.10	0.54	0.11	0.45
012731	Up Muhal Shuru	Naggar	0.22	0.17	0.17	0.31
012732	Up Muhal Jamari	Naggar	0.20	0.56	0.00	0.55
012733	Hallan-I (24/42)	Naggar	0.61	0.22	0.00	0.58
012734	Up Muhal Rangri	Naggar	0.63	0.00	0.08	0.46
012735	Up Muhal chaki	Naggar	0.61	0.27	0.04	0.59
012736	Up Muhal Sarsai	Naggar	0.61	0.54	0.14	0.66
012737	Up Muhal Kumartee	Naggar	0.56	0.45	0.00	0.66
012738	Up Muhal Raman	Naggar	0.53	0.48	0.01	0.66
012739	Up Muhal Batahar Bihal	Naggar	0.41	0.62	0.00	0.67
012740	Nagar (24/43)	Naggar	0.62	0.46	0.35	0.54
012741	Up Muhal Pulag	Naggar	0.52	0.58	0.22	0.60
012742	Up Muhal Rumsu	Naggar	0.55	0.55	0.12	0.65
012743	Up Muhal chachogee	Naggar	0.58	0.46	0.11	0.62
012744	Up Muhal Madi	Naggar	0.52	0.88	0.22	0.73
012745	Up Muhal Mashda	Naggar	0.63	0.33	0.11	0.59
012746	Up Muhal Ghadopa	Naggar	0.66	0.12	0.25	0.45
012747	Katrain (22/35)	Naggar	0.69	0.42	0.60	0.44
012748	Up Muhal Jatehad	Naggar	0.68	0.33	0.35	0.51
012749	Dawara (22/34)	Naggar	0.61	0.54	0.34	0.57
012750	Up Muhal Dachnee	Naggar	0.62	0.52	0.11	0.67
012751	Meha (22/33)	Naggar	0.59	0.61	0.23	0.64
012752	Up Muhal Bhujnu	Naggar	0.62	0.47	0.01	0.69
012753	Pichlihar (29/64)	Naggar	0.63	0.49	0.01	0.70
012754	Up Muhal chukdee	Naggar	0.69	0.63	0.11	0.75
012755	Up Muhal Jalog	Naggar	0.63	0.55	0.00	0.73
012756	Up Muhal Jigling	Naggar	0.64	0.53	0.00	0.73
012757	Up Muhal Kabhi	Naggar	0.64	0.53	0.11	0.68
012758	Up Muhal Kaistha	Naggar	0.67	0.54	0.11	0.70
012759	Up Muhal Galang	Naggar	0.68	0.59	0.11	0.72
012760	Up Muhal Nari	Naggar	0.69	0.57	0.23	0.67
012761	Up Muhal Bagnee	Naggar	0.69	0.54	0.00	0.76
012762	Up Muhal Daral	Naggar	0.62	0.61	0.23	0.66
012763	Up Muhal Damchin	Naggar	0.63	0.36	0.01	0.65
012764	Up Muhal Pradee	Naggar	0.63	0.46	0.23	0.59
012765	Fojal (29/63)	Naggar	0.65	0.41	0.24	0.58
012766	Up Muhal Runga - Ist	Naggar	0.69	0.80	0.11	0.82

Village/ Town Code	Village/ Town Name	Block	Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)	Vulnerability V=(E+S)/AC
012767	Up Muhal Runga - II nd	Naggar	0.63	0.46	0.11	0.65
012768	Up Muhal Dhara	Naggar	0.63	0.40	0.11	0.62
012769	Up Muhal challogee	Naggar	0.61	0.29	0.22	0.52
012770	Up Muhal Bulang Jhakdi	Naggar	0.64	0.45	0.12	0.64
012771	Up Muhal Demarcated Reserve Forest fozal Badon	Naggar	0.63	0.40	0.00	0.67
012772	Mandalgarh (28/62)	Naggar	0.71	0.56	0.11	0.72
012773	Up Muhal Himri	Naggar	0.66	0.50	0.00	0.72
012774	Up Muhal Parvi	Naggar	0.66	0.38	0.11	0.62
012775	Up Muhal Kral	Naggar	0.63	0.32	0.23	0.53
012776	Up Muhal Grahan	Naggar	0.64	0.41	0.00	0.68
012777	Up Muhal Galchet	Naggar	0.62	0.38	0.00	0.66
012778	Up Muhal Trisdee	Naggar	0.62	0.44	0.01	0.68
012779	Up Muhal Khdihar	Naggar	0.61	0.33	0.12	0.58
012780	Up Muhal salingcha	Naggar	0.60	0.39	0.22	0.55
012781	Up Muhal Shaldee	Naggar	0.65	0.40	0.11	0.63
012782	Dobhi (28/61)	Naggar	0.68	0.60	0.45	0.58
012783	Up Muhal Dohlonallha	Naggar	0.72	0.26	0.35	0.49
012784	Up Muhal Mahiliser	Naggar	0.58	0.25	0.23	0.48
012785	Up Muhal Shim	Naggar	0.78	0.52	0.35	0.63
012786	Shirar (27/59)	Naggar	0.65	0.22	0.37	0.44
012787	Up Muhal Shirar - Ist	Naggar	0.66	0.54	0.23	0.64
012788	Up Muhal Shirar - II nd	Naggar	0.89	0.58	0.22	0.76
012789	Benchi (27/58)	Naggar	0.72	0.60	0.23	0.69
012790	Up Muhal Pangan	Naggar	0.88	0.41	0.47	0.58
012791	Up Muhal Chattanseri	Naggar	0.87	0.26	0.23	0.61
012792	Up Muhal Raison	Naggar	0.68	0.38	0.49	0.47
012793	Shillihar (27/60)	Naggar	0.74	0.64	0.23	0.72
012794	Up Muhal Jallohra	Naggar	0.67	0.46	0.23	0.61
012795	Up Muhal Kamarda	Naggar	0.66	0.53	0.23	0.64
012796	Up Muhal Janehda	Naggar	0.72	0.61	0.22	0.70
012797	Up Muhal Mathi shil	Naggar	0.69	0.53	0.22	0.66
012798	Up Muhal Kufri	Naggar	0.73	0.40	0.00	0.71
012808	Manjhlihar (27/57)	Naggar	0.74	0.51	0.11	0.72
012809	Up Muhal Kahudhar	Naggar	0.73	0.46	0.11	0.69
012810	Up Muhal Lohadi	Naggar	0.71	0.43	0.00	0.72
012811	Up Muhal Sajuni	Naggar	0.76	0.52	0.22	0.68
012812	Up Muhal Kharga	Naggar	0.71	0.51	0.22	0.66
012813	Nathan (24/45)	Naggar	0.70	0.26	0.23	0.54
012814	Up Muhal Dalashan	Naggar	0.69	0.34	0.36	0.51
012815	Up Muhal Nashalla	Naggar	0.65	0.48	0.23	0.61
012816	Up Muhal Laran Keloo	Naggar	0.67	0.49	0.23	0.62
012817	Up Muhal Ghod dor	Naggar	0.69	0.22	0.34	0.47
012818	Up Muhal Mahilee	Naggar	0.69	0.19	0.00	0.60
012819	Up Muhal Hirnee	Naggar	0.69	0.12	0.23	0.47
012820	Up Muhal Bhiyalee	Naggar	0.73	0.26	0.11	0.60
012821	Up Muhal Chatee	Naggar	0.71	0.10	0.24	0.47
012822	Up Muhal Nayanu sari	Naggar	0.72	0.43	0.23	0.62
012823	Up Muhal Paljot	Naggar	0.68	0.27	0.24	0.53
012824	Up Muhal Shanshr	Naggar	0.67	0.51	0.00	0.73
012825	Up Muhal Tilla Shadnee	Naggar	0.57	0.41	0.00	0.65
012826	Up Muhal Kharol	Naggar	0.56	0.47	0.11	0.62
012827	Up Muhal Dhanaseri	Naggar	0.60	0.49	0.00	0.69
012828	Up Muhal Thach	Naggar	0.66	0.43	0.00	0.69
012829	Up Muhal Ganesh Naggar	Naggar	0.75	0.50	0.35	0.61
012830	Jana (24/46)	Naggar	0.73	0.67	0.24	0.72
012831	Up Muhal Parsh	Naggar	0.70	0.50	0.11	0.69
012832	Up Muhal Sharan Gran	Naggar	0.74	0.53	0.22	0.68

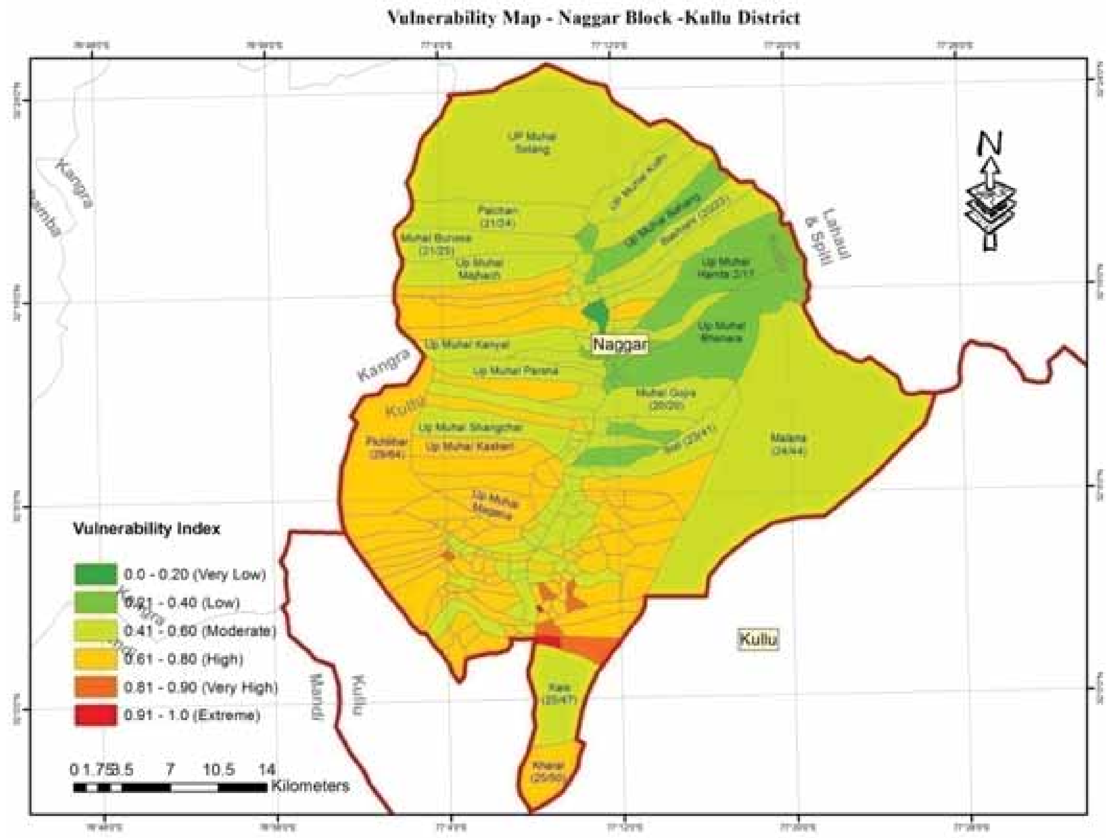
Village/ Town Code	Village/ Town Name	Block	Exposure (E)	Sensitivity (S)	Adaptive Capacity (AC)	Vulnerability V=(E+S)/AC
012833	Up Muhal Shahadgran	Naggar	0.69	0.76	0.11	0.80
012834	Up Muhal Ladi Chanon - Ist	Naggar	0.72	0.40	0.00	0.71
012835	Up Muhal Ladi Chanon - II nd	Naggar	0.73	0.43	0.00	0.72
012836	Up Muhal Mehra Bag	Naggar	0.73	0.66	0.00	0.83
012837	Up Muhal Barnot	Naggar	0.67	0.73	0.11	0.78
012838	Up Muhal Deogra	Naggar	0.77	0.83	0.12	0.86
012839	Up Muhal Sharnee	Naggar	0.69	0.68	0.11	0.77
012840	Up Muhal Archandee Ist	Naggar	0.84	0.71	0.23	0.79
012841	Up Muhal Archandee IInd	Naggar	0.68	0.33	0.11	0.61
012842	Up Muhal Mahilee	Naggar	0.67	0.56	0.00	0.76
012843	Up Muhal Baga Mahilee	Naggar	0.85	0.72	0.00	0.90
012844	Up Muhal Dhama	Naggar	0.86	0.64	0.00	0.87
012845	Up Muhal Junkhra Dham	Naggar	0.75	0.69	0.00	0.85
012846	Up Muhal Phata Ban	Naggar	0.76	0.45	0.00	0.75
012847	Up Muhal Gohru	Naggar	0.87	0.67	0.00	0.89
012848	Up Muhal Kalmidhar	Naggar	0.71	1.01	0.00	0.97
012849	Kais (25/47)	Naggar	0.69	0.81	0.72	0.56
012870	Kharal (25/50)	Naggar	0.90	0.77	0.56	0.70
012882	Malana (24/44)	Naggar	0.61	0.61	0.46	0.55



Map 9.29 Village level Vulnerability Map

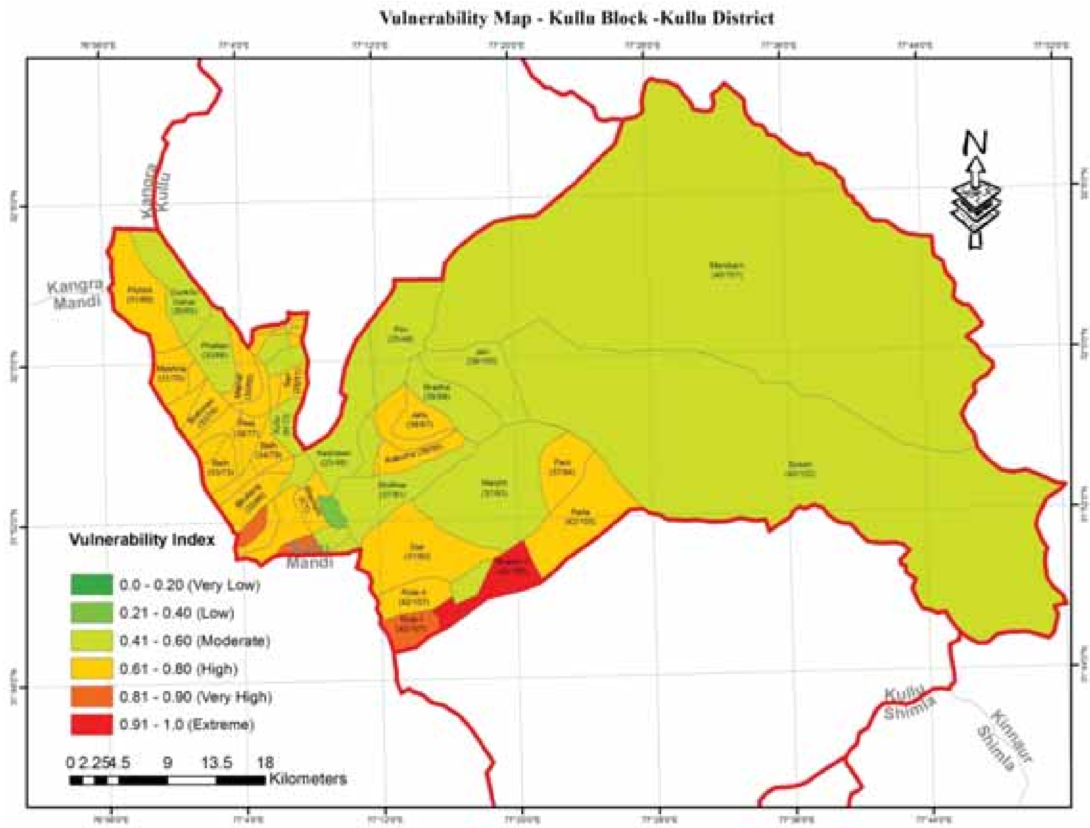
Vulnerability Map 9.29 shows the village level vulnerability. For better understanding the vulnerability is grouped in 1-6 levels and certain range is given to each level. For very low vulnerability range has been fixed between 0.00-0.20, for low vulnerability range has been fixed between 0.21-0.40, for moderate vulnerability range has been fixed between 0.41-0.60, for high vulnerability range is fixed between 0.61-0.80, for very high vulnerability range has been fixed between 0.81-0.90 and 0.91-1.00 range has been fixed for extreme vulnerability. Vulnerability map depicts that the climate change vulnerability of the Banjar Block is high as compare to the Naggar & Kullu Blocks. The major reasons of this high vulnerability is less adaptive capacity and high exposure & sensitivity to the changing climate.

Further the vulnerability maps has been generated separately for each blocks Kullu, Naggar & Banjar along with the categorization of the villages vulnerable to the changing climate in 6 different levels (Extreme, Very High, High, Moderate, Low, Very Low).



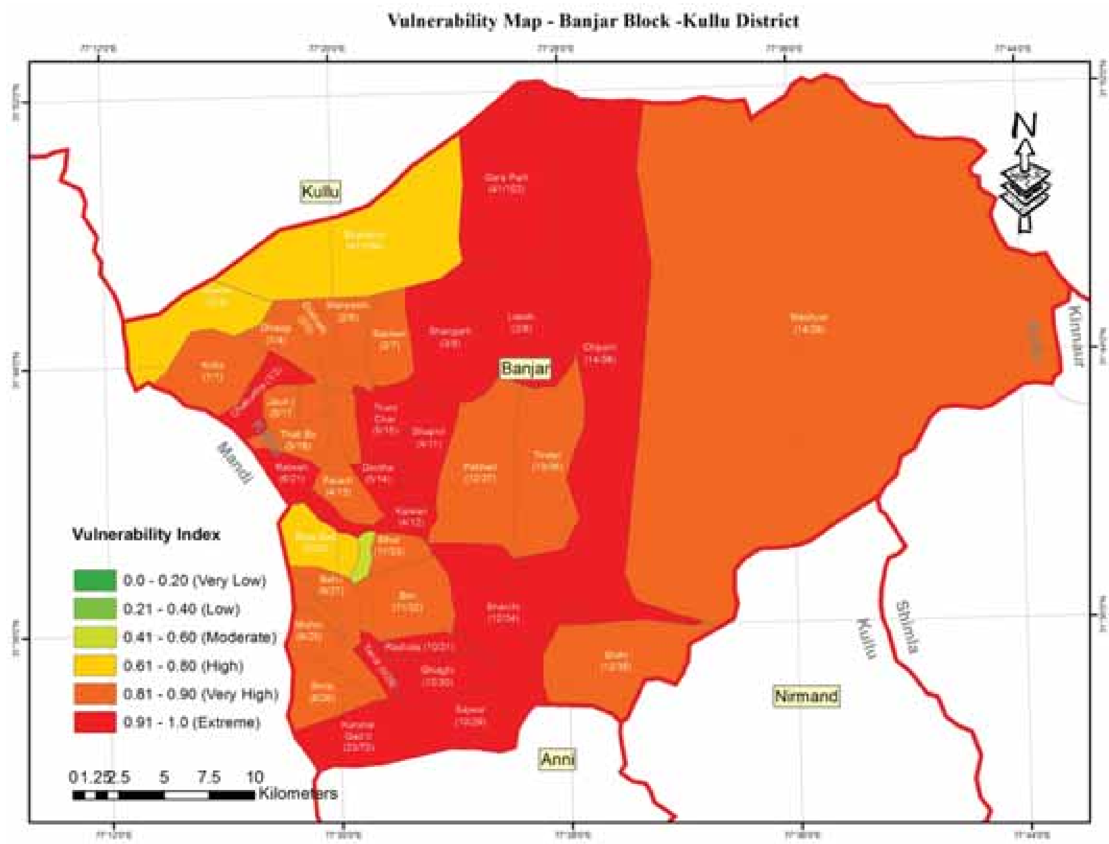
Vulnerable Villages – Naggar Block – District Kullu					
Very Low (0.00-0.20)	**Low (0.21-0.40)**	**Moderate (0.41-0.60)**	**High (0.61-0.80)**	**Very High (0.81-0.90)**	**Extreme (0.91-1.00)**
Manali (M Cl) 0.00	Up Muhal Hamta 0.40 Up Muhal Vyas Tibba 0.38 Up Muhal Bhanara 0.37 Up Muhal Bahanu 0.37 Up Muhal Gaushal 0.36 Sajla 0.35 Up Muhal Hamta 0.35 Up Muhal Bahang 0.34 Muhal Jagatsukh 0.34 Up Muhal Buruwa Majhach 0.33 Karjan 0.33 Up Muhal Shuru 0.31 Up Muhal Simsa 0.29	Up Muhal Pulag 0.60 Up Muhal Chachoga 0.60 Up Muhal Mahilee 0.60 Up Muhal Bhiyalee 0.60 Up Muhal Pradee 0.59 Up Muhal Mashda 0.59 Up Muhal chaki 0.59 Up Muhal Dhamasu Kalaun 0.58 Hallan-I 0.58 Dobhi 0.58 Fojal 0.58 Up Muhal Pangan 0.58 Up Muhal Khdihar 0.58 Dawara 0.57 Up Muhal Majhach 0.57 Up Muhal Dharanu 0.56 Up Muhal Shangchar 0.56 Kais 0.56 Up Muhal salingcha 0.55 Muhal Buruwa 0.55	Up Muhal Shahadgran 0.80 Up Muhal Archandee 0.79 Up Muhal Barnot 0.78 Up Muhal Sharnee 0.77 Up Muhal Shirar - II 0.76 Up Muhal Bagnee 0.76 Up Muhal Mahilee 0.76 Up Muhal Phata Ban 0.75 Up Muhal chukdee 0.75 Up Muhal Tarashi 0.73 Up Muhal Jalog 0.73 Up Muhal Shanshr 0.73 Up Muhal Madi 0.73 Up Muhal Jigling 0.73 Up Muhal Himri 0.72 Up Muhal Galang 0.72 Mandalgarh 0.72 Jana 0.72 Up Muhal Ladi Chanon - II 0.72 Shillihar 0.72 Manjhlihar 0.72 Up Muhal Lohadi 0.72 Up Muhal Kufri 0.71	Up Muhal Baga Mahilee 0.90 Up Muhal Gohru 0.89 Up Muhal Dhama 0.87 Up Muhal Deogra 0.86 Up Muhal Junkhra Dham 0.85 Up Muhal Mehra Bag 0.83 Up Muhal Runga - I 0.82	Up Muhal Kalmidhar 0.97

Vulnerable Villages – Naggar Block – District Kullu					
Very Low (0.00-0.20)	**Low (0.21-0.40)**	**Moderate (0.41-0.60)**	**High (0.61-0.80)**	**Very High (0.81-0.90)**	**Extreme (0.91-1.00)**
	Up Muhal Chhalala 0.24	Up Muhal Parsha 0.55 Up Muhal Jamari 0.55 Malana 0.55 Up Muhal Kanyal 0.55 Aarkshit Van R-I Dhungri 0.54 Up Muhal Gumidhar 0.54 Jangal Mehduda Mehfuja Aleu Vihal 0.54 Up Muhal Haripur 0.54 Nagar 0.54 Nathan 0.54 Up Muhal Kral 0.53 Up Muhal Klath 0.53 Up Muhal Paljot 0.53 Up Muhal Barnar 0.52 Up Muhal Gadherani 0.52 Up Muhal Kaliganch 0.52 Up Muhal challogee 0.52 Badgran 0.51 Up Muhal Somvan 0.51 Up Muhal Sajal Vihal 0.51 Up Muhal Dalashan 0.51 Muhal Shallin 0.51 Up Muhal Dobha 0.51 Muhal Riyara 0.51 Up Muhal Jatehad 0.51 Up Muhal Shanag 0.50 Muhal Bran 0.50 Bashisht 0.49 Up Muhal Dohlonallha 0.49 Up Muhal Syal 0.49 Palchan 0.48 Soil 0.48 Up Muhal Mahiliser 0.48 Muhal Manali 0.48 Up Muhal Rampur 0.48 Up Muhal Khakhanal 0.47 Up Muhal Hirnee 0.47 UP Muhal Solang 0.47 UP Muhal Kothi 0.47 Up Muhal Raison 0.47 Up Muhal Aleu 0.47 Up Muhal Ghod dor 0.47 Up Muhal Chatee 0.47 Up Muhal Kaushal 0.46 Up Muhal Tyan Padhar 0.46 Up Muhal Rangri 0.46 Up Muhal Klaont 0.45 Up Muhal Hamta 0.45 Up Muhal Ghadopa 0.45 Muhal Bari 0.45 Muhal Gojra 0.45 Katrain 0.44 Shirar 0.44 Muhal Pangan 0.42 Up Muhal Chhiyal 0.42 Muhal Prini 0.42 UP Muhal Kulang 0.41 Up Muhal Manali Ser 0.41	Up Muhal Ladi Chanon 0.71 Pichlihar 0.70 Up Muhal Janehda 0.70 Kharal 0.70 Muhal Shigli 0.70 Up Muhal Kaistha 0.70 Up Muhal Thach 0.69 Benchi 0.69 Up Muhal Dhanaseri 0.69 Up Muhal Parsh 0.69 Up Muhal Kasheri 0.69 Up Muhal Bhujnu 0.69 Up Muhal Kahudhar 0.69 Up Muhal Sajuni 0.68 Up Muhal Kabhi 0.68 Up Muhal Grahan 0.68 Up Muhal Trisdee 0.68 Up Muhal Sharan Gran 0.68 Up Muhal Batahar Bihal 0.67 Up Muhal Dachnee 0.67 Up Muhal Demarcated Reserve Forest fozal Badon 0.67 Up Muhal Nari 0.67 Muhal Nasogi 0.66 Up Muhal Dhungri -2 0.66 Up Muhal Shilha 0.66 Up Muhal Kumartee 0.66 Up Muhal Sarsai 0.66 Up Muhal Magana 0.66 Up Muhal Raman 0.66 Up Muhal Daral 0.66 Up Muhal Galchet 0.66 Up Muhal Mathi shil 0.66 Up Muhal Kharga 0.66 Up Muhal Mandhon 0.65 Up Muhal Chharogi 0.65 Up Muhal Nayalag 0.65 Up Muhal Rumsu 0.65 Up Muhal Damchin 0.65 Up Muhal Runga - II 0.65 Up Muhal Tilla Shadnee 0.65 Up Muhal Bulang Jhakdi 0.64 Up Muhal Shirar 0.64 Meha 0.64 Up Muhal Manu Nagar 0.64 Up Muhal Kamarda 0.64 Up Muhal Shim 0.63 Up Muhal Shaldee 0.63 Muhal Hallan-II 0.62 Up Muhal chachogee 0.62 Up Muhal Parvi 0.62 Up Muhal Laran Keloo 0.62 Up Muhal Manali Koot 0.62 Up Muhal Defri 0.62 Up Muhal Dhara 0.62 Up Muhal Nayanu sari 0.62 Up Muhal Kharol 0.62 Up Muhal Jallohra 0.61 Up Muhal Chattanseri 0.61 Up Muhal Nashalla 0.61 Up Muhal Ganesh Naggar 0.61 Up Muhal Archandee II 0.61 Up Muhal Jhunjhari 0.61		



Vulnerable Villages – Kullu Block – District Kullu

Very Low	Low	Moderate	High	Very High	Extreme
(0.00-0.20)	(0.21-0.40)	(0.41-0.60)	(0.61-0.80)	(0.81-0.90)	(0.91-1.00)
	Bhuntar (NP) 0.37	Bandrol 0.60 Up Muhal Maltibag 0.60 Bajaura 0.60 Phallan 0.59 Shillihar 0.59 Manjhli 0.58 Jandor 0.55 Bhallan-I 0.55 Hat 0.54 Bradha 0.53 Chong 0.52 Sosan 0.50 Jari 0.50 Kashawri 0.49 Mohal 0.48 Banogi 0.48 Dunkhri Gahar 0.46 Pini 0.46 Manikarn 0.45 Kullu (M Cl) 0.45	Rajgiri 0.80 Raila 0.79 Mashna 0.77 Bhullang 0.77 Shillihar 0.76 Balh 0.76 Biasar 0.75 Brahman 0.74 Bastori 0.74 Up Muhal Thalli 0.73 Barahar 0.73 Ratocha 0.72 Up Muhal Harabag 0.71 Up Muhal Nangabag 0.71 Sari 0.71 Pichhli 0.71 Up Muhal Bagu Nalha 0.70 Gahar 0.70 Gramang 0.70 Up Muhal Mapak 0.69 Bhalyani 0.68 Kharihar 0.68 Majhat 0.66 Up Muhal Ropa sari 0.65 Bhumtir 0.65 Diar 0.65 Dughilag 0.65 Peej 0.65 Shat 0.64 Khokhan 0.63 Rote-II 0.63 Jallu 0.63 Balh 0.62 Parli 0.62 Shamshi (CT) 0.61	Rote-I 0.89 Neol 0.81	Bhalan-II 0.91



Vulnerable Villages – Banjar Block – District Kullu

Very Low (0.00-0.20)	Low (0.21-0.40)	Moderate (0.41-0.60)	High (0.61-0.80)	Very High (0.81-0.90)	Extreme (0.91-1.00)
		Banjar (NP) 0.48	Bala Gad 0.79	Shangarh 0.90	Ratwah 0.94
			Kanon 0.76	Mashyar 0.90	Karshai Gad-II 0.93
			Shanshar 0.73	Chanon 0.90	Kalwari 0.93
				Bahu 0.90	Tandi 0.92
				Shilhi 0.89	Deotha 0.92
				Chethar 0.88	Gara Parli 0.91
				Bini 0.87	Lapah 0.91
				Palach 0.86	Rashala 0.91
				Seraj 0.86	
				Mohni 0.85	
				Khabal 0.84	
				Dusharh 0.84	
				Manyashi 0.83	
				Sehuli 0.83	
				Jauri 0.83	
				Tinder 0.82	
				Sachen 0.82	
				Thati Bir 0.82	
				Bihar 0.82	
				Kotla 0.81	
				Pakhari 0.81	
				Dhaugi 0.81	

As depicted above, all villages of three developmental blocks Naggar, Kullu & Banjar of district Kullu falling in Beas River Basin have been placed according to their corresponding vulnerability levels Extreme, Very High, High, Moderate Low & Very Low. An adaptation plan/ framework needs to be evolved in order to reduce climate change vulnerability of these villages falling in Extreme, Very High & High levels of vulnerability.

10

Analysis Report - Conclusions

10 Analysis Report - Conclusions

The task wise outcomes are given as follows:

10.1 Summary of Vulnerability Assessment at Village level

After detailed analysis of the study area using hydrological and climate change modelling we have been able to determine and identify those villages, which are vulnerable to the climate change. It is evident that change in climate is definitely going to have an impact on agriculture, horticulture, forests and water resources of vulnerable areas. Therefore, in order to reduce vulnerability there is an urgent need to apply clear-cut strategies to cope with the climate change vulnerability in these sectors both long term as well as short term.

The agriculture & horticulture is critical for food, nutritional and livelihood security of people of the district. The district Kullu has made significant progress during the past five decades or so and has become a self-sufficient district by producing various cash crops mainly apples and vegetables. However, with passage of time, it is presently facing several challenges like increase in temperature, un even distribution of rainfall/ snow fall, climate change induced diseases, stagnation in net sown area, decrease in crop yield, deterioration of soil quality, reduction in per capita land availability etc. are emerging issues.

The Forests are also playing very important role in determining the accumulation of greenhouse gases in the atmosphere; they absorb 2.6 billion tonnes of carbon dioxide each year, about one-third of the carbon dioxide released from the burning of fossil fuels. However, this great storage system also means that when forests are cut down, the impact is big. Deforestation accounts for nearly 20% of all greenhouse gas emissions — more than the world's entire transport sector. At the same time, the GHG's off setting capacity of forests is decreased as forests either illegally cut or lost gradually or not quality forests.

Forests are important for reducing impacts of climate change both present and future effects on people. For example, forest goods tend to be more climate-resilient than traditional agriculture crops and so when disasters strike or crops fail, forests act as safety nets protecting communities from losing all sources of food and income. They also regulate waterways; protect soil, temperature for an entire regions, and more.

There is a need to analyse how forest management can be improved and grow tree cover to benefit the environment and livelihoods. Our research needs to consider everything from REDD+ implementation to land-use change and wetland carbon stores, all of which contribute to our goals of effective climate change mitigation and adaptation.

As the earth's temperature continues to rise, we can expect a significant impact on our fresh water supplies regime with the potential for devastating effects on these resources. As temperatures increase, evaporation increases, sometimes resulting in droughts. In addition, rising temperatures are melting glacial ice at an unprecedented rate and are noted in this region unpresidently. Glaciers are an important source of freshwater here, and some, like those at Glacier National Park, are under critical threat of disappearing within the 21st century. Once these glaciers melt away, they can't be restored. Areas that previously depended on glaciers for freshwater will then have to seek other sources i.e. entire river system in beas basin will be affected. The relationship between climate change and water doesn't end there. The systems used to treat and move public water supplies require large amounts of energy, produced from hydropower projects are in turn under tremendous threat.

The adaptation to climate change has the potential to reduce many of its adverse impacts and may lead to enhanced benefits. The key features of climate change vulnerability and adaptation are related to variability and extremes. The limited economic resources, information and skills, poor infrastructure and insufficient levels of technology makes the blocks inadequate to adapt and highly vulnerable. Increase in adaptive capacity is necessary for reducing vulnerability to climate changes, encountered in the frequency and intensity of extreme events, like floods and droughts which have sever impacts on agriculture and livelihood of local community.

The villages of the three developmental blocks (Kullu, Naggar & Banjar), vulnerable to climate change, need intervention at policy plan and programme level with higher priority. The results are useful for stakeholders such as farmers, policy makers and technical advisors, the scientific community and traders for targeting financial resources and better management of resources towards adaptive capacity with village level analysis. The most of the areas of Beas River Basin falling in Kullu District observed to be quite vulnerable to climate change. In the Panchayats, which are highly vulnerable, policy makers are required to take immediate measures to support effective management of environmental resources (e.g., soil, vegetation and water resources); promote increased market participation, especially within the large subsistence farming sector; stimulate both agricultural intensification and diversification of livelihoods away from agriculture practices; and introduce social programs and including on health, education and welfare, which can help in maintaining and augmenting both physical and intangible human capital.

Investment is required for developing infrastructure in rural areas, and in highly exposed regions, priority is required to be accorded to the development of more accurate systems for early warning of extreme climatic events (e.g., drought or flood) apart from appropriate relief programs and financial inclusion programmes are required for both agri-horti sectors. In addition to the usefulness of the study for policy makers and stakeholders, the study is expected to act as a baseline to further improve the methodologies for assessing vulnerability of agriculture to climate change.

10.2 Vulnerability & Potential for Adaptation:

The most important factor for agriculture/ horticulture, forests & water resources is timely availability of rain and irrigation facilities. The farmers of the Kullu district are completely dependent on the rain for irrigation of farms and orchards. People residing along the banks of Beas River Basin somehow manage to irrigate their farms but farmers residing on higher altitude are dependent of rain only there is no option except rain. During summer it gets very sever, when all the natural water resources dries up. Due to the tough geographical condition, it is difficult to connect all the villages with irrigation schemes besides economic reasons.

So far as the government schemes for irrigation are concerned they are not at present available to the all farmers in the region. There are villages where the irrigation schemes were initiated but these are functional as on date and are pending for one or the other reason.

The State Government is implementing various schemes in order to improve agricultural, horticultural production, increasing forest cover and water resource management in sustainable manner various watershed programmes are being run for local communities. Proper implementation of these schemes in the district could help the farmers manage the adverse impacts of climate change and in reduction of climate change vulnerability while improving adaptive capacity of farmers. These schemes should be implemented across all sectors, regions for maximum coverage horizontally and vertically.

10.3 Indicative Priority Area/ Sector Climate Change Adaptation-Measures to Reduce Vulnerability:

10.3.1 Possible Strategies for Climate Change Adaptation – Water Sector

- Planning, development and management of water resources need to be governed by common integrated perspective considering local, regional, State and national context, having an environmentally sound basis, keeping in view the human, social and economic needs.
- Principle of equity and social justice must inform use and allocation of water.
- Good governance through transparent informed decision making is crucial to the objectives of equity, social justice and sustainability. Meaningful intensive participation, transparency and accountability should guide decision making and regulation of water resources.
- Water needs to be managed as a common pool community resource held, by the state, under public trust doctrine to achieve food security, support livelihood, and ensure equitable and sustainable development for all.
- Water is essential for sustenance of eco-system, and therefore, minimum ecological needs should be given due consideration and priority.
- Safe Water for drinking and sanitation should be considered as pre-emptive needs, followed by high priority allocation for other basic domestic needs (including needs of animals), achieving food security, supporting sustenance agriculture and minimum eco-system needs. Available water, after meeting the above needs, should be allocated in a manner to promote its conservation and efficient use.
- All the elements of the water cycle, i.e., evapo-transpiration, precipitation, runoff, river, lakes, soil moisture, and ground water, sea, etc., are interdependent and the basic hydrological unit is the river basin, which should be considered as the basic hydrological unit for planning.
- Given the limits on enhancing the availability of utilizable water resources and increased variability in supplies due to climate change, meeting the future needs will depend more on demand management, and hence, this needs to be given priority, especially through (a) evolving an agricultural system which economizes on water use and maximizes value from water, and (b) bringing in maximum efficiency in use of water and avoiding wastages/ spillages.
- The impact of climate change on water resources availability must be factored into water management related decisions. Water using activities need to be regulated keeping in mind the local geo climatic and hydrological situation.
- All data and entire information (except data of sensitive and classified nature) should be placed in public domain.
- The initial projections of the impact of climate change on water resources including the likely changes in the water availability in time and location to be targeted.
- Reassessment of basin wise water availability and demands.
- Empowerment and involvement of Panchayati Raj Institutions, urban local bodies, Water Users‘ Associations and primary stake holders in management of water resources with focus on water conservation, augmentation and harvesting.
- Promote participatory irrigation management.
- Encourage participation of NGOs in various activities related to water resources management, particularly in planning, capacity building and mass awareness.
- Involve and encourage corporate sector / industries to take up support and promote water conservation, augmentation and preservation within the industry and as part of corporate social responsibility.
- Sensitization of all Panchayat members and their functionaries on water availability.
- Promotion of water efficient techniques and technologies including (a) promotion of micro irrigation techniques such as sprinkler and drip irrigation and (b) expansion of Farmers Participatory Action Research Programme, moisture management techniques.

- Undertake Pilot projects for improvement in water use efficiency.
- Promote Water Regulatory Authorities for ensuring equitable water distribution and rational charges for water facilities.
- Promote mandatory water audit including those for drinking & irrigation.
- Adequate provision for operation & maintenance of water resources projects.
- Incentive through award for water conservation & efficient use of water.
- Incentivize use of efficient irrigation practices and fully utilize the created facilities.
- Guidelines for different uses of water e.g., irrigation, drinking, industrial etc. particularly in context of basin wise situations.

10.3.2 Possible Strategies for Climate Change Adaptation – Agriculture & Horticulture Sector Sector

- In order to increase the production of food grains, emphasis to be laid on distribution of seeds of high yielding varieties to the farmers.
- Establishment of Seed Multiplication Farms from where foundation seed to be distributed to registered farmers.
- In order to increase the production of crops, adoption of plant protection measures is of paramount importance. During each season, campaigns to be organised to fight the menace of crop disease, insects and pest etc.
- In order to maintain the fertility of the soil during each season, soil samples to be collected from the farmers field and analysed in the soil testing laboratories. Soil testing laboratories should be established in all the blocks of the district Kullu, where as mobile soil testing vans/labs ply in each panchayat in operation for testing the soil samples at site.
- The organic farming is becoming popular being suitable, environmental friendly and health concern to all concerned. Organic farming is to be promoted in each block in a systematic manner by providing trainings, laying out demonstrations, organizing fairs/ seminars to the farmers.
- Set-up vermi-composting units at every house & financial & technical assistance to the farmers is to be provided.
- Keeping in view the depleting sources of conventional fuel i.e. firewood etc., biogas plants have assumed great importance in the high hills in the Kullu district. To overcome this issue Bio-gas plants needs to be propagated.
- Sustainable use of fertilizer to increase the production to be promoted.
- Crop insurance scheme against crop loss especially due to climate change is to be provided to the farmers through financial inclusion programmes.
- In order to maintain the quality of the seeds and also ensure higher prices of seeds to the growers, Seed certification programme has to be given due emphasis.
- With the objective to safeguard the interest of the farming community the regulated markets established in different parts of the Blocks to be providing useful services to the farmers. A modernised market complex at least in each Block needs to be made functional for marketing of agricultural produce, besides construction of market yards in cluster in different Blocks.
- New farm implements/ machines are to be popularized among the farmers. Testing of new machines be carried out and popularize the small power tillers suited to hilly conditions.
- Due to topographical factors the soil is subject to splash sheet and Gully erosion resulting into degradation of the soil. Besides this there is biotic pressure on the land. To curb this menace particularly on the Agriculture lands effective soil and water conservation programme should be implemented.
- Water conservation and minor irrigation programme to be accorded priority in order to boost agriculture production.
- Harvesting of rain water and construction of tanks, ponds, check-dams and storage structures needs to be prioritized. Besides this, optimum use of water by low lifting water

devices and efficient irrigation system through sprinklers, drip irrigation are to be popularized in rural areas.

- Establishment of Farmer Product Organizations (FPO) in each block.
- Promote sustainable agriculture practices- adopting organic farming, crop rotation, reducing land degradation and soil conservation.
- Improve land management strategies used to protect the environment, boost productivity, strengthen livelihood and enhance food security among marginal sections of society.

INDICATIVE OPTIONS FOR ADAPTATION AT VILLAGE LEVEL INTERVENTION

Climate Change Adaptation measures to reduce vulnerability of rural areas of identified blocks. The indicative option for improving the adaptive capacity of different blocks based on the selected variable at village level is listed in following table:

Adaptive Capacity Indicators		**Possible intervention- Adaptation Options**					
ID	**Indicator Description**	**Extreme (0 .90-1.00)**	**Very High (0.80-0.90)**	**High (0.60-0.80)**	**Moderate (0.40-0.60)**	**Low (0.20-0.40)**	**Very Low (0-0.20)**
VI-A01	Educational Institutes	Educational institutes required. Road networks.	Educational institutes required.	Educational institutes networks. Efforts to improve quality of educational institutes	Strengthen educational institute's network. Efforts to improve quality of educational institutes.	Efforts to improve quality of educational institutes	Efforts to sustain educational networks.
VI-A02	Health Institutes	Health institutes required. Road connectivity.	Set up health dispensary.	Set up health dispensary.	Improvement in existing infrastructure. Set up health dispensary. Health camps.	Improvement in existing infrastructure. Health camps	Improvement in existing infrastructure.
VI-A03	Road Network	Develop road connectivity. Develop mobile crop collection centers.	Develop road connectivity. Develop mobile crop collection centers.	Develop road connectivity. Improve road networks. Develop mobile crop collection centers.	Built pucca all weather roads Improve road network	Built pucca all weather roads Improve road network. Improve existing roads.	Maintain road network.
VI-A04	Agricultural Credit Societies	Establishment of Agricultural Credit Societies. Develop networking with existing agri societies in block.	Establishment of Agricultural Credit Societies. Develop networking with existing agri societies in block.	Develop networking with existing agri societies in block. Improve networking with farmers.	Develop networking with existing agri societies in block. Improve networking with farmers.	Strengthen agri societies with new interventions.	Strengthen agri societies with new interventions.

Adaptive Capacity Indicators		Possible intervention- Adaptation Options					
ID	Indicator Description	Extreme (0 .90-1.00)	Very High (0.80-0.90)	High (0.60-0.80)	Moderate (0.40-0.60)	Low (0.20-0.40)	Very Low (0-0.20)
VI-A05	Self Help Group	Create Self Help Groups	Create Self Help Groups required	Strengthen Self Help Groups. Self Help Group networks.	Strengthen self help groups. Effective networking. Training on seed banking.	Improve operational domain of self help groups. Training on seed banking.	Improve operational domain of self help groups. Training on seed banking.
VI-A06 VI-A07	Mandis/ Regular Market. Agricultural Marketing Society	Develop market infra structures for day to day crops. Develop collection Centers. Develop mobile crop collection centers. Establishment of Agricultural Credit Societies. Develop networking with existing agri societies in block.	Establishment of Agricultural Credit Societies. Develop networking with existing agri societies in block. Develop on farm collection Centers. Develop mobile crop collection centers.	Develop networking with existing agri societies in block. Improve networking with farmers. Develop on farm collection Centers. Develop mobile crop collection centers.	Develop networking with existing agri societies in block. Improve networking with farmers. Develop on farm collection Centers. Develop mobile crop collection centers.	Strengthen agri societies with new interventions. Develop on farm collection Centers. Develop on farm mobile crop collection centers.	Strengthen agri societies with new interventions.
VI-A08	Hand Pump	Survey to set up hand pumps be carried out.	Survey to set up hand pumps be carried out.	Survey to set up hand pumps be carried out. Revive existing hand pumps	New hand pumps, Revive existing hand pumps	Water recharging be done. Revive existing hand pumps	Water recharging. .
VI-A9	Spring Source	Survey to explore possibility of natural water sources. Ground water recharge.	Survey to explore possibility of natural water sources. Revival / restoration of natural water sources. Ground water recharge.	Conservation of natural water sources. Ground water recharge.	Revival / restoration of natural water sources. Ground water recharge.	Conservation, Revival / restoration of natural water sources.	Conservation of natural water sources.
VI-A10	Tank/Pond/Lake	Create Tank/Pond/Lake. Built new water harvesting structure.	Create and conserve Tank/Pond/Lake. Built new water	Create and conserve Tank/Pond/Lake. Built new water	Conserve existing Tank/Pond/Lake. Effective use of water	Conserve Tank/Pond/Lake. Restore traditional	Conserve traditional ponds

Adaptive Capacity Indicators		Possible intervention- Adaptation Options					
ID	**Indicator Description**	**Extreme (0 .90-1.00)**	**Very High (0.80-0.90)**	**High (0.60-0.80)**	**Moderate (0.40-0.60)**	**Low (0.20-0.40)**	**Very Low (0-0.20)**
			harvesting structure. Restore traditional ponds.	harvesting structure. Restore traditional ponds	harvesting structure. Restore traditional ponds	ponds	
VI-A11	Irrigated Area	Survey for water sources and irrigation potential. Built Irrigation schemes. Water harvesting structures.	Built Irrigation schemes. Survey for water sources and irrigation potential. Water harvesting structures.	Built Irrigation schemes. Survey for water sources and irrigation potential. Water harvesting structures. Channelization of water. Check leakage of water. Link water ponds, water channels with farms.	Water harvesting structures. Channelization of water. Check leakage of water. Link water ponds, water channels with farms.	Water harvesting structures. Channelization of water. Check leakage of water. Link water ponds, water channels with farms. Assess irrigation potential.	Enhance irrigation coverage. Assess irrigation potential.

10.4 Framework to reduce vulnerability to Climate Change

The framework has been developed in accordance with the State Strategy and Climate Change Action Plan, This framework is intended to complement the SAPCC. It is necessary o develop strategies and plans at regional and local level. Efforts are required to identify resource management and economic opportunities that climate change may pose to these areas. This framework may help to position marginal farmers in these areas to take effective early steps to avoid potential consequences of climate change. The purpose of this framework is to:

- Identify likely future climate conditions that pose major risks for livelihood security of the marginal farmers.
- Assess the capacity of state programs to effectively address climate-related risks to marginal farmers, local communities, infrastructure, and natural resources. Identify short-term and low- or no-cost priority actions to mitigate such climate induced risks.
- Provide context and initial direction for additional coordination and planning for future climate conditions.

As per recommendations of SCCAP the state Government has initiated the process to develop strategic framework to address climate change vulnerability assessment including following:

- Determine how climate change will affect local regions.
- Support stakeholder organizations/ institutions and individuals in responding to climate change.
- Transform planning processes to deal with climate change from local level.
- Incorporate the agricultural, public health implications of climate change in to planning process.
- Continue to develop and refine a climate change research agenda for local level planning.

This framework could only act as an initial step; it by no mean completes the work needed to be fully implemented. Considerable work is required, especially in collaboration with local farmers, local governments and federal agencies, to fully address climate risks to region. In order to design the potential adaptation options it is important to indicate and scope the associated risks that may pose threat to the local communities.

The most vulnerable resources in the Beas River Basin

Resource	Drivers of vulnerability	Adaptive capacity
Natural systems		
Human resources	– The obvious impoverishment of most people, especially in rural areas, and the increasing stratification of society. – A deteriorating demographic situation caused by a negative natural increase of the population and the aging of societies against the increase in morbidity and	For its maintenance a radical revision of people residing around the Beas River better social and economic policies is needed.

Resource	Drivers of vulnerability	Adaptive capacity
	mortality. – A decline in the quality of education and its incompatibility with the contemporary needs of society and, above all, the economy. Public risks associated with extreme events.	
Water resources	– The high probability of exposure to the consequences of climate change and variability because “a river is a product of climate.” – Evident increase of variability of the Beas River runoff regime and quantity of flow, which makes more difficult their evaluation and prognosis. – Disastrous ecological conditions of small rivers, often being at risk of extinction, and reduction of their contribution to the basin's water resources. – Deterioration of surface water quality due to water temperature increase, decrease in runoff, and anthropogenic pollution. – Very likely continued decline of groundwater levels due to increased climate aridity, intense water withdrawal, and lack of the monitoring of ground water storage and quality.	Ample enough, with the anticipated maintenance or 15% increase in river flow and in the case of extending the network of water reservoirs, a competent river flow control and strict ensuring a minimum environmental runoff, as well as matching the water use with water resource availability.
Forest resources	– A likely change in species composition and wood species’ horizontal and vertical areas; the disappearance of certain species. – A very likely emergence of new diseases and pests. An ongoing unauthorized felling, often caused by high poverty levels.	Intensive afforestation is needed.
Ecosystems and wetlands	– Very likely decrease of biodiversity and the	At present is low, being in essence reduced to autonomous adaptation.

Resource	Drivers of vulnerability	Adaptive capacity
	replacement of primary successions by low-productive secondary ones. − Very likely decrease of natural habitats of indigenous species due to their drying, water quality deterioration at higher temperatures, and alien species invasion. − Likely deficit of water supply due to the priority use of Beas River water by certain "privileged" users, for example, hydropower.	
Branches of economy		
Agriculture	− A very likely increase of aridity; more frequent and intensive droughts and extreme weather phenomena (frost, heavy rains, hail, and rainless periods), especially in the middle and lower parts of the basin. − Almost complete destruction of the previous irrigation system, combined with a shortage in water resources available for irrigation. − Likely deterioration of soil fertility due to a possible increase in soil salinity, water erosion, and landslides. − Likely emergence and invasion of new plant pests and animal diseases. − Very likely further depopulation of rural areas and the declining contribution of agriculture to GDP.	Low due to reduced production, rural depopulation and rural-to-urban or abroad migration, and to destruction of large farms. The absence of public subsidies that reduces the competitiveness of domestic products on local and foreign markets and export potential. Reducing the capacity and efficiency of agricultural science.
Water supply and sanitation	− The likely falling of groundwater table and drying up of wells and springs that are main sources of water in rural area. − Lack of proper diversification of water delivery to its users. Likely shortages of available water resources and the	Low if the present economic situation will continue.

Resource	Drivers of vulnerability	Adaptive capacity
	worsening of water quality.	
Fish industry	Likely change in the fish fauna, reduction of its biodiversity, and commercial fish catches due to the disappearance or reduction of spawning grounds.	Medium in the case of the strict control of fishing and spring water releases for spawning fish.
Infrastructure	Likely deterioration due to both climate change direct effects (e.g., high summer temperatures or heavy rainfalls) and the lack of material resources to its maintaining.	Low due to the obvious lack of resources for maintenance and improvement.

10.5 Risk assessment encompassing Water & Agriculture sector:

Scoping Climate Risks

Under this assignment the initial tasks were to identify likely changes in block's climate conditions at Panchayat level and that how it has merged for the last ~ 40 years. The working team identified and worked on several indicators to identify the climate change vulnerability.

In this framework, these likely changes- vulnerability has been defined as climate risks. As the work team refined the inventory of risks, characterizing the risks to economic systems became more and more difficult. More to the point, very limited information is available on the likely economic effects of climate change in the State. Risks to GOHP's economy that were identified by the work team were really risks to other systems restated in very general economic terms. In other words, climate-related risks to GoHP's economy reflected the economic consequences of risks to natural systems, built and developed systems, public health and safety. In the end, while this framework attempted to include the economic effects of future climate conditions within its scope, there is limited information available to do so with confidence in given time. Further collaboration with economists and organizations outside government is necessary to improve the assessment of the possible or likely economic consequences of climate change on marginal farmers and the State at a whole.

Following climate risks listed below and in the table and the indicative mainstreaming options constitute the substantive foundation for the adaptation framework. Climate risks have varying degrees of likelihood; that is, not all the identified climate risks are equally likely to occur in District. The risks are listed according to likelihood levels; the three levels of Very likely, Likely, and More likely than not correspond roughly to 90 percent, 66 percent, and 60 percent confidence levels, respectively. In planning for future climate conditions, it will be important to recognize variability and uncertainty in climate risks.

Potential Consequences of Climate Risks

The team compiled a survey of likely consequences for each climate risk. Some of the consequences are summarized below. The summaries are by no means exhaustive, but rather are intended to help identify state responsibilities and programs that will likely need to prepare for and adapt to the effects of climate change.

Risks Very likely to occur	Risks Likely to occur	Risks More likely than not to occur
Increase in average annual temperatures and likelihood of extreme events. Overall, increased average temperatures will result in increased water temperatures and reduced flows in streams, which over the long term will cause shifts in aquatic habitats, species, and communities. There is serious risk that increased average air temperatures will affect water temperatures and aquatic habitats to the extent that important native species will go extinct. In main plain region low altitude areas hot air will result in increased deaths and illness among vulnerable human populations. The elderly, infants, chronically ill, low income communities, and outdoor workers are the main groups threatened by high temperatures. Higher temperatures increase the threat of human illness from both waterborne diseases and vector borne illnesses. In addition, heat waves, drought and changes in hydrology will contribute to an increase in the threat of wildfire, which will result in increased exposure of vulnerable groups, including marginal farmers. In creased temperature will lead to shift in cropping pattern, change in seed quality, with negative change in soil quality living adverse impacts on marginal farmers. Changes in hydrology and water supply; reduced snowpack and water availability in some basins; changes in water quality and timing of water availability Changes in hydrologic patterns in major river basin i.e. Beas river basin which comprises of ~ 70 % area under study with some micro watersheds will	Loss of wetland, water bodies ecosystems and services Water bodies and Wetlands play key roles in major ecological processes and provide a number of essential ecosystem services, such as flood reduction, groundwater recharge, pollution control, recreational opportunities, and fish and wildlife habitat, including for endangered species. As such, increases in air temperature and changes in hydrology will exacerbate impacts to already degraded and fragmented wetland and other water bodies- ecosystems. The consequences for losing water bodies, wetland ecosystems and their associated services will potentially affect all systems—natural, built and developed systems, public health and safety, and local economy. Examples of the effects of a loss or reduction in water bodies, wetland ecosystem services include increased flood damage to agricultural lands, and roads; increased requirement of new and expanded drinking water treatment facilities; and increased need for water storage facilities for flood control and to meet seasonal water demand. The loss of wetland ecosystems and services will have indirect consequences on a range of economic activities. Loss of water bodies that provide habitats can eventually reduce the soil quality, fertility. Loss of seasonal wetlands and water bodies will impact waterfowl and shorebird populations. Loss of wetland that provide flood protection may result in higher damage costs as a result of increased flood related damages. Loss of wetland,	Increased frequency of extreme precipitation events and incidence and magnitude of damaging floods Extreme precipitation events have the potential to cause localized flooding due partly to inadequate capacity of storm drain systems. Extreme events can damage or cause failure of even dams. Increased incidence and magnitude of flood events will increase damage to property and infrastructure, and will increase the vulnerability of areas that already experience soil changes. Areas thought to be outside the floodplain may experience flooding. Many of these areas have improvements that are not insured against flood damage, and thus floods will probably result in catastrophic property damage and losses. Finally, increased flooding will disrupt ecosystems, thereby affecting the distribution of water, agriculture, and essential services. Increased incidence of landslides Increased landslides will cause increased damage to property and infrastructure, and will disrupt transportation and the distribution of water, agriculture, and essential eco services. Widespread damaging landslides that accompany intense rainstorms and related floods occur during spring seasons, monsoon season. Particularly high-consequence events occur about every decade as reported in SCCAP.

affect supplies of water for all uses, and will contribute to increased water quality problems. Reduced availability of water will affect marginal irrigators, changed water supply planning in many micro watersheds, and affect the quality and availability of water for some public drinking water systems as well. Proposals for surface water storage may increase. Changes in the timing and quality of available water will affect aquatic, wetland, and riparian ecosystems and species, especially species that need adequate water in stream to survive and populations that are already identified as threatened or endangered. Hydrologic changes will exacerbate temperature-related water quality problems. Water users suffering the most adverse consequences will be the marginal farmers- irrigators. Irrigated agriculture is a primary economic driver in Kullu districts so without careful planning for the consequences of climate change, the agricultural economy may suffer significantly. Changes in hydrology have the potential to significantly affect agricultural productivity until crops suited to new hydrologic conditions are developed.	water bodies that purify water may result in the need for expanded or additional drinking water treatment facilities. Loss of wetland, water bodies that provide water storage may result in the need for the construction of expanded and additional infrastructure to prevent flooding and to meet summer time water demands. Increase in stream temperatures, with potential for changes in rivulets chemistry Higher temperature of water bodies will have a negative effect on some local native species and could result in dramatic changes in local ecosystems. Changes in temperature and upwelling may be positive for some species and negative for others off. If there are large increases in temperatures, there is a potential for significant restructuring of the ecological communities on the rivers basin. Population variation of many local species is likely to increase due to direct biological effects of climate change and indirect cascading ecological effects. Increased incidence of drought Longer and drier growing seasons and drought will result in increased demand on ground water resources and increased consumption of water for irrigation, which will have potential consequences for natural systems. Droughts affect wetlands, stream systems, and aquatic habitats. Drought will result in drier forests and increase likelihood of forest fires. Droughts will cause significant economic damage to the agriculture industry through reduced yields and quality of some crops. Droughts can increase irrigation-related water consumption, and thus increase irrigation costs. Drought conditions can also have a	

	significant effect on the supply of drinking water. Increased soil erosion and risk of inundation from increasing levels due to rain intensity and increasing storm intensity Increased storm, and high rain intensity levels can lead to loss of natural buffering functions of land scapes, wetlands. Accelerating soil erosion has been observed, and may require increased applications of check dams, protective structures. Soil alterations typically reduce the fertility, chocking of wetlands, and dune to adjust to new conditions. Increasing temperatures, dry conditions will increase soil erosion and likely increase damage to irrigated lands, agricultural lands and infrastructure situated on river banks. Soil erosion and the common response to reduce soil erosion can lead to long-term loss of natural buffering functions of irrigated lands and micro watersheds. Applications for soil alteration permits to protect property and such infrastructure are increasing, but in the long term they may reduce the ability of micro watershed systems to adjust to new conditions. Changes in abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife Changes in temperature and precipitation regimes will result in a gradual migration of some species and habitats north and to higher elevations. Species that cannot migrate or shift their range quickly enough to respond to climate change, or that have specific life-history needs that cannot be met through migration, will likely experience a decline in population numbers, potentially leading to extinction. Changes in temperatures and hydrology will affect aquatic, wetland, and	

	riparian ecosystems and species, especially species or population units that are already identified as threatened or endangered. Risk of damage by insect and plant pests, which can result in significant damage to native species and communities, will increase with warmer temperatures. Alterations to the species composition of native ecosystems will likely result in a decline in important ecosystem services, including water quality and quantity, carbon storage, soil stabilization, flood control, and nutrient cycling. Increase in diseases, invasive species and insect, animal and plant pests Invasive species can negatively impact native plants, fish, and wildlife in agricultural ecosystems by displacing native species, changing habitat characteristics, consuming significant amounts of water, and changing fire regimes. Invasive species have already caused damage forests, grasslands, and wetlands, and agricultural economy. Spread of infectious diseases in the some of micro watershed is occurring, with increased vulnerability to local ecosystems to existing and emerging conditions. Increase in wildfire frequency and intensity Increased temperatures, the potential for reduced precipitation in summer months, and accumulation of dry leaves, pine needles in forests due to insect and disease damage (particularly in eastside forests) present high risk for catastrophic fires. An increase in frequency and intensity of forests fire may damage larger areas, and likely cause greater ecosystem and habitat damage. Forests fires may causes crop	

	damages, human health risks due to exposure to smoke etc. Increased risk of forests fire may result in increased potential for economic damage at the urban-forest land interface. Forests fire destroy property, recreational opportunities, and ecosystem services. Some buildings and infrastructure subject to increased fire risk may not be adequately insured against losses due to fire. Increased fire danger will increase the cost to prevent, prepare for, and respond to forests fires.	

Selecting Short-Term Priority Actions

From the above climate risks one can easily look at;

1) The basic capacities of different organizations to address the identified risks; and
2) to compile a list of immediate or short-term actions that may help to improve local capacity to address the risks.

This effort is indicative primarily an initial scoping exercise. There may be many other short-term actions that may be needed to effectively address the identified risks. But given resourceand time considerations makes it paramount to limit the list of needed actions to a few relatively low-cost actions. Resources are not indicated to implement any or more than only a few of the needed actions. It thus in turn necessary to identify a limited set of top priority, short-term, low-cost actions from the list. In consultation with nodal department, stakeholders, local agencies, the team prioritized needed actions according to the benefits of each one relative to all the other actions. In selecting priority actions, the team based its assessment on a very general idea of the relative magnitude of the costs and benefits for each of the actions. In attempting to narrow its focus on low cost, high benefit actions, the team assigned high, medium, and low cost and benefit values to each action, relative to the costs and benefits of the other actions, using the following guidelines in the evaluation:

Costs

- Costs to the state: The approximate individual cost to implement the action.
- Costs to major farmers, landowners and growers: Costs to private parties and businesses associations of implementing the action.
- Costs to the public and to particular vulnerable communities, marginal farmers: All other costs to the public, including infrastructure costs and costs to local governments.

Benefits

- Higher priority actions respond to higher likelihood of risks.
- Avoided costs: Reduced losses and damage from climate conditions that will be achieved in a 10-20 year timeframe if the actions are initiated now onwards.
- Higher priority actions address the effects of more than one risks simultaneously.

More time and detailed information about the costs and likely benefits of required actions are necessary to improve the process of identifying priority actions. The present study in given time & resources, preparation of inventory of gaps and actions is by no means exhaustive, nor is it intended to be the last one in identifying climate change adaptation priorities. This framework represents a starting point and initial assessment of State capacity to deal with present and future climate risks at local level. The table as follows lists the short-term priority actions needed to improve local farmer's capacity to address the identified climate risks.

10.6 Climate Risks and Short-Term Priority Actions

<table>
<tr><th>Sr. No.</th><th colspan="2">Risk</th><th>Action</th></tr>
<tr><td rowspan="2">1.</td><td rowspan="2">Very likely to occur</td><td>Increase in average annual temperatures and likelihood of extreme events.

Hail storms</td><td>– Enhance and sustain public health system capacity to prepare for and respond to high temperatures and crop protection measures, pests attacks, air pollution incidences, and improve delivery of information on high temperatures and possible ways to deal with it, especially for isolated and vulnerable populations.
– Enhance infrastructural support to marginal farmers on drip irrigations/ precision irrigations.
– Provide high quality seeds.
– Provide support to marginal farmers to use antihail nets on at least horticulture farming.
– Enhance reach of protected cropings.</td></tr>
<tr><td>Changes in hydrology and water supply; reduced snowpack and water availability in some basins; changes in water quality and timing of water availability</td><td>– Maintain the capacity to provide assistance to local farmers to restore water bodies, wetlands, uplands and riparian zones to increase the capacity for natural water storage.
– Improve real-time forecasting of water delivery and basin yields to improve management of stored water.
– Improve capacity to provide technical assistance and incentives to increase storage capacity and to improve conservation, reuse, and water use efficiency among all consumptive water uses.
– Enhance water harvestings in micro watersheds.
– Built water storage tanks for marginal communities.
– Systematic approach for coping with floods – mapping of areas likely to experience floods, establishing hydraulic and hydrological models and developing comprehensive schemes for flood management and reservoir sedimentation.
– Crop diversification among marginal farmers.</td></tr>
<tr><td rowspan="2">2.</td><td rowspan="2">Likely to occur</td><td>Loss of water bodies, wetland ecosystems and services</td><td>– Support implementation of priority actions for Risks 2, 5, 6, 7, and 10 related to hydrologic changes, drought, soil erosion and inundation, habitats, and flooding.</td></tr>
<tr><td>Increase in water</td><td>– Increase research on the impacts of changes in</td></tr>
</table>

Sr. No.	Risk		Action
		bodies temperatures, with potential for changes in water regime/ chemistry and increased pollution loads	water temperature and regime/ chemistry river basin, micro watershed habitats and resources. – Promotion of traditional system of water conservation. – Physical sustainability of groundwater resources.
		Increased incidence of drought	– Improve capacity to provide technical assistance and incentives to increase water storage capacity to marginal farmers and to improve conservation, reuse, and water use efficiency among all consumptive water uses. – Comprehensive assessment of ground water to be made. – All over-exploited areas should be covered by recharge of ground water. – Expeditious implementation of water resources projects particularly the multipurpose projects with carry over storages benefitting drought prone and rain deficit areas – Development of guidelines for incentivizing recycling of water including wastewater.
		Increased soil erosion and risk of inundation from increasing levels due to rain intensity and increasing storm intensity	– Inventory and map micro watersheds- irrigated lands that are at risk of soil erosion or inundation, or are barriers to migration, and develop long-term state and local adaptation strategies. – High flooding zonations and potential threat zoning.
		Changes in the abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife	– Identification of ways to manage ecosystems that will improve their resilience to changes in climate conditions. – Local / native species inventory.
		Increase in diseases, invasive species, and insect, animal and plant pests	– Increase monitoring, detection and control measures for pest insects and plant and wildlife diseases. – Increase surveillance and monitoring for climate-sensitive infectious diseases to crops and humans. – Increase outreach and community education about disease and invasive species prevention measures. – Seek new means of securing resources to detect and combat diseases and invasive species. –
		Increase in forests fire frequency and intensity	– Include forest fires in planning to reduce vulnerability to natural hazards. – Restore fire-adapted ecosystems to withstand natural recurring forest fires.

Sr. No.	Risk		Action
			– Develop short- and medium-term climate change adaptation strategies for forests and other fire-prone habitats, and improve development standards to reduce exposure to fire risk at the urban-forests land interface. – Improve the capabilities of public health agencies to plan for and respond to the public health and safety risks of forest fire emergencies.
3.	More likely to occur than not	Increased frequency of extreme precipitation events and incidence and magnitude of damaging floods	– Inventory past flood conditions and define and map future flood conditions. – Improve capability to rapidly assess and repair damaged transportation infrastructure, in order to ensure rapid reopening of transportation corridors. – Soil quality checking center development.
		Increased incidence of landslides	– Develop public education and outreach on landslide risks and how to adapt to landslide risks associated with the agriculture.

10.7 Mainstreaming Adaptation- Implementation Framework

Climate variability and change will affect almost 75 % local communities residing in rural areas and nearly every important sector of these three blocks district economy in the coming decades will be under stress. Mounting and maintaining an effective response effort within State government requires coordination and collaboration among local agencies. Given the continuing long-term challenge, climate change and adaptation needs to be 'mainstreamed' in programs and operations.

The local farmers group and the inter departmental working group should be coordinated through effective framework. The District level authorities, as a steering group, should provide oversight for the coordinated implementation of the short-term priority actions and the implementation of recommendations.

Implementing the short-term priority actions shall help local community to make a start on a long-term path for improving community resilience on climate change. Implementing the priority actions initiate the process of factoring information on climate risks in policy and planning at the block, district and state level. But in case implementation of the framework is limited to just the priority actions, several important issues will remain unaddressed. The framework includes a series of recommendations related to these issues, which are not tied exclusively to any one risk.

Sr. No.	Actions	Relevance	Recommendations
1.	Identify Research Needed for Management	Just like all planning efforts, the anticipated future conditions that form the foundation for the framework involve some uncertainty. Further planning for climate change should involve continued identification of needed research to help ensure that measures being	– Compile an inventory of research needed to improve the effectiveness of adaptation measures at the state and local levels in following prioritized areas:

Sr. No.	Actions	Relevance	Recommendations
		considered are the most appropriate measures. In particular, research is needed on the potential economic costs and benefits of alternative adaptation strategies.	1. Irrigation & Public Health 2. Agriculture 3. Horticulture 4. Forests 5. Soil
2.	Monitoring for Management	Monitoring is an underappreciated element of effective resource management. District or local agencies draw on information from many sources, and may monitor a variety of conditions, to improve local level efficiencies and the management of resources. The foundation of information for managing natural resources and state infrastructure could be improved, however, and such improvements will almost invariably improve local's ability to respond to the effects of future climate conditions.	– Compile an inventory and maps of current surveillance (for crop diseases) and monitoring (for environmental conditions) efforts, and assess the feasibility of integrating different monitoring efforts into a district wide monitoring system. – Monitoring of Crop diversification and traditional seed banking management.
3.	Sectoral Program Assessments	State agencies already have some important capacities to prepare for, respond, and adapt to the effects of future climate conditions. However, the challenge that climate variability and change present to marginal farmers, local communities is that conditions are changing faster than has generally been experienced before. Therefore, it is important that local level policy, program, and permit choices in the future incorporate information about likely future climate conditions, so as to avoid policies that might have clear climate-related future costs.	– State agencies should undertake an initial broad-scale assessment to identify policy and program elements that could result in decisions that place local people, resources or infrastructure at risk such as excessive crop diversification.
4.	Integrating Economic Information into Adaptation Planning	Development of this framework has been somewhat hampered by the absence of reliable information about either 1) the economic costs of projected changes to local climate, especially over time; and 2) the likely cost to effectively respond to such changes, especially at the local level. The framework had to be developed on the basis of the estimated magnitude of costs-of both the effects of climate conditions and actions to address those effects-	– State Government should work with economists and climate adaptation specialists and existing groups or institutes with expertise in economics to compile plan to analyse the data that can be used to improve the effectiveness of planning for climate variability and change.

Sr. No.	Actions	Relevance	Recommendations
		relative to other effects and actions. It is necessary to improve the economic foundation for future adaptation planning.	
5.	Inter-departmental / organizations Coordination	Building resilience to the effects of climate change will require coordination among all levels of government, and should include non-government entities as well. The most effective adaptation strategies will be implemented at the local or regional level, but may well be a function of state or National initiatives. The private and non-profit sectors will also be actively engaged at the local, statewide, and national scale in building resilience in areas such as the economy and social welfare. Activities at all levels will need to be coordinated to assure cost effectiveness and to avoid working at cross-purposes.	– Himachal Pradesh state agencies should consult with National agencies, stakeholders, representatives of local panchayats, and the private and nonprofit sectors to identify ways to coordinate the implementation of climate adaptation initiatives.
6.	Integrating Adaptation and Mitigation Strategies	There is very little in the way of credible scientific challenge to the conclusion that much of the change in climate at the global scale is being driven by increased carbon dioxide emissions from the combustion of fossil fuels. One of the priority overarching actions of an adaptation framework should be to renew the commitment to reducing the generation of greenhouse gasses.	– Assess existing emission reduction strategies to determine how best to incorporate climate change preparedness considerations.
7.	Communications and Outreach	Given the village level exposure to the effects of climate variability and change, the somewhat unpredictable nature of some climate-related events, and the potential to make decisions that increase vulnerability to various effects of climate change, it is critical to increase communications and outreach with the public about preparing for climate change. Communication and outreach efforts to inform local communities about the likely effects of future climate conditions should include information on how individuals and marginal communities can reduce exposure to	– Improve ways to ensure effective messaging and outreach to the public related to preparing for climate change.

Sr. No.	Actions	Relevance	Recommendations
		climate-related risks, and on how individuals can become involved in community-level efforts to prepare for climate change.	

11

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Appendices

Appendix-I(a)

Questionnaire for Field Survey

1.	Name of District	
2.	Name of Block	
3.	Name of Panchayat	
4.	Name of Village	Village Code: Name:
5.	Details of Information Provider (Preferably Panchayat Representative)	Name & Address: Contact No:
6.	Average Land Holdings (in Ha.)	Total Land Holding (Ha.) Agricultural Activities (Ha.) Horticultural Activities (Ha.) Other Activities (Ha.)
7.	District Head Quarter	Name Distance
8.	Average Crop Production	Crop Type (Rabi/Kharif) / Crop Name / Production (Q/Ha.)
9.	Drought History & Impact	**Year** / **Crop Loss** 1. <50% 2. 50 - 75 % 3. > 75% / **Surface Water** 1. Adequate 2. Manageable 3. Poor / **Livestock Death** 1. > Normal 2. Normal 3. <Normal
10.	Schematic Enrolment	**Scheme** / **Enrolment (Yes/No)** *MGNREGA* *Old Age Pension* *Public Distribution System* *Crop Insurance* *Agricultural Credit* *Irrigation Source* *Other (Specify)*
11.	Local Climate/ Environment (Last 10 years)	**Temperature** *(Increase/ Decrease)* / **Rainfall** *(Increase/ Decrease)* / **Rainfall Shift** *In Time/Late/ Earlier*
12.	Problems & Coping during Drought	**Problems** / **Yes/No** / **Coping Strategy** *Food Grain Shortage* *Seeds availability* *Scope of employment* *Portable Drinking Water* *Water for livestock* *Water for irrigation*

		Other (Specify)		
13.	Government support during Drought	**Support** **Yes/No** **Benefit availed** *Debt Relief* *Free seeds* *Input subsidy* *Grain support through PDS* *Insurance Premium waiver* *Wage Employment Scope* *Emergency Feeding* *Special Financial Package* *Other (Specify)*		
14.	Farmer Produce Organization	**Available (Yes/No)** **Name** **No. of Members**		
15.	Details of Association with Self Help Group/ CBOs Other Institutions/ Organization	**No. of Members** | **Type of Product/ Activity** | **Amount Lent (In Rs.)** | **Bank Linkage (Yes/No)**		
16.	Infrastructure Facility	**Infrastructure Type** Storage & Market *Warehouse* *Cold Storage* *Market Yard (Mandi)* *Others (Specify)* Irrigation Infrastructure *Hand Pump* *Natural Spring* *River/Canal (Kulh)* *Lake/Pond/Tank* *Dug Well* *Bore Well* *Lift Irrigation Scheme* *Flow Irrigation Scheme* *Others (Specify)* Drinking Water *Drinking Water Supply Scheme* *Natural Spring* *Other (Specify)* Health Infrastructure *Hospital* *Dispensary* *Primary Health Centre*	**Nos.**	**Distance (Mtrs)**

		Community Health Centre *Anganwadi Centre* *Animal Husbandry Hospital* *Others (Specify)* <u>Educational Institution</u> *University* *College* *School* *Technical Institute* *Others (Specify)* <u>Roads</u> *National Highway* *State Highway* *District Road* *Motorable Village Road* *Foot path* *Waterways* *Other (Specify)* <u>Transportation</u> *Railways* *Government Bus Service* *Private Bus Service* *Taxi Service* *Other (Specify)* <u>Sanitation</u> *Public/Community Toilet (Male)* *Public/Community Toilet (Female)* *Toilet in House* *Sewage Treatment Plant* *Biomedical Waste Treatment Plant* *Garbage Collection/ Disposal Plant* *Other (Specify)* <u>Electricity/Energy</u> *Power Supply* *Solar Light* *Other (Specify)* <u>Commutation</u> *Landline Telephone* *Mobile Phone* *Post Office* *Internet Cafes* *Others (Specify)* <u>Broadcasting Service</u> *TV* *Radio* *Others (Specify)* <u>Financial Services</u> *Bank* *Agricultural Credit Societies* *ATMs* *Others (Specify)*		

		Industries *Large Scale Industries* *Small Scale Industries* *Handicrafts* *Handlooms* *Other (Specify)* Other Infrastructure *Public Distribution Service (Shop)* *Field Office (Horticulture Deptt.)* *Field Office (Agriculture Deptt.)* *Field Office (Animal Husbandry Deptt.)* *Agriculture & Horticulture Service Shop* *Seed Shop* *Fertilizer Shop* *Others (Specify)*		

Discussions

Measures taken during drought to save crop?

Paddy:
Wheat:
Pulses:
Vegetables:
Fruits:
Others:

What are the impacts of climate change on crop health?

Sr. No	Disease	Impacts	Measures taken

Awareness on drought proofing measures (put)

Sr. No	**Drought proofing measures**	**Fully aware**	**Have heard but not fully**	**Not aware**
1	Change in cropping pattern			
2	Judicious use of ground water			
3	Water Conservation method			
4	Rain water harvesting			
5	MGNREGA/BRGF/Watershed projects			
6	Govt alert warning on drought			
7	Others (specify)			

What are the problems faced during drought situation?

a. Social:

b. Economic:

C: Livelihood:

What are the measures taken during drought situation (last time)

a. Govt…………………

b. Own…………………….

c. NGO/CBO/Others

Is there any migration situation aroused during drought in the village? If yes then discuss it elaborately. Yes

a. How many people migrated during last drought? Approximately
b.
c. Where they have migrated and for how many days?

Women participation in watershed Committee

Total No. of member in the watershed Committee

Total No. of women in the watershed Committee

Whether this watershed committee 1. Functional 2. De-Funct

What do you suggest to tackle the drought situation? (Suggestion of the participants)

Certify that the above information is correct as per the best of my knowledge and experience.

Signature/Thumb Impression

Appendix-I(b)

Proforma to collect/update data

Sr. No.	Block/Panchayat	No. of households	Total population	Male	Female	Total S.C. Population	Male S.C.	Female S.C	Total S.T. Population	Male S.T.	Female S.T	Cultivated Area	Total Cropped Area	Horticulture Area	Total Irrigated Area	Total Agricultural Workers (Nos)	Primary	Middle	High	Sr. Sec.	Colleges	ITI Centre	B.Ed. College	Tailoring Centre	BalWariCentres	AganWariCentres	Other Professional Centre	Out of School Children (6-14 Years)	No. of Schools Without Water & Toilet Facilities	Total Literate in the village	Hospital	CHC	PHC	Dispensary	Sub centre	Private Clinic	Hospital	Dispensary	Homeopathic Dispensary	Unani Dispensary	Childern age (0-5)	Birth in Ref. Year	Death in Ref. Year Age (0-1)	Death in Ref. Year	Veterinary Dispensary	B.P.L Famlies	B.P.L. S.C Famlies	B.P.L. S.T Famlies	Population under poverty alleviation Prog.	Fair Price Shop	HH' s Purchases Food Grain through PDS	Houses Constructed for Houseless Families	No. of Houses with Toilets	Electricity Yes-1; No-2	HHS with Tap water	Water Supply Scheme Yes-1; No-2	Motorable Yes-1; No-2
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58

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