



# Integrated watershed management for a changing climate

A report, highlighting the current status  
of risks in Naugaon watershed.

September 2020



Partners for Resilience (PfR) is a global network of about 50 civil society organisations and their networks, working in hazard prone areas to strengthen people's resilience in the face of rising disaster risks.

PfR is active at grassroots, national, regional and global level.



Himalayan Action Research Centre (HARC), is an autonomous voluntary development organization, which aims to help the mountain people by working for their holistic, integrated and sustainable development based on the indigenous knowledge, cultural values, and local resources. HARC has a vast experience of working with government departments, institution and agencies of last 23 years.

### Content

Mahendra Singh Kuwar: Chief Functionary Himalayan Action Research Centre

Shivanjali: Project Manager: PfR:SP Himalayan Action Research Centre

Dushyant Mohil: Program Coordinator: PfR:SP

Harish Kukreti: Prg. Manager

### Editor

Shreeja Nair

# Table of Contents

<b>Chapter 1: Introduction.....</b>	<b>3</b>
1.1. Background .....	4
1.2. Need for integrated watershed approaches.....	8
1.3. Objectives.....	10
1.4. Methodology.....	10
<b>Chapter 2: Study Area.....</b>	<b>13</b>
2.1. Physiography.....	13
2.2. Elevations.....	14
2.3. Geology.....	14
2.4. Climate, Drainage Network and Hydrology.....	16
2.5 Soil Conditions.....	19
2.6. Conclusion.....	20
<b>Chapter 3: Hazard Analysis.....</b>	<b>21</b>
3.1. Landslides.....	23
3.2. Flooding .....	24
3.3. Climate Risks.....	25
3.4. Conclusion.....	26
<b>Chapter 4: Understanding risks.....</b>	<b>27</b>
4.1. Key factors enhancing vulnerability.....	27
4.2. Understanding Risks.....	34
<b>Chapter 5: Ecosystem Services Shared Value Assessment (ESSVA).....</b>	<b>36</b>
5.1. Introduction.....	36
5.2. Results.....	36
5.3. Conclusion.....	42
<b>Chapter 6: Problem Identification and Analysis.....</b>	<b>44</b>
<b>Chapter 7: Watershed Management – Strategies and Activities.....</b>	<b>47</b>
7.1. Capacity Building.....	47
7.2. Building trust in Government Institutions and PRIs.....	49
7.3. Building a Knowledge base.....	51
7.4. Implementing Watershed Management Activities.....	41
7.5. Conclusion.....	58
<b>Chapter 8: Way Forward.....</b>	<b>59</b>



## Chapter 1: Introduction

Watershed areas in the Himalayan ranges of the country (India) are situated in the fragile eco-systems. The changing climate coupled with unplanned development and environmental degradation, are leading to depletion of water resources in this region, increasing water mediated risk among the communities residing in the region and recurrent natural calamities.

One such watershed is the Naugaon watershed situated in Uttarkashi District of Uttarakhand, India. It is part of the of Upper catchment of Yamuna River system in the Garhwal Himalayas. The residents residing in the region and downstream are highly depended on the local streams for water and the local livelihood is highly influenced by the waterflow in the streams and the local climatic conditions. In the recent times the inhabitants in the region are facing numerous problems like drinking water crises in summers, decrease in water availability for irrigation/livestock/routine activities; exacerbating risks like landslides, forest fires, debris flow, tree falling, expansion of invasive species etc.

This report is a study on Integrated Watershed Management practices based on reducing water mediated risks undertaken by Himalayan Action Research Centre (HARC) with support from Wetlands International South Asia as part of the programme Partners for Resilience (PFR), in Naugaon Watershed.



**FIG 1: PICTURE OF NAUGAON WATERSHED AREA, UTTARAKHAND**



*The Himalayan watersheds are under constant threat of mass wasting and erosion caused by depletion of forest cover, unscientific agronomic practices, hydrologic imbalances and natural calamities.*

The watershed management approach advocated in this publication, i.e. the Integrated Risk Management (IRM) approach to reduce water mediated risks is an holistic approach for addressing complex and interconnected challenges in which Disaster Risk Reduction (DRR), Climate Change Adaptation (CCA) and Livelihood are at the core. IRM focuses on strengthening the community resilience through integrating ecosystem management & restoration and CCA into risk reduction approach into the development plans and undertaking capacity building at various levels.

The study is based on the five year intervention undertaken by HARC in Naugaon watershed area. It aims at identifying the problems and address vulnerabilities caused by degradation of the Naugaon watershed, in Uttarkashi district Uttarakhand. It carefully identifies the indicators which are often are interlinked and thereby recommends solutions focused on three elements namely – DRR, CCA and Livelihood enhancement.

Watershed management has been widely accepted as an integrated approach to environmental protection and development, addressing conservation of water, land and biodiversity resources and improvement of local livelihoods through enhanced and diversified production. HARC in Naugaon has adopted integrated watershed management in Nuagaon to address degradation in the region. The integrated watershed management approach is then mainstreamed into Gram Panchayat Development Plans and District Disaster Management Plans, based on engagement with multiple stakeholders which include the government, communities, local CSOs working together in developing plans and interventions focussed on the most vulnerable population. The approaches are mainstreamed into development plans based on a knowledge base on the watershed, which investigates vulnerabilities. Regular dialogues with the decision makers at the village, district and state level are held to promote integrated approaches for risk reduction which can wipe out development gains. Local communities are also capacitated to adopt climate smart agriculture practices and increased disaster risk awareness. The interventions encourage inclusivity and are participative in nature for increasing ownership of the communities for future sustainability.

### 1.1. Background

The state of Uttarakhand in India is well endowed with forest and water resources. It has more than 12,000 glaciers and 8 major river catchments comprising of 8 watersheds, 116 sub watersheds and 1110 Micro Watersheds<sup>1</sup>, forming headwaters for the most important rivers in India, Ganga and Yamuna.

The state has experienced rapid urban growth during last three decades. More recently, comparatively less accessible areas have also come under the process of rapid urbanization mainly owing to improved road connectivity, increase in tourist sites, economic boom and gradual shift from primary resource development practices to secondary and tertiary sectors; and due to absence of urban land use policy. In the recent times the state has also faced recurrent natural calamities like burst, landslide, extreme rainfall.<sup>2</sup>

Currently, Himalayan Ecosystems are under constant of climate risks which compounded by degradation of the fragile ecosystem by depletion of forest cover, unscientific agronomic practices, hydrologic imbalances and natural calamities.<sup>3</sup>

*Naugaon Watershed constitutes of 10 Gram Panchayats and one Nagar Panchayat with total of 1963 households.*

The ever increasing population, the need to provide a better quality of life to the people is increasing the pressure on the ecosystem<sup>4</sup>.

The fragile mountain ecosystem makes communities in the region vulnerable to risks due to remoteness by location, hence marginalisation and limited capacities to adapt to the changing climate and vulnerabilities is on rise. The impacts of climate change are wide ranging from receding glaciers and upward moving snowline, together with depleting natural resources and erratic rainfall patterns have put a stress on biodiversity and livelihoods. The increase in invasive species such as pine trees and drying up of perennial streams, illustrates the complexity of problems that the people face. The shifting in cultivating zones of apples and other horticulture crops, advancing cropping seasons have further put their livelihoods under stress.

Clearly, the climate variability and other human activities cause the greatest impact on the ecosystems and increase water mediated risks in such environments.<sup>5</sup>

To address these complex and interconnected challenges, a holistic approach to watershed is required. Naugaon watershed was identified to demonstrate the effectiveness of IRM approach for Watershed management. Integrated IRM approach entailed working on multiple integrated indicators which defined the status of the watershed with respect to water mediated risks and also help in determining future pathways and intervention.

Naugaon watershed, situated in district Uttarkashi of the state of Uttarakhand is a part of the of Yamuna River catchment in the Garhwal Himalayas. The area lies between 30044'50.668"N to 30048'2.415"N latitude and 7807'3.001"E to 7809'19.517"E, longitude, falling on the Survey of India Toposheet No 53J/1 and 53J/2 (1:50,000). The total area covered is 26.7sq.km. The area is mostly covered by the reserved forest, the rocky and barren land, cultivated area and settlements.

Naugaon watershed constitutes of 10 Gram Panchayats (Bingsi, Matiyali, Naini, Kimmi, Kwari, Kandaun, Bhatiya1, Bhatiya2, Krishna and Tunalka) and 1 Nagar Panchayat (Naugaon) with 1963 households. The total population of the region is 9359, with 67% of the families belong to OBC, 32% to Scheduled Castes and 1% to Scheduled Tribes category. Mountain springs are the primary source of water for rural households in the Himalayan region. A major proportion of drinking water supply in Uttarakhand is spring based.<sup>6</sup> Naugaon is no different. As per a survey conducted by HARC on water sources in the region over 80% of all households in Nagaon Watershed region are depended on the local springs for drinking water and other purposes. Primarily an agrarian community, there is high dependence on natural resources for their livelihood generation including stream water for irrigation, rains for cropping etc. Adding to this, the recurrent extreme events and instances of disasters are leading to further stress on the already marginalised community residing in the region.

During community interactions as part of HVCRA it was observed that the region has been observing increase in temperature, less snowfall, drying up of water springs during summers, reduction in forest cover and increasing pine trees, reduced soil fertility, increased soil erosion etc.

Demographic and livelihood profiling of the region are major indicators to be considered while determining the interventions for watershed management. This is because, most of the issues arising due to scarcity of a particular natural resource in watershed planning can be traced back to the way humans are using and changing the natural environment for their livelihood or survival. Their dependence on the existing water resources in the watershed region influences the participatory decision making process that IRM approach envisages here.



Naugaun watershed constitutes of 10 Gram Panchayats (Bingsi, Matiyali, Naini, Kimmi, Kwari, Kandaun, Bhatiya1, Bhatiya2, Krishna and Tunalka) and 1 Nagar Panchayat (Naugaun) with approx 1963 households.

The pastoralist communities in the area are Pahari and Gujjar. They are nomad and move from near villages to Bugyals (high altitude grass land for rearing of livestock) during summer months. The forest division issues permit for rearing the livestock in Mussorrie, Raipur and Kalsi forest division of Uttarakhand in winter (November-April). Natural resource in the area is scattered to different land that is



*Agriculture and livestock rearing is the primary occupation in the region making them extremely dependant on their immediate environment for livelihood sustenance. There are no other major industry in the region.*

managed by revenue and forest department. Amendments made in the forest act have limited the availability and accessibility of ecosystem services especially timber for local communities. The forest produce can only be accessed with requisite permissions from local authorities.

In Naugaun watershed, 87.91% population have permanent (Pucca) housing structures and 6.6% have semi-permanent (Semi-Pucca) while 5.72% have completely temporary structures (Kutchha). Most of the inhabitants residing in the region since generations, have their own houses ( accounting to approximately 79% of the total population). Few of the houses are built using traditional technologies and design, like wood and slate houses. But most are built of cement and bricks i.e. majority are pucca houses. The families residing in wooden houses are mostly living near the forest area and therefore face major threat to forest fires. Those with pucca houses are reside within the densely populated regions of the the watershed. These deserly populated pockets have witnessed atleast 3-4 major fire incidents in the past due to LPG cylinder burst, short circuits; and therefore face equally high threat of fire hazards.

### **Mountain livelihoods**

Agriculture and livestock rearing is the primary occupation of the communities in the region. Livestock and animal husbandry have made these communities highly dependent on their immediate environment. Changes in weather and climate has led to local population resorting to farming of seasonal vegetables, which has also aided in increasing their disposable income. These vegetables are exported to Delhi through local cooperative societies. Apart from this, farmers of Naugaun watershed are shifting to floriculture as they are able to find market for flowers. The main flowers grown by farmers in the valley are Liliun and chrysanthemum.



**FIG 3: A PANOROMIC VIEW OF AGRICULTURAL LAND IN NAUGAON**

The region doesnot have any major industry and therefore diversification of occupation still remains a serious challenge.

### **Agriculture and Cropping Pattern**

Agriculture is the main occupation of the people of Naugaun Watershed with close to 80% of the total population residing in region and are dependant on agriculture for livelihood. The agricultural activities of the area are restricted to river terrace, hill slope and intermountain valleys. Some cultivation is done on steep hill as well where terracing and tilling can't be done and the place is cleared by burning shrubs and bushes. The seeds are sown with the help of hoe. Rabi and Kharif are the main crops. Besides these, wheat, paddy, maize, madua and sawa are also being cultivated in the region. Wheat is sowed in about 78% of the total cropped area during Rabi. The production of commercial crops like potato and oil seeds too bears great significance. Pulses like Rajma (Kidney beans), Toor, Urad (Black Gram), Horse Gram (Kolth)}, millets {Mandua (Eleusinecoracana), Jhangora (Barnyard Millet), potatoes and seasonal vegetables like Beans, Tomato, Peas, Cauliflower, Pumpkin, Green vegetables, Walnut, Pear, Apples, Wild apricot etc. are also cultivated. Among fruits, apples cultivation comprises 80 per cent share in livelihood source.

### **Irrigation**

The sources of irrigation are springs locally known as gad (small streams), gadheras (small river tributaries), private gools (irrigation channels) and government canals. Nearly 81% of the cultivable land is irrigated through these sources including gools and gadheras. The spring water that flows through the gads and gadheras is diverted to small canals and gul, but due to drying up of water streams these channels also receive less water and hence affect the water availability to fields/farms. Insufficient water also affects the overall soil health which is leading to decreased quality crop production and environmental degradation on other side.

### **Animal Husbandry**

Animal Husbandry is an important source of supplementing income of rural population. According to district statistics most are bovine, among them buffaloes, sheep, goats, mules, horses and ponies. There are also poultry birds. Sheep rearing is an important industry in the district and all efforts have been made to improve the production of wool.

### **1.2. Need for integrated watershed approaches**

Communities in Naugaon are dependent on natural resources of the watershed like the natural spring water for domestic and livelihood needs like drinking water and irrigation. Over last few years, this dependency has led to exploitation especially for domestic use and for agriculture, the effects of which have turned around to cause increased stress to the people in the region. Even with abundant fresh water resources, the villages in the region have been facing severe water crises since last decade.

Springs are a vital component of the ecosystem that provide essential services to people and landscape. In Naugaun watershed, over 80 percent of the households are completely dependent on the springs for drinking water purposes. Decrease in the water flow of streams and even instances of a few streams drying up, has a significant impact on the lives of the people in the region. Further, the increasing temperatures, change in rainfall pattern, decrease soil fertility and decrease in access to water from spring for irrigation has severely impacted

*From drinking water shortage, overall decrease in water availability for irrigation/livestock, poor quality of water in monsoons, recurrent landslides, forest fires, debris flow, deforestation etc. the problems for inhabitants of Naugaon have kept compounding year after year.*



*The IRM based watershed management plan for Naugaon was a three pronged approach whereby activities were undertaken in the ambit of 3 clusters – Engagement with policy & decision making at different levels, Capacity Building and Knowledge & Evidence Building*

the income from existing livelihoods. The problems regarding the encroachment of water sources and overexploitation of watershed services by people living upstream have led to scarcity of drinking water downstream as well.

From drinking water shortage, overall decrease in water availability for irrigation/livestock/routine activities; poor quality of water in monsoons, recurrent landslides, forest fires, debris flow, deforestation etc. the problems for inhabitants of the region have kept compounding year after year.

A closer analysis by HARC based on GIS mapping tools, participatory analysis, Baseline assessments etc., it was concluded that the roots of these problems in the region can be attributed to the following:

- Rapid population growth
- Degradation of natural resources due to overdependency and use
- Limited knowledge of climate smart agriculture practices;
- Limited capacities of communities to manage risks
- Very little ownership to undertake watershed management actions on their own
- Limited awareness of DRR, CCA and EMP
- Unscientific development



FIG 4 : MAIN TRANSPORT ROAD IN NAUGAON



### 1.3. Objectives

Effective watershed management primarily depends on sustained political commitment and investment. It includes actions at the national, subnational and local levels. As the changes due to climate and the increase in weather related . Strong evidence from field experiences and implementation-oriented research is needed to influence policy dialogue, decision-making and investment priorities at the District level.

Since 1960s, many soil conservation and watershed development projects have been undertaken in the world under diverse agro-climatic conditions. These projects usually aimed at reducing soil erosion and preventing land degradation besides increasing crop and biomass productivity. However, while evaluating these projects, during and post project periods, it was observed that no concrete conclusions could be drawn, mainly due to non-availability of tools and techniques for effective monitoring of project outcomes and impacts.

The challenge is not only to evaluate the performance of any project in terms of inputs and outputs delivery, but to assess the added-value of an integrated project approach, which hinges on the interactions and synergies among the institutional, social, economic and technical driving forces to reverse or prevent a trend in soil and environmental degradation of a specific watershed

Since objectives often relate to both physical factors, such as erosion and hydrological status, and socio- economic and sustainability factors, including local institution development, capacity building, participation rates, financial performance and resource leveraging, a wide range of direct or proxy indicators need to be established. Further, continuous improvement in project performance requires identification of even more effective indicators to take the informed decisions.

Combining scientific monitoring of complex interactions with participatory monitoring of some easy-to measure biophysical parameters in watersheds by local communities is a more promising approach

Given the understanding of a watershed as a socio-ecological system and the definition of watershed management as an iterative collaborative process, a system is needed that monitors the environmental and institutional processes taking place in the watershed.

Objectives of the programme

- PRIs and Municipal Corporation integrate watershed management as a risk reduction measure in GPDs and Nagar Panchayat Plan.
- Watershed conservation actions by government and CSOs are guided by interventions based on integrated risk management.
- A knowledge base on watershed is generated to support integrated watershed management and linking with District Disaster Management Plan.

### 1.4. Methodology

In brief, the tools adopted in the study were: Participatory Hazard Vulnerability Assessment (HVCRA) using transect walk and FGDs; assessment of landscape features using GIS and a perceptual mapping of ecosystem services using the ecosystem services shared value assessment (ESSVA) tool, NDVI, NDWI. Other needs assessment were evaluated using consultative meetings .

*Tools adopted in the study included HVCRA, GIS mapping, NDVI, NDWI, ESSV etc.*

*Based on maps and reports interventions were defined and recommended to be implemented as part of the development plans.*

#### **1.4.1. Pre-field Interpretation**

The process was initiated with a thorough ground assessment of the region using varying tools including consultative meetings with community members and authorities, study of existing secondary data and . The secondary data related to demography and the physical, environmental and economic development and natural resources and environmental services were collected from the concerned municipality and Village offices. The collected information/data were compiled and reviewed. Various base maps generated using Survey of India Toposheet and satellite data on 1:50,000 scale were studied. Then some of the thematic layers like, base map (containing the road, major settlements, major drainages etc.), lithology map, geomorphology, land use/land cover, fault and lineament maps were prepared.

Regular consultations were held with community members and authorities to understand needs and aspirations. Existing development plans were studied to understand the current situation and design intervention based on the needs.

#### **1.4.2. Developing Maps**

GIS based bivariate statistical hazard susceptibility assessment was considered in the evaluation of terrain conditions under which landslides have occurred in the past and those specific terrain conditions have been used to statistically predict the landslide hazard susceptibility zones. The RS and GIS software used for this work were Arc MAP and ILWIS (Integrated Land and Water Information System) 3.3 Version. The details of each slide area were collected, which involved locations details, mode of failure, type of material, geological formation, prime causative factors and losses occurred by the landslides. Remote sensing techniques have been used for demarcation of landslides. All the layers were scanned and Geo referenced according to the specifications desired for the area i.e. Projection system UTM, datum and spheroid-Everest. Drainage and relief information has been taken from topographical maps. The maps were mosaic to prepare the theme layer for the entire area. From the mosaic relief map DEM was prepared for the area and subsequently Slope and Aspect map was generated.

HARC also developed NDVI and NDWI maps for assessing the of land degradation, ascertaining productivity of a region and water stress in the region.

#### **1.4.3. Field Work**

A field survey was carried out to demarcate the landslide location in the study area and to verify the marked landslide from SOI and satellite data. The landslide location marked on the maps by using GPS. Emphasis was given to collect data regarding the lithology, the trend of the bedding and joints present, the slope and aspect of the location point, the land use/land cover, geomorphology, vegetation cover, presence of any anthropogenic factor such as road cutting, mining, quarrying etc. if any. The theme layers prepared before field work were validated with the actual ground truth and modified as necessitated. A frequent field visit was made in the study area to validate the generated information.

Hazard, Vulnerability and Capacities Assessments (HVCA) were undertaken through focus group discussions, meetings and consultative workshops. Dialogues were carried out to identify the issues, problems and their causes and consequences. The assessments were carried at household level and stakeholder specific interactions in form of consultative meetings were undertaken. The interviews with key informants were carried out separately. For Ecosystem Services Shared Value Assessment (ESSVA) interviews were undertaken to assess the community's perceptions, preferences and attitudes for ecosystem services of Naugaon Watershed.

#### 1.4.4. Post- Field Interpretation and Analysis

The household survey data and information were firstly compiled and checked. Field surveys were carried out to check the final thematic information derived. The inputs obtained from field verifications on base map, land use change map and other thematic maps were entered into the GIS and the final maps were acquired on respective themes. Every thematic map has validated in the field verification, those map has found some correction that map also remark during field visit, with the actual ground truth and modified as necessitated.

Similary, the inputs received from focussed group discussions, indivisual meetings and consultative wokshops were compiled and experts were engaged to interpret results based on the respective tools used.

Stakeholder consultation meetings were carried out on the discussions of inception and progress reports. The inputs obtained from the discussions were incorporated into the report . In case of maps With the help of field data the maps were corrected and modified.

#### 1.4.5. Result Generation

Thematic layers were converted to grid to enable raster based operation which is critical for integration. These grids were integrated based on the index overlay method to generate a final output map. These maps included DEM, NDVI, NDWI, Landslide zonation maps etc. Additonally, reports such as Risk profile reports, village wise HVCA reports, ESSVA reports etc. were prepared. Based on the maps and reports interventions were defined and reccomended to be implemented as part of the development plans. The process also entailed determing the existing capacities of various stakeholders and designing capacity building programmes accordingly.



FIG 5: HVCRA ACTIVITY IN PROGRESS



## Chapter 2: Study Area

This chapter deals with the study area mainly in two aspects: bio-physical profiles and socio-economic profile of Naugaon watershed. Physiography, geology, climate, drainage, hydrology and vegetation of the study area are highlighted in this chapter.

### 2.1. Physiography

*Naugaon watershed is extremely vulnerable to natural calamities by virtue of its geographical setting and complex development dynamics.*

Naugaon Watershed falls in the Naugaon Block of Uttarkashi district, Uttarakhand State. The study areas lies between 30044'50.668"N to 30048'2.415"N latitude and 7807'3.001"E to 7809'19.517"E, longitude, falling on the Survey of India Toposheet No 53J/1 and 53J/2 (1:50,000). The total area covered is 26.7sq.km. The watershed lies in the upper catchment part of River Yamuna in the Garhwal Himalayas. The area is mostly covered by the reserved forest, the rocky and barren land, cultivated area and settlements.

Naugaon watershed constitutes of 10 Gram Panchayats (Bingsi, Matiyali, Naini, Kimmi, Kwari, Kandaun, Bhatiya1, Bhatiya2, Krishna and Tunalka) and 1 Nagar Panchayat (Naugaon) with approx 1963 households. In fact it was during HARC's project intervention period in Naugaon that Naugaon Nagar panchayat was formed. It is thereby now identified it as peri-urban area (from a rural structure previously) in administrative lens. The area witnessed significant and rapid urbanisation during the project period.

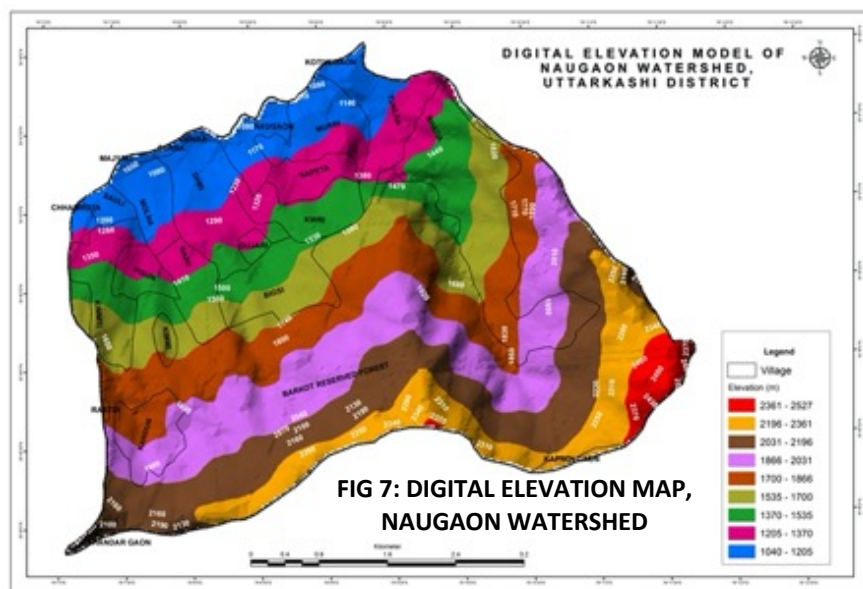
Naugaon watershed region is extremely vulnerable to disaster by virtue of its geographical setting and complex development dynamics. Landslides, forest fires, cloudbursts and flash-floods occur almost every year between April and August.



FIG 6: LANDSCAPE VIEW OF NAUGAON

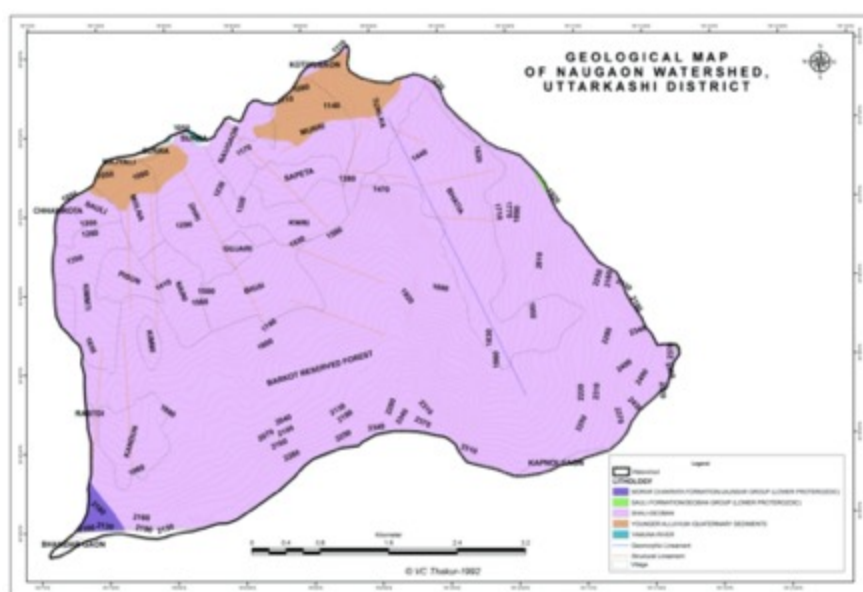
## 2.2. Elevation

The Digital Elevation Model (DEM) is an excellent source to derive topographic attributes determining drainage flow patterns, slope, relative relief and aspect data layers. Slope angle is one of the key factors in inducing slope instability. Digital elevation model (DEM) is indispensable for many analyses such as topographic feature extraction, runoff analysis, landslide susceptibility analysis etc. Minimum elevation of the study area is 1040m and maximum elevation is 2527m.



## 2.3. Geology

Geology, plays an important role in shaping the ground water scenario of an area. To identify major problems in the region leading to degradation of watershed, it is imperative to know the geology of the area. The basic geologic information is related to erosion and sedimentation<sup>7</sup>. Rock types, depth of weathering, structures, are other factors that were considered during the study.





In case of Uttarakhand state, the geology of the area is highly complex, since the rock formations have undergone repeated tectonic activities.<sup>8</sup> The geology, of the area, is explained with the help of super sequences, which are based on the chronology of the group of rocks.

For Naugaun, this super sequence, in Lesser Himalaya, is represented by two groups, viz. the older Jaunsar Group and the younger Dudatoli Group. The rocks of Jaunsar group are continuously exposed in the outer Lesser Himalaya from the Tons Valley in the west to eastern boundary of the district and beyond. It is divided into three formations, viz. Mandhali, Chandpur and Nagthat. The main rock types of Jaunsar Group are quartzite, slate, phyllite, siltstone, greywacke and sandstone. The area was reshaped by repeated tectonic activities, which gave rise to the development of folds, faults and joints.<sup>9</sup> These structures helped developing the secondary porosity and permeability. This paved path for groundwater movement. Thier occurrence in combination with the favourable topography aids in water table formation. Owing to this the occurrence of springs is a common phenomenon in the entire district of Uttarkashi.

The topography in Naugaon is highly undulating and geological formations are moderately to steeply dipping. Due to frequent undulations of high magnitude a continuous water table doesn't exist. Wherever, permeable formation overlies an impermeable one, the water table exists; its extension depends upon the distribution of the aquifer forming rocks and topography. The moving groundwater surfaces out as springs at the contact of different rock types and through joints/fractures etc. The topographic breaks also are the favourable location for spring formations.



FIG 9: A SENSITIVE ZONE IN THE NAUGAON WATERSHED



*It was found that water discharge rate of 18 out of 31 streams has gone down leading to lesser water level in 3 perennial streams that creates water crisis and puts community's livelihood activities on hold.*

## 2.4. Climate, Drainage Network and Hydrology

### 2.4.1. Climate & Rainfall

Naugaon's climate is classified as warm and temperate. The summers are much rainier than the winters in Naugaon. The average annual temperature is 19.7° C here. The temperatures are highest on average in June, at around 26.9° C. The lowest average temperatures in the year occur in January, when it is around 10.7° C.

The climate in this region is mainly governed by monsoon. The average annual rainfall is 1931 mm. The altitude of this valley extends from 1040m to 2527m (seasonal snow covered area). The high peaks are more than 2527 m, in this catchment area. The climate varies from Sub-tropical monsoon type (mild winter, hot summer) to tropical upland type (mild & dry winter, short mild summer). The northern part of the district is perennially under snow cover. Here the climate is sub-arctic type as the area is represented by lofty Himalayan Range. The district is represented by mainly four seasons viz. the cold winter season, (December to February), the hot weather season (March to May), southwest monsoon season (June to September) followed by post monsoon season (October to November). Rainfall, spatially, is highly variable depending upon the altitude. Larger part of the district is situated on the southern slopes of the outer Himalayas, monsoon currents can penetrate through trenched valleys, and the rainfall reaches its maximal in the monsoon season. About 75% of rain occurs in this zone during the monsoon season. August is the wettest month. Rainfall rapidly decreases after September and it is minimum in November. About 17% of the annual precipitation occurs in four winter months. The winter precipitation is in association with the passage of the western disturbances and is mostly in the form of snowfall, particularly at higher elevations. The precipitation during the pre-monsoon month, which is about 7% of the annual total and the post-monsoon months, is frequently associated with thunderstorms.

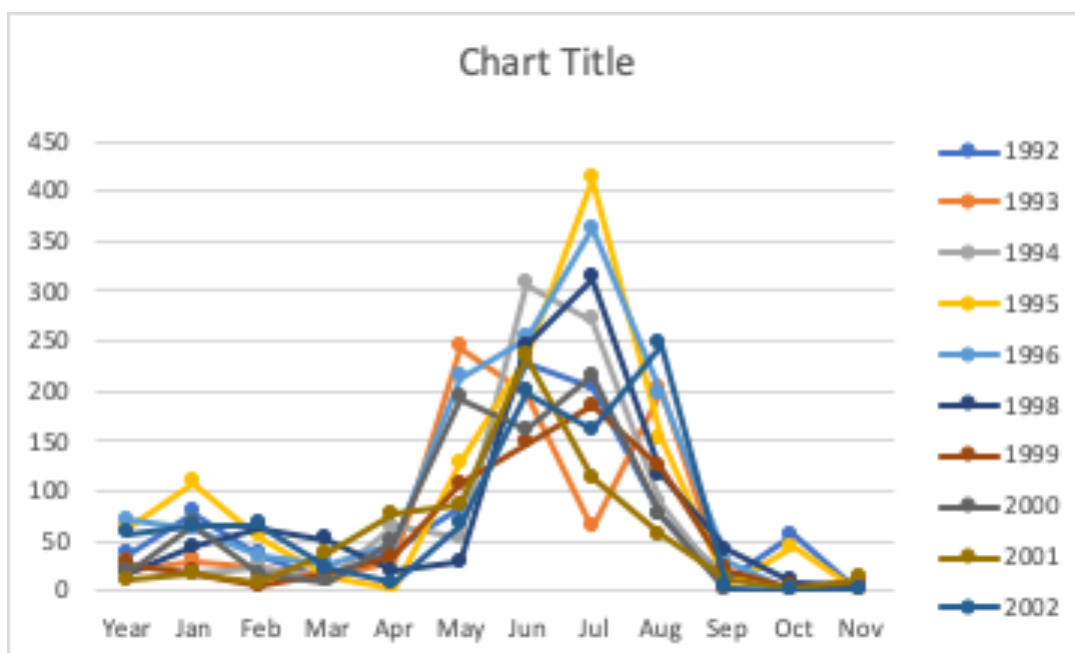


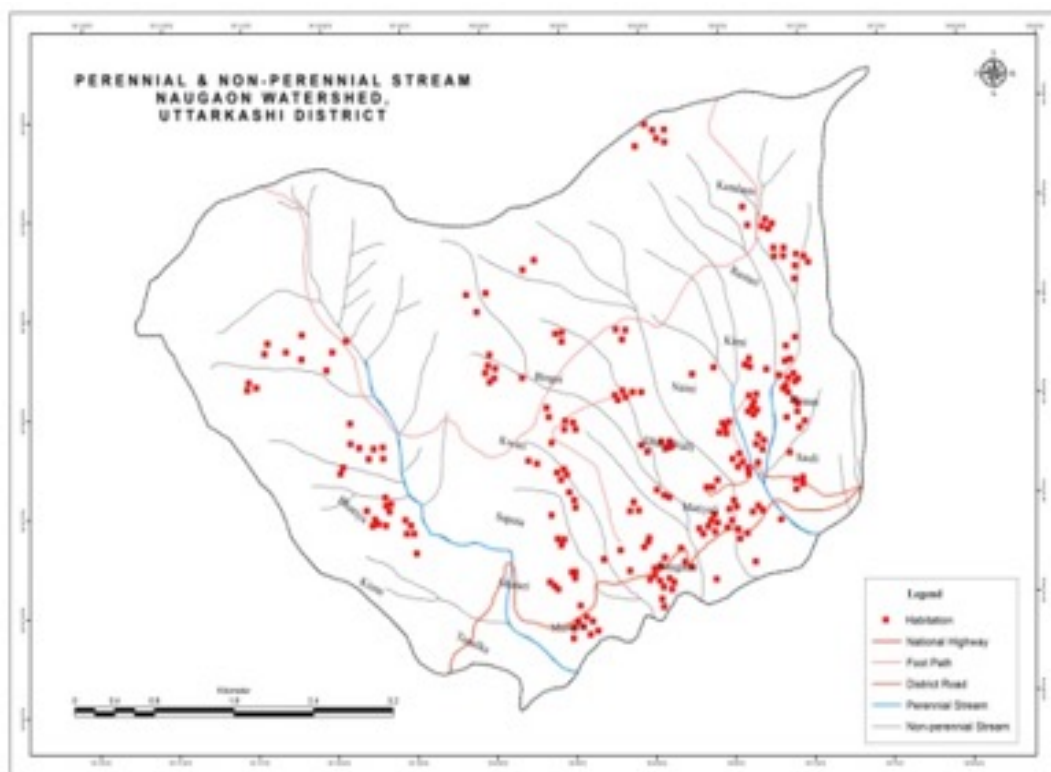
FIG 10: MONTHLY MEAN FIGURES FOR PRECIPITATION FOR UTTARKASHI DISTRICT (FROM 1992 TO 2002)

Source: [http://www.indiawaterportal.org/met\\_data/](http://www.indiawaterportal.org/met_data/)

#### 2.4.2. Drainage

The drainage density is an important indicator of the linear scale of landforms element in stream eroded topography and defines as the total length of stream of all orders/drainage area and may be an expression of the closeness of spacing of channels. The knowledge of drainage characteristics is an important pre-requisite to evaluate watershed hydrology. The significance of drainage density is recognized as an element determining the time travelled by water. The low drainage density is favoured in regions of highly permeable subsoil material, under dense vegetative cover where the relief is low.

The drainage of the study area digitized from Survey of India (1962-63) toposheets i.e. 53J /14, No 53J/1 and 53J/2 (1:50,000) is depicted above. The streams within a drainage basin form certain patterns, depending on the slope of land, underlying rock structure as well as the climatic conditions of the area. Most of drainage comprises of dendritic. The dendritic pattern develops where the river channel follows the slope of the terrain. The streams with it are tributaries which resemble the branches of a tree, thus the name dendritic. Generally the drainage is controlled by underlying rocks and their structures. The significance of drainage density is recognized as an element determining the time travelled by water. The low drainage density is favoured in regions of highly permeable subsoil material, under dense vegetative cover where the relief is low and high drainage density is favoured in regions of weak or impermeable sub-surface materials, sparse vegetation and high mountain relief.



**FIG 11: MAP DEPICTING PERENNIAL AND NON- PERENNIAL STREAMS IN NAUGAON WATERSHED**



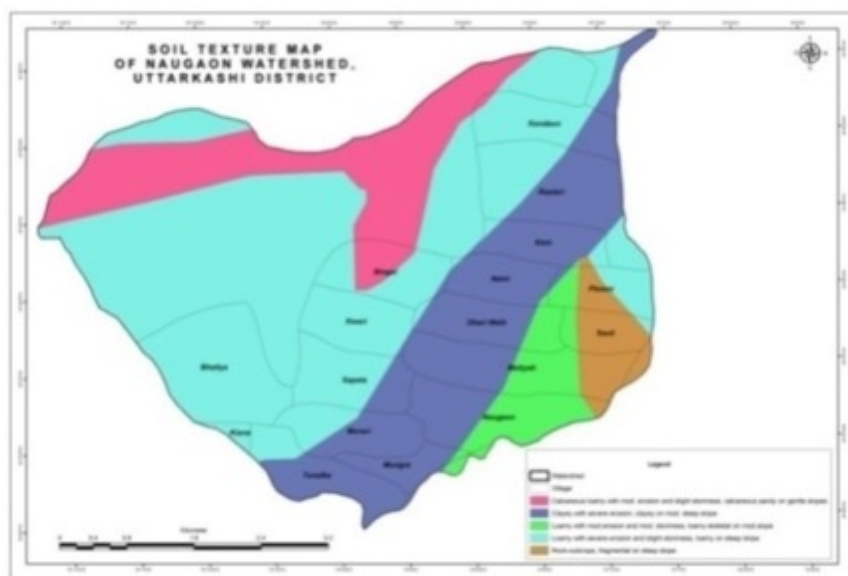
*The soil in Naugaon was fertile & known for their high yield. However, years of commercial farming, lack of sufficient knowledge on appropriate practices, least consideration to maintaining soil health and aggravated soil erosion has brought about severe harm to the quality of the soil and degraded them nutritionally.*

## 2.5. Soil Conditions

The type of soil which are found in Naugaon watershed are gravel sand, sandy loam, clayey loam, heavy clay and calcareous soil. They differ in color and texture according to locality altitude and the composition of subsoil rocks. The largest area of watershed that lies at steep slope is covered by loamy soil. Both reserve forest and agricultural and of watershed along with some pockets of village land are at gentle slope have calcareous soil having sandy properties.

Soils with texture of clay could be seen in agricultural land of 7 villages that is erodible. A smaller area of watershed is covered with loamy soil but it is loamy skeletal on mod slope, and very less part is covered by rock outcrops soil which is fragmented on steep slopes of watershed.

Out of 17 villages, 14 are well drained and 3 villages are excessive drained. Well drained villages depicts that water keeps on removing from the soil readily but not rapidly and also that water should be available to plants in most of the growing seasons. On the contrary, the excessively drained Gram Panchayats indicate that water from the soil is removed rapidly and soil is commonly coarse structured and have very high hydraulic conductivity or is shallow.



**FIG 13: SOIL TEXTURE MAP OF NAUGOAN WATERSHED**

The soil in Naugaon was fertile and known for their high yield. However, years of commercial farming, lack of sufficient knowledge on appropriate practices, least consideration to maintaining soil health and aggravated soil erosion has brought about severe harm to the quality of the soil and degraded them nutritionally. Further practicing of the 'Banjara System' i.e. multi cropping system unfit to the region, also severely impacted the soil health. These interplay of various factors has major bearing on the security of food & livelihood of the communities in the region. The health of soil here has degraded over the years.



Owing to its topography and geology the area remains is highly fragile and sensitive to even minor changes in its environment.



**FIG 14: SOIL DRAINAGE MAP OF NAUGAON WATERSHED**

## 2.6. Conclusions

The communities of Naugaon watershed since past few years now have been facing the changing local weather effects indicated by changed seasons/weather patterns, decreased farm production, increase in particular type of vegetation etc. People are highly dependent on these ecosystem services and majorly on water which is lifeline for every individual. The area lays in rainfed zone hence any change in precipitation affects the availability of water component in various meteorological process which ultimately affecting the ecosystem, and somehow putting risks because of excess or limitations of water in different forms. Owing to its topography and geology the area remains is highly fragile and sensitive to even minor changes in its environment.



**FIG 15: A LANDSLIDE PRONE AREA IN NAUGAON WATERSHED**

## CHAPTER 3: HAZARD ANALYSIS

Being a part of the Uttarkashi district Naugaon is extremely vulnerable to natural calamities. According to the Uttarkashi District Disaster Management plan (DDMP), owing to its location, the district is highly prone to risks such as earthquake, landslides, and floods. The district has the Main Central Thrust (MCT) and the main boundary thrust (MBT) passing through it. Most parts of the district falls in Zone V of the Seismic Zoning Map of India.

The recurring disasters in the region are an affirmation to its vulnerability. From earthquakes to flash floods and landslides, the district has a long and devastating list of disasters and the losses. A closer look at the history of damage suffered by the district due to natural calamities as mentioned in the DDMP is as under:

**Table 3:** Record of disasters in Uttarkashi

DATE	LOCATION	DESCRIPTION OF LOSS	TYPE
1971	Kanauldia Gad	A major landslide on the bank of the Kanauldia gad, a tributary of the Bhagirathi river upstream from Uttarkashi formed a debris cone which impounded water to a height of 30 m. Its breaching caused flash floods downstream.	Flood
Aug 1978	Uttarkashi	The Kanauldia Gad, a tributary joining the Bhagirathi river upstream from Uttarkashi in the Uttarakhand formed a debris cone across the main river, impounding breaching caused flash floods, creating havoc. A the river to a height of 30 m. Its 1.5 km long and 20 m deep lake was left behind as a result of the partial failure of the landslide dam.	Flood
October 1991	Uttarkashi	768 people died, 4 Lakh people affected and 1819 villages were affected, an estimated population of 4.22 lakhs was directly affected and About 90,000 houses were damaged.	Earthquake
Dec 1991	Uttarkashi	Three People died	Flood
Sep 2003	Varunavat Parvat, Uttarkashi	Incessant rains triggered massive landslide in the area, causing the burial of numerous buildings, hotels, and government offices located at the foot of the hill slopes	Hydro meteorological disaster causes landslide
03Aug 2012	Asi Ganga Valley, Uttarkashi	The worst affected areas were Gangotri, Sangam, Chatti and Bhatwari. About 7,389 people from 1,159 families in 85 villages were affected. Nearly 28 people were killed in flash floods and landslides.	Flood
16-17 June 2013	Bageshwar, Chamoli, Pithoragarh, Rudraprayag & Uttarkashi	Flash flood induced landslide. 68026 people died, and 4,117 missing. Huge devastation to infrastructures and other properties mainly in 5 districts of Uttarakhand	Cloudburst induced flood & Landslide

These natural calamities in Uttarkashi is attributed to its tectonic activity, lithological, structural and ecological settings, topography and changing landscapes owing to various natural and human induced activities. Being a part of the this region, Naugaon too experiences the same fate as the district.

Natural hazards like earthquake, landslides, cloudbursts, flash floods, floods, lightening and forest fires are frequent in Naugaon causing loss of lives and property from time to time. As per the Hazard, Vulnerability and Capacities Assessments (HVCA) undertaken by HARC in Naugaon, since 2010 Naugaon watershed has witnessed five cloudburst events followed by heavy rainfall and thunderstorms, which damaged water resources, soil bunds, crops (agriculture/horticulture), road connectivity and death of many livestock.; 41% of people believe that hazards are climate induced, 32% perceived them as human induced where unplanned development told as the major reason, and 27% as natural process.

Most of the people in the region attribute this to spurt of development oriented activities which are happening in the region, like construction of roads, buildings, houses etc. The side effects of these activities seems to have amplified the intensity of naturally occurring disasters and their impacts.

Mountain environments are generally “fragile” and extremely vulnerable to numerous factors including deforestation, overgrazing by livestock, cultivation on marginal soils and progression of urbanization etc. These can result in:

1. A rapid degradation of biodiversity and water resources
2. Increase in temperature and shorter cold season are evident in the area now.

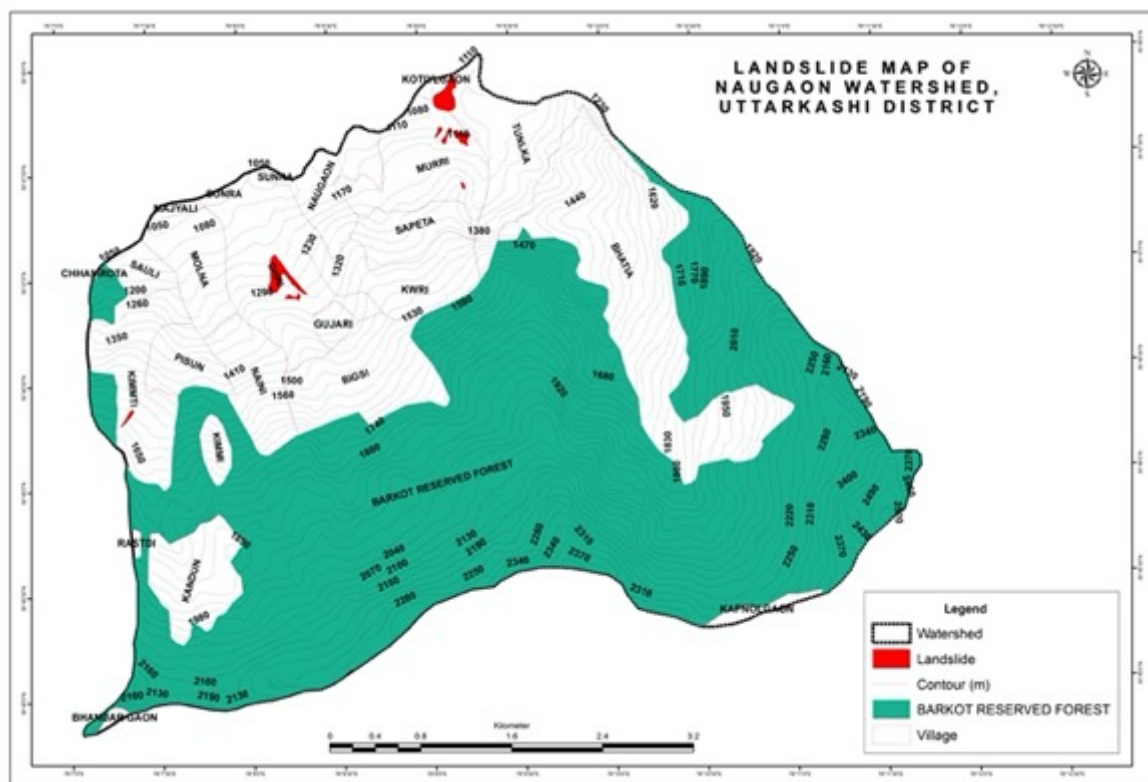
Untimely heavy rainfall resulting to mass debris movement enhances the slope destabilization in the area an increase in natural hazards, hence putting adjacent populations at risk.

The monsoon months starting May to September is infamous for the array of disaster events. Following chart depicts the a typical seasonality of hazards in the Naugaon region through a year.

<b>Table 4: Seasonality of hazards in Naugaon through a year</b>												
<b>Hazards</b>	<b>Months</b>											
	<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>Jun</b>	<b>Jul</b>	<b>Aug</b>	<b>Sep</b>	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>
Cloudburst												
Hailstorm												
Forest Fire												
Heavy Rainfall												
Thunderstorm/ Lightening												
Landslides												

### 3.1. Landslides

During monsoons season, landslides and slope failures are a common phenomenon in Uttarkashi district as a whole. Owing to its geographical location, it is extremely vulnerable to landslides. However, the intensity and impact of landslides in the recent years has increased many folds, leading to extensive loss of lives and property, damage to infrastructure like roads and buildings, destruction of agriculture and ecosystems etc. in the region.



**FIG 21: LANDSLIDE MAP OF NAUGAON WATERSHED**

*HARC developed a Landslide Hazard Zonation (LHZ) map of Naugaon using rating method of each parameter like slope, aspect, lithology, structure (confirmed thrusts, faults), lineaments density, land use and land cover, drainage density, drainage, drainage buffers digital elevation model, contour, recharge structure, Geomorphology, Village, agroclimatic zone and anthropogenic factors*

Naugaon watershed too has been experiencing washing off of agriculture land, soil erosion, landslides debris movement. Various villages in watershed are connected by an alternative route to Naugaon market; the route lies in the landslide fault zone which is short and becomes slippery and untradeable even after light rain showers. The route is mostly used by animal keeper/shepherds for logistics purpose. Human settlements with other infrastructures like primary schools in the area are situated in these fault zones which are threat to lives and assets of Naugaon watershed community.

As a possible solution to reducing extreme landslide disaster event, is to identify the landslide vulnerable areas in the region and ensure that the development plans for the region are prepared with thorough consideration to these vulnerable areas. For example, construction of building in high landslide prone areas must be strictly prohibited and foresting and increasing vegetation schemes should be implemented in such zones. A collective action at village level based on these insights can aid in reducing instances of disastrous landslide.



HARC developed a Landslide Hazard Zonation (LHZ) map of Naugaon using rating method of each parameter like slope, aspect, lithology, structure (confirmed thrusts, faults), lineaments density, land use and land cover, drainage density, drainage, drainage buffers digital elevation model, contour, recharge structure, Geomorphology, Village, agroclimatic zone and anthropogenic factors like distance to road that are associated with landslide activity. The corresponding thematic layers were then generated using remote sensing and GIS techniques. Then using the weightage rating system, a landslide hazard zonation map of the area was prepared. Each class within a thematic layer was assigned an ordinal rating from 1 to 9. Summation of these attribute values was then multiplied by the corresponding weights to yield different zones of landslide hazard. A landslide hazard zonation map having five different zones ranging from very low hazard zone to very high hazard zone was prepared with the objective to create a reliable database for pre and post-disaster management and for planning developmental activities in the watershed.

[illegible]

**FIG 22: HAZARD MAP OF NAUGAON WATERSHED**

### 3.2. Flooding

Increased intensity of rainfall, in the recent years, especially during the monsoon period, leads to a flood like situation in the region and significant erosion of soil from the watershed. This increased soil erosion reduce the carrying capacity of the rivers. The water crises situation in the Naugaon is obvious result of this. Yet another major issue caused by floods in Naugaon is loss of crops. Naugaon watershed is primarily an agrarian economy. Floods lead to significant loss of crops in the region, further impacting the livelihoods of inhabitants and overall food and socio-economic security.

In July 2010, Naugaon experienced floods which resulted in water logging conditions for a long duration and also rendered the kutchi internal road non-viable for commute. Although no human or livestock loss was reported, but during FGDs and community meetings, it came to light that a few kothars and alternative short route to the market had suffered damaged and had to be rebuilt. Villagers complained that every year they experience water logging in fields and mudflows due to heavy rainfall in months May and August, thereby disrupting their daily activities.

*Increased intensity of rainfall, in the recent years, especially during the monsoon period, leads to a flood like situation in the region and significant erosion of soil from the watershed.*

On the basis of past records for 2010, 2011 and 2013, events were recorded in the Matiyali, Bingsi, Kimmi and Naugaun, which reported incidences of debris fall and landslides. It was observed that these incidences had been on rise during monsoon seasons. Many a times, they damaged the existing infrastructure like houses, shops and animal sheds and road to the market. Along with infrastructure, there was huge damage to crops like vegetables and other horticulture crops due to which people had to bear economic losses and this affected their purchasing power and had indirect impact on their lives and health conditions.

The developmental activities in the region especially with regard to livelihoods and water conservation must be conceptualised keeping in mind these flooding situations and ways to handle them, without posing any further threat to the fragile ecosystem.

### 3.3. Climate Risks

Uttarakhand remains one of the most vulnerable regions in the country to climate risks. As per the SPACC 2014 it is expected that the region will have much more erratic rainfall, with decreased water availability, complete absence of winter rains. Glacier retreat remains another major concern with winters expected to shorter, warmer with less snowfall. All these can greatly affect the lives and livelihoods of the people. Specific climate related events are recorded below.

#### Cloudbursts

Cloudburst events lead to flashfloods or massive landslides, which often have a catastrophic impact on the inhabitants of the region. During the last few years, Uttarkashi has experienced a number of cloud burst events which may be attributed to the increased anthropogenic activities and the climate change phenomena. The intensity of destruction caused by the past cloud burst events defines the magnitude of danger it poses.

One such incident is the cloudburst event that happened on July 17, 2018 around 2:30 am, at the SaptrishiKund, the origin Point of Yamuna River. The event led to severe destruction to the Yamnotri shrine in Uttarkashi district. The shrine is a major

pilgrimage site attracting thousands of pilgrims during the season. The foot bridge connecting to the shrine was washed away. Most part of the Dharamshala (Kali Kamli) was damaged, the hot water bath Kunds were filled with debris. The pilgrims were left stranded and many even forced to run for their lives. Many had stories of narrow escape. About 50 meter of walking track was also washed away.

There have been at least three other major cloud burst events (in 2004, 2007 and 2013 respectively) in the past at Saptrishi Kund, in last 14 years. Cloudbursts leads to bursting of existing lakes or formation of transient lakes in upper catchment areas of the rivers and which later burst to cause flashfloods in the valley region. Burst of Trivani lake (GOLF) in 2004 and 2007 owing to cloud bursts caused significant damage in downstream areas like Shyanachatti, Kharadi, Barkot and Naugaun.

An early warning system predicting cloud burst is essential in such regions to enable inhabitants of the region to prepare accordingly and ensure no loss of life and property. The development plans therefore must focus on adopting local measures for predicting and preparing for such events.

*Almost 60- 70% of Naugaon landscape is covered by forests and during summers, forest fire incidents have occurred repeatedly year after year, leading to loss of animal and vegetation.*

### **Forest Fires**

Forest fires are not a new phenomenon to the Himalayan region. There have been major fire instances in the past in the region including those recorded for 1911 and 1921. Subsequently, each decade has seen at least one major fire instance. State of Uttarakhand witnessed major forest fires annually from year 2002 to 2018. In fact, reports indicate that the number of forest fires in India went up from 13,898 in 2011 to 35,888 in 2017. Clearly, fire is a recurrent concern in the Himalayan region. Naugaon Watershed area is no exception. Almost 60-70% of Naugaon landscape is covered by forests and during the summers, forest fires incidents have occurred repeatedly year after year, leading to loss of animal life and vegetation. As per local inhabitants, depleting ground water and dry vegetation in the area are found to be the main cause of forest fires here. Climate change surely has a major role to play in this context.

### **Hailstorm**

Nuagaun horticulture production is highly influenced by the local temperature in the region. It has been perceived by the local farmers here that unexpected rainfall and hailstorm is damaging the crops excessively. Hailstorms not only lead to decline in production of horticulture crops but also have significant impact on the quality of the production. This further causes significant economic loss to the farmers in the region. Considering that for most farmers in the region, this is the only source of income, such losses have tremendous impact on their lives.

## **2.4. Conclusion**

The existing trend of underlying vulnerabilities leading to skewed access to resources, services and institutions, are only going the rise with climate changes and climate induced events. The extreme weather conditions will have major impact on water crisis situation, health conditions and livelihood opportunities of the people living in the watershed region. These implications coupled with changes in demographic and socioeconomic changes might further aggravate the underlying vulnerabilities. Further, inappropriate development policies and programmes; constraints of livelihood; rampant poverty; unplanned development; and increasing frequency and severity of natural hazards and disasters and the resultant risks of food and livelihood insecurity have accelerated the livelihoods and environmental risks during the recent years.



## Chapter 4: Understanding Risks

This chapter deals with the physical features of the watershed in an analytical approach. Land capability and landform system for the watershed has been analyzed in this chapter. The land features have been classified as per the slopes of the terrains and are in order of the land use plan in the watershed.

Risk mapping of the watershed indicates that due to increase in surface temperature there is change in vegetation like increase in pine trees, invasive grass species. Depletion of natural water resources lead to water shortage due to which community people face challenges with routine activities, and also affects the agricultural productivity due to insufficient water for irrigation purpose. Forest fires in the region is also linked to ground water depletion and increase of pine trees while take human side on consideration few community perceptions with the traditional perception of land and manure lights up the small area that turns into a huge fire incident.

Increase in intense and unpredictable rainfall leads to surface runoff, soil erosion and debris flow. Cloudbursts in the region has become so common in the region and striking of this event leads to heavy rainfall resulting in flashfloods causing destruction of properties and damages to lives and livelihoods of the people. Infrastructure and development projects in the district certainly lead to evident change in increasing the risk, dams and unscientific road development make the area more prone to landslides. There is a constant threat among downstream communities regarding heavy flooding in the region due to dams. Change in landscape and local climatic conditions majorly affects the people's livelihoods. Agriculture expansion has led to decreased forest cover which could mitigate excessive run off and erosion limiting landslides and floods.

Understanding watershed hydrology and the hydrologic processes involved is critical, as it is vital for reliable assessments of water quantity and quality as a result of rapid urbanization and other land use changes happening within the developed watershed. Hence, it is important to consider the various land-surface processes of the targeted watershed to understand the issues of water mediated risks meticulously. Accurate and timely forecasts of rainfall, river runoff have the ability of providing critical information for agriculture optimization, water resource management, and disaster mitigation.

### 4.1 Key Factors in enhancing vulnerability

The Naugaon watershed of Uttarkashi district is a well forest covered area. In the watershed vegetation categories identified is evergreen/semi green, agricultural land, open forest etc. Human settlements are mainly located in the shallow water zones or around the localities near to springs. Agricultural practices are confined to areas of low relief which are underlain by weak rock formation, i.e., schists, phyllite, weathered gneisses and crushed quartzites. Forest is more frequent over steeper slopes to moderate slopes. The vulnerability of the fragile landscape is further aggravated by rapid change in land use, land cover due to unsound development activities.

Availability of water is challenging the people's daily life or routine activities, and it is also creating human wild conflict. Due to which wild animals are seen in agricultural fields. Water depletion abolishes the soil moisture and it is also a reason of wild fire in the area. Water has increased landslide risks in the area whether it is due to dry and slippery nature of soil or because of heavy rainfall. Degrading ecosystem has severely impacted services like provisioning (availability of food from fields, water from natural springs, fodder and NTFP from forests),

*Land Use study enables to monitor the impact of integrated watershed management approach as key to improving the land use/cover of watershed, which further contributes to sustainable development besides improving the livelihood of the local community.*

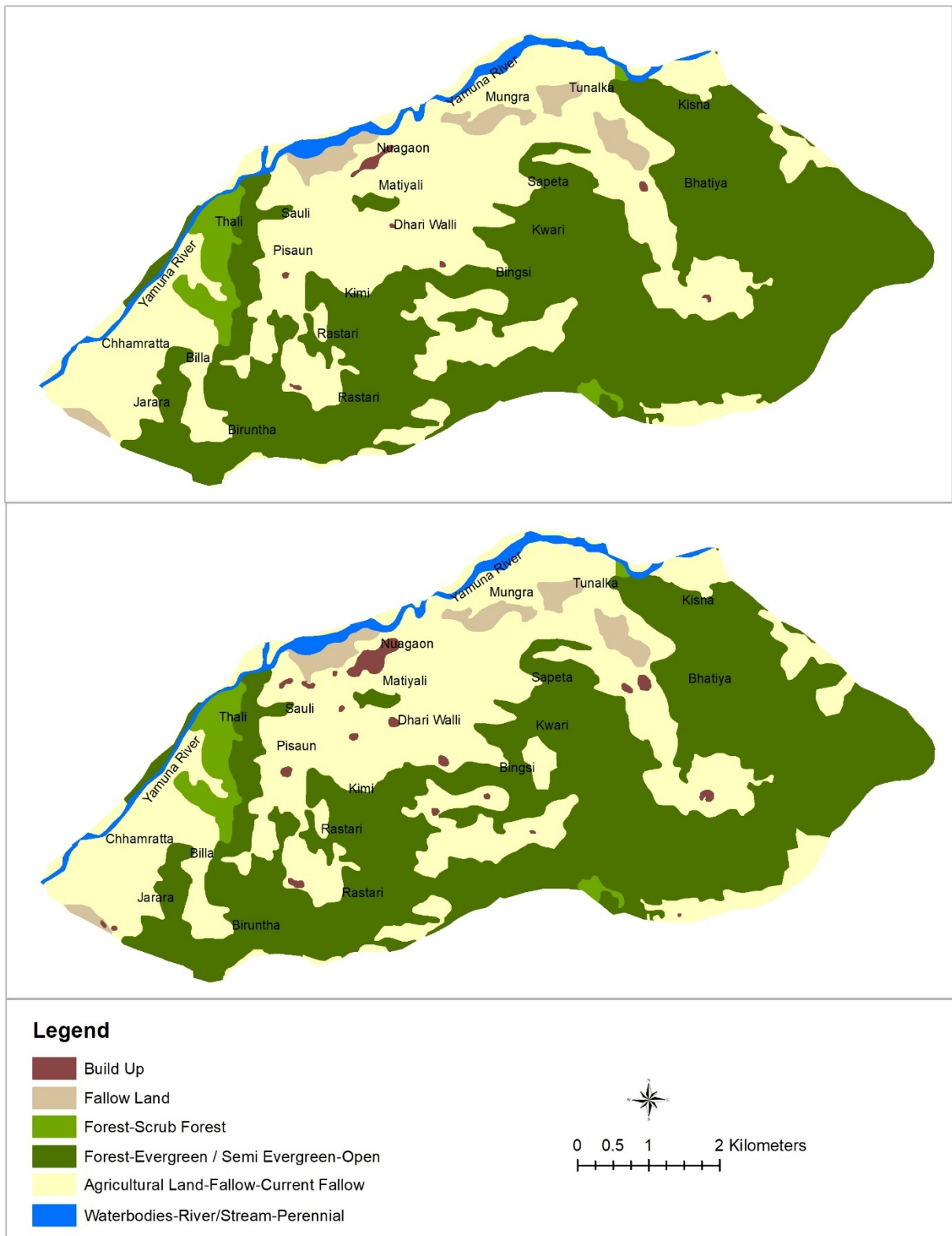
regulating (water regulation, temperature regulation, precipitation) and supporting services (maintaining soil moisture, recharge of natural springs etc. Community is exposed to a great extent to climate variability as the natural resources and their availability are changing.

In the watershed, panchayats remain the only functional institutions, along with a few dysfunctional self-help groups. Remoteness of the villages also makes it more susceptible to risks, there is no general grocery store where people at least could purchase daily items; hence people come to market which is at a distance 5kms (average), public transport remains limited to private vehicles. For legal or any judicial work people either have to go to Barkot at a distance of 10 kms or to Uttarkashi which is 91.9kms far. There is a public health care centre that is situated in Naugaun market, along with other facilities like banks, post offices, junior, senior high schools and colleges. And for major illness or accidents patients or injured are referred to Dehradun (124.7 kms away).

The comparative analyses of land use/land cover through satellite data over a certain period of time reveal the significant changes that have occurred within the watershed under major land use/land cover categories. The study enables to monitor the impact of integrated watershed management approach as key to improving the land use/cover of watershed, which further contributes to sustainable development besides improving the livelihood of the local community.

The Naugaon watershed of Uttarkashi district is a well forest covered area, most of the part of the valley covered is non-wasteland. In this catchment land use/land cover categories identified is forest evergreen/semi green, agricultural land, open forest etc. Human settlements are mainly located in the shallow water zones or around the localities near to springs. Agricultural practices are avoided and are confined to areas of low relief which are underlain by weak rock formation, i.e., schists, phyllite, weathered gneisses and crushed quartzites. Forest is more frequent over steeper slopes to moderate slopes.

<b>Table 1: A comparison of Land Use/Land cover area of Naugaon over two periods of 1961-62 and 2016</b>			
<b>Type of Land cover</b>	<b>1972</b>	<b>2018</b>	<b>Change</b>
Forest Evergreen/Semi Evergreen	15.93	14	↓
Agricultural Land	1781.03	1822.44	↑
Forest evergreen	0.33	0	↓
Forest scrub			
Fallow Land	101.34	100.95	↓
Built up	8.7	34	



**FIG 15: LAND USE AND LAND COVER OF NAUGAON WATERSHED FROM 1972 TO**



*Land Use study enables to monitor the impact of integrated watershed management approach as key to improving the land use/cover of watershed, which further contributes to sustainable development besides improving the livelihood of the local community.*

The Land use maps show that the land use/land cover patterns have changed in the Naugaon watershed; forest land has declined whereas the cultivable area has increased. This rise in agricultural land use indicates increase in agricultural activities in the region.

Agriculture is primary and traditional source of income for 80% of people inhabited in this region. Migration being a major concern in the region, increase in agricultural activity is a good sign indicating options for increased livelihoods through agricultural. However, it also indicates that the climate change adaptive cropping must be promoted for higher yield and to increase income. With the change in climate, people are diversifying livelihoods options and adapting to floriculture and horticulture. At higher altitude, communities have apple orchards, pear, walnut, pomegranate, orange are among other horticulture crops.

The increase in built up area is also observed when assessing the land use maps over the two timelines from 1972 to 2018. The increase is almost 290% from 8.7 km sq to 34 km sq. Naugaon watershed lies in seismic zone 4; the tough terrain makes it physical vulnerable to unsound development for infrastructure building at fault zones and other eco-sensitive zones, the increase in built up areas appears unplanned and the construction of roads remains a constant cause for landslides. Growing population and increasing demands puts another reason for change in land use and land cover of the area.

### Normalised Difference in Vegetation index (NDVI)

NDVI is primarily used for assessment of land degradation at differed scales and for a range of applications including resilience of agro systems. NDVI aids in ascertaining productivity of a region. Evidence is drawn from a wide range of investigations, primarily from the scientific knowledge. Normalized Difference Vegetation Index (NDVI) is a compilation of visible and near infrared bands, ranges in value from -1.0 to 1.0, and is used to measure the VIGOR of vegetation i.e. a measure of the increase in plant growth or foliage volume through time in a region.

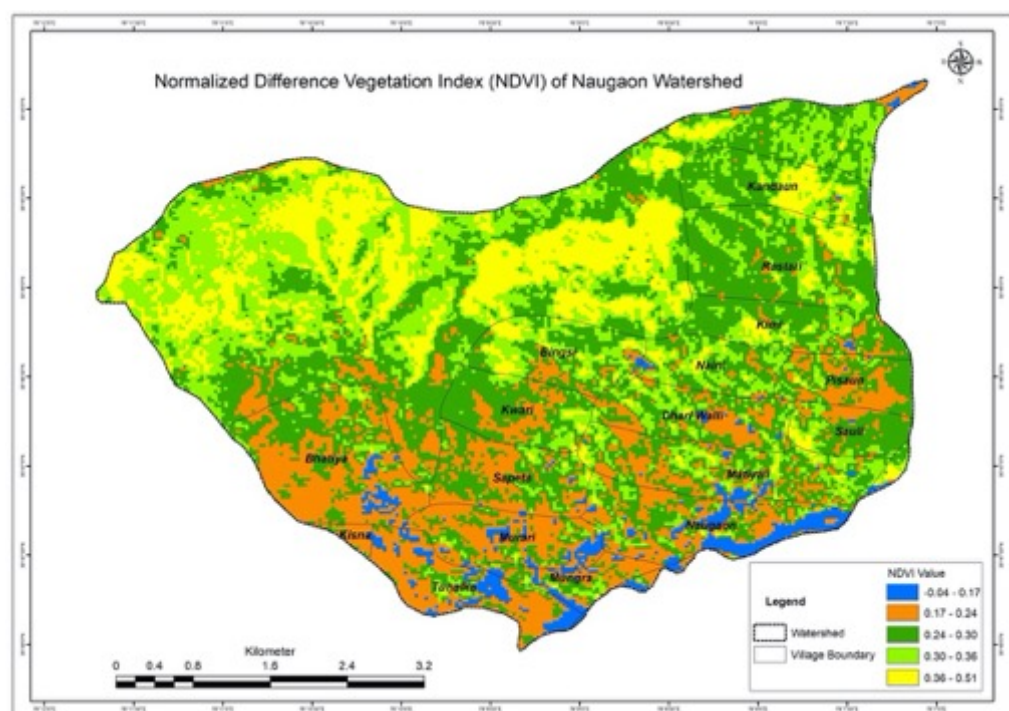


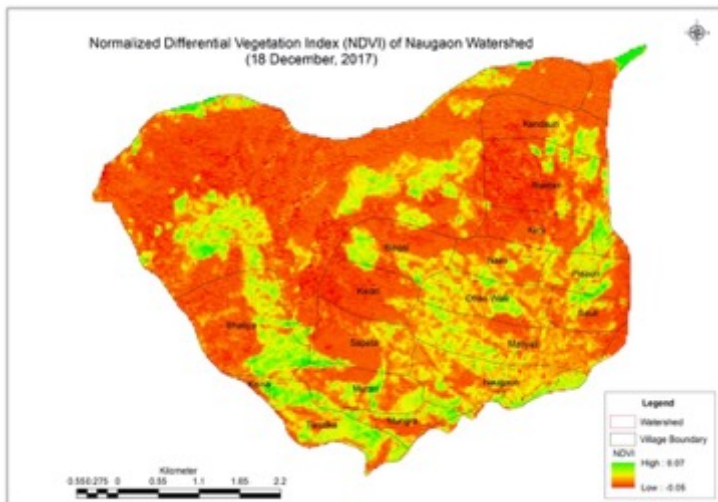
FIG 16: NDVI MAP OF NAUGAON WATERSHED

*The overall NDVI map indicates relatively a good and fertile vegetative index for the region. However, the transformation during the seasons are a concern with vegetation drastically decreasing during summers.*

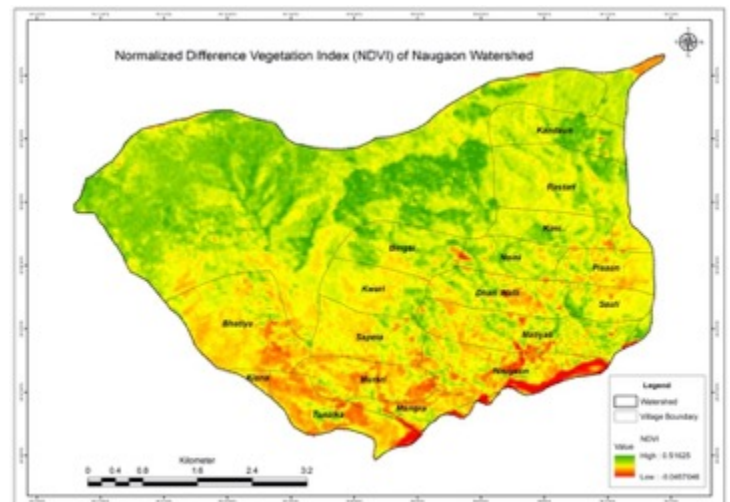
This image service is colorized with a color ramp that ranges from brown to green. Very low values of NDVI (0.1 and below, which is displayed as light brown) correspond to barren areas of rock, sand, or snow. Moderate values (0.2 to 0.3, displayed as light green) represent shrub and grassland, while high values (0.6 to 0.9, displayed as dark green) indicate temperate and tropical rainforest.

Because NDVI is a spectral measurement of the photosynthesis occurring in a defined spatial area, the value generally increases throughout the growing season, and then decreases during the plants' senescent period. Additionally, NDVI can change from year to year because of environmental changes, like amount of rainfall or temperatures in the prior seasons.<sup>9</sup> Therefore it is important that varying time frames also be considered while studying and developing the indexes.

For Naugaon, while the overall NDVI map indicates relatively a good and fertile vegetative index for the region. However, the transformation during the seasons are a concern with vegetation drastically decreasing during summers. The water crises in the region during the summers, with streams drying up and with high depededance on water from streams and rainfall is highly attributable to the this pattern of NDVI.



**FIG 17: NDVI CALCULATED ON 18<sup>TH</sup> DECEMBER 2017 FOR NAUGAON WATERSHED**



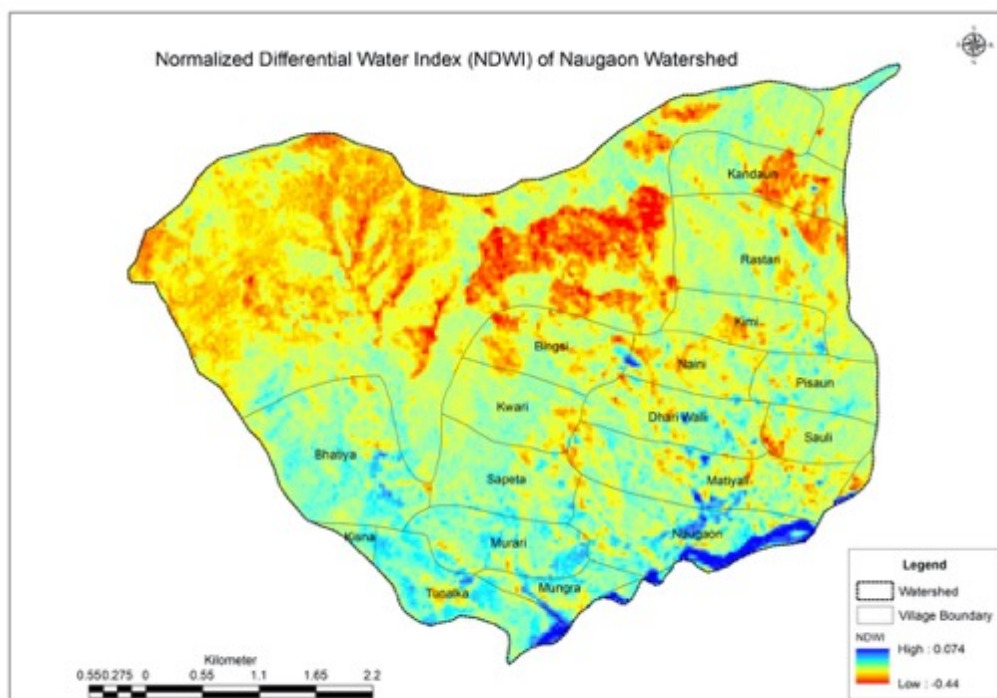
**FIG 18: NDVI CALCULATED ON 11 MAY 2018 FOR NAUGAON**

### Normalised Difference in Water index (NDWI)

NDWI study helps in developing an efficient procedure that would allow a GIS to integrate remote sensing and its capability of detecting surface features, with a GIS, and its capability to spatially analyze data, to identify water index of the region. Water index of the region would indicate the water stress in the region and thereby help in planning to avert risks of water scarcity, crop failure, low crop production etc.

The index helps in identifying the stress to the various stakeholders in the region, water sources and agriculture. The information hence can be utilized to plan interventions to increase agriculture yield, reduce water stress in the region etc.

The map for Naugaon indicates multiple high stress points. These stress points are concentrated majorly in the agricultural land use area and also most of them densely populated pockets of the watershed. Clearly indicating that the current activities are posing a high stress on the water level in the region including groundwater sources, streams etc.



**FIG 19: NDWI MAP OF NAUGAON WATERSHED**

### Soil Fertility

Crop production has been decreasing in the past decades, due to some extent to the rapid population growth, coupled with the increase population of livestock in a region. As a result, there has been an increasing pressure on land and cultivation. Land mismanagement, inappropriate soil management and farming practices among others have accentuated soil erosion, nutrient depletion as well as environment degradation. Soil plays a crucial role in Watershed region and therefore emphasis needs to be shifted to a better understanding of the role of watershed as a provider of nutrients for soil quality improvement.

As is case in Naugaon, in most watershed regions in this part of the country, agriculture remains the primary source of sustenance. Farmers are marginal with small & scattered land holdings & mainly practice rain-fed agriculture. Once widely known for its fertile soils, the region is continuously witnessing aggravated effects of global phenomenon of climate change that has adversely affected the natural resources of the area, especially the quality of soil, thereby threatening the security of food & livelihood of the region. Besides, the practice of excessive cultivation of commercial crops and increased soil erosion due to erratic high frequency rainfall has further degraded the nutritional status of soil affecting overall yield & the economy of the region perilously.

*The practice of excessive cultivation of commercial crops & increased soil erosion due to erratic high frequency rainfall has further degraded the nutritional status of soil affecting overall yield & the economy of the region perilously.*



**Table 2:** Soil nutrient status table

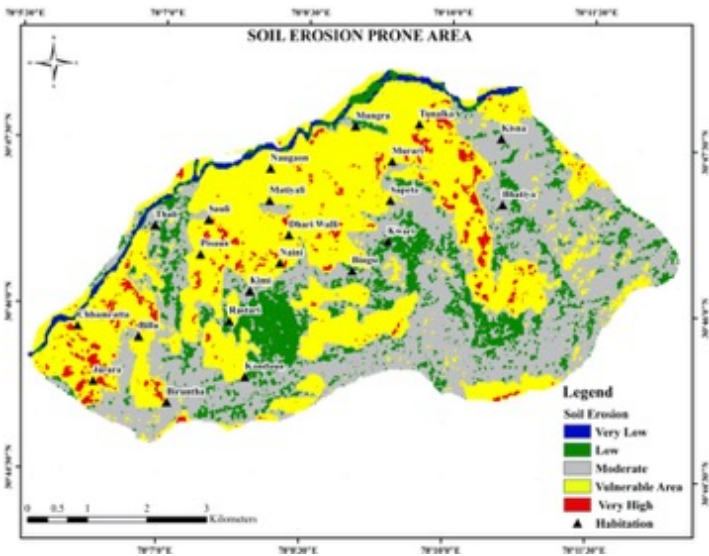
Land	N(kg/ nali)	P(kg/na li)	K(kg/nali )	OC (%)	pH	EC(dsM <sup>-1</sup> )
Agriculture	4.97	0.190	1.42	1.07	7.34	0.270
Horticulture	4.49	0.130	3.17	0.93	7.38	0.220

As per the analysis of soil testing data of the region found soil nutrients status is very poor of maximum areas. Electrical conductivity found medium in all villages. While conducting the study, major challenge which came in front was lack of awareness in the region. Farmers of the region were not aware of the importance of soil nutrient and its health.

## Soil Erosion

Using Geographical Information System (GIS), we have considered parameters like land use and cover, slope, distribution of rainfall, flow direction to determine soil erosion in the area.

S.No.	CLASS_NAME	AREA_HEC
1	LOW	880.01
2	MODERATE	530.47
3	VERY HIGH	983.11
4	VERY LOW	156.16
5	VULNERABLE AREA	414.49



**FIG 20: MAP DEPICTING SOIL EROSION PRONE AREAS IN NAUGAON WATERSHED**

Major part of the Naugaon Watershed region falls under the vulnerable area in the for soil erosion. There are several pockets of very high soil erosion indicating incidence to high soil erosion. These high instance pockets are largely the populated areas indicating direct link with recent infrastructure development as possible reason for loosening of the soil. The areas with moderate vulnerability are largely forest area indicating that high density vegetation cover ensuring low soil erosion.

*Development of landscape based risk reduction plans underlines the need for restoration of ecosystem services through sustainable utilization and conservation of critical natural resources, engaging stakeholders like scientific institutions/experts, decision makers and investors etc; and further evolving effective CCA and DRR strategies; and their mainstreaming into the overall process of development programmes /policies, particularly at watershed level*

## **Water resources**

In a survey conducted by HARC in Naugaun watershed to calculate discharge rate of perennial and non-perennial streams, it was found that water discharge rate has declined in almost 10-12 springs out of 31 surveyed springs. The condition of depleting water resources is seriously affecting the livelihoods, soil, with reduced vegetation increasing chances of forest fires and reduced availability of water for domestic use.

### **4.2. Understanding risks**

Risk mapping of the watershed indicates that due to increase in surface temperature there is change in vegetation like increase in pine trees, invasive grass species. Depletion of natural water resources lead to water shortage due to which community people face challenges with routine activities, and also affects the agricultural productivity due to insufficient water for irrigation purpose. Forest fires in the region is also linked to ground water depletion and increase of pine trees while take human side on consideration few community perceptions with the traditional perception of land and manure lights up the small area that turns into a huge fire incident.

Increase in intense and unpredictable rainfall leads to surface runoff, soil erosion and debris flow. Cloudbursts in the region has become so common in the region and striking of this event leads to heavy rainfall resulting in flashfloods causing destruction of properties and damages to lives and livelihoods of the people. Infrastructure and development projects in the district certainly lead to evident change in increasing the risk, dams and unscientific road development make the area more prone to landslides. There is a constant threat among downstream communities regarding heavy flooding in the region due to dams. Change in landscape and local climatic conditions majorly affects the people's livelihoods. Agriculture expansion has led to decreased forest cover which could mitigate excessive run off and erosion limiting landslides and floods.

Understanding watershed hydrology and the hydrologic processes involved is critical, as it is vital for reliable assessments of water quantity and quality as a result of rapid urbanization and other land use changes happening within the developed watershed. Hence, it is important to consider the various land-surface processes of the targeted watershed to understand the issues of water mediated risks meticulously. Accurate and timely forecasts of rainfall, river runoff have the ability of providing critical information for agriculture optimization, water resource management, and disaster mitigation.

The fragile ecosystem of Naugaun watershed has gone through developmental processes such as road construction, terraced cultivation which is adding to the physical vulnerability of the area. The absence of local level water conservation efforts, drying up of natural springs and water sources have become common occurrences in the past few years. The sub-surface water levels are also fast depleting. Communities in the region are primarily engaged in agriculture services. However limited irrigation facilities and water crises during summers, makes their agricultural practices wholly dependent on rainfall. Soil and water conservation techniques along with climate resilient farming can help communities adapt to the changing ecosystem.

Both the proportion of agricultural land as well as the farm-productivity has declined steadily and significantly. As result, the household level income from agriculture is much lower than the total household income contributed by rural off-farm sectors,

which clearly indicates that people are practicing agriculture in highly compelling circumstances in the absence of other viable means of livelihood.

It also shows that the conventional land based economic sectors, specifically, crop-animal husbandry combination is not capable of generating adequate surplus to meet the needs of growing population and a livelihood above subsistence level in watershed, particularly keeping in view, the ongoing process of land use intensifications and resultant depletion of natural resources and the impending threat of changing climatic conditions therefore calls for looking beyond the traditional agricultural system and generation of rural employment opportunities in off-farm and non-traditional sectors in the region. Increasing trend of out-migration has affected the overall quality of rural life by increasing the responsibilities, hardship and workload of rural women; and retarding the process of development.

Nevertheless, the enormous value of large forest areas with water sources characterized by well endowed landscapes, with a variety of flora and fauna, enthralling wilderness and rich biodiversity have so far not been linked to the improvement of rural livelihoods and rural income generation that indeed demands community managed biodiversity conservation practices and investment.<sup>10</sup> Development of landscape based risk reduction plans underlines the need for conservation of ecosystem services through sustainable utilization and conservation of critical natural resources, particularly, land, water, forests, and biodiversity; engaging stakeholders like scientific institutions/experts, decision makers and investors etc; and further evolving effective climate change adaptation and disaster risk reduction strategies; and their mainstreaming into the overall process of development programmes /policies, particularly at watershed level is the crucial need of hour.

**FIG 29: STEPPE FARMS IN NAUGAON**





## Chapter 5: Ecosystem Services Shared Value Assessment (ESSVA)

### 5.1. Introductions

In a human-dominated world, it is increasingly appreciated that ecosystem services are not generated only by ecosystems, but by social-ecological systems of which human form an integral part. The perceptions, attitudes and preferences humans hold for ecosystem services are important institutions in themselves to engender changes in the ways stakeholders engage with management of ecosystems by acting as a societal feedback mechanism, alerting the society on the consequences of consumption choices and behavior. However, there is a paucity of research on understanding the behavioural dimensions of ecosystem services (Martín-López et al., 2012; Asah et al., 2014), thus limiting their effective integration in management planning and decision making.

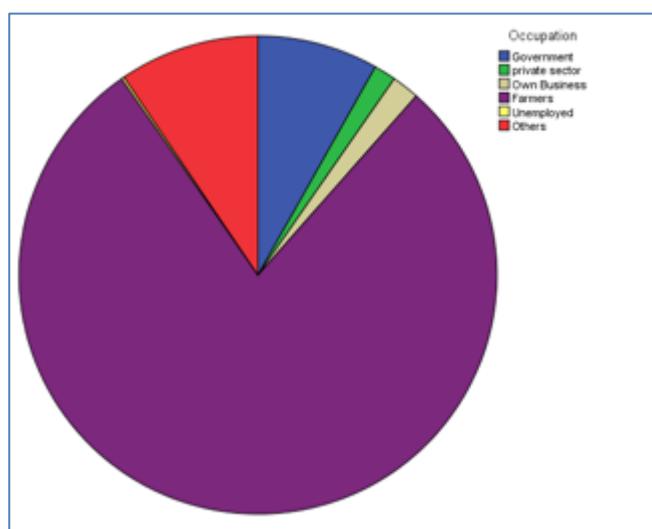
HARC used Ecosystem Services Shared Value Assessment (ESSVA) tool to assess community perceptions, preferences and attitudes for ecosystem services of Naugaon Watershed.

The tool enables engagement with communities living around the watershed, and its upstream and downstream reaches, linking ecosystem services with various drivers of change and implications for well-being. Behavioural data is elicited through a structured questionnaire

*HARC used Ecosystem Services Shared Value Assessment (ESSVA) tool to assess community perceptions, preferences and attitudes for ecosystem services of Naugaon Watershed.*

### 5.2. Results

Communities values and benefits from watershed ecosystem were assessed through ESSVA tool. Trained enumerators from HARC conducted surveys with 544 community members in 18 villages, to understand community dependence on the streams.



**FIG 23: CHART DEPICTING THE STAKEHOLDERS CONSIDERED FOR ESSVA**

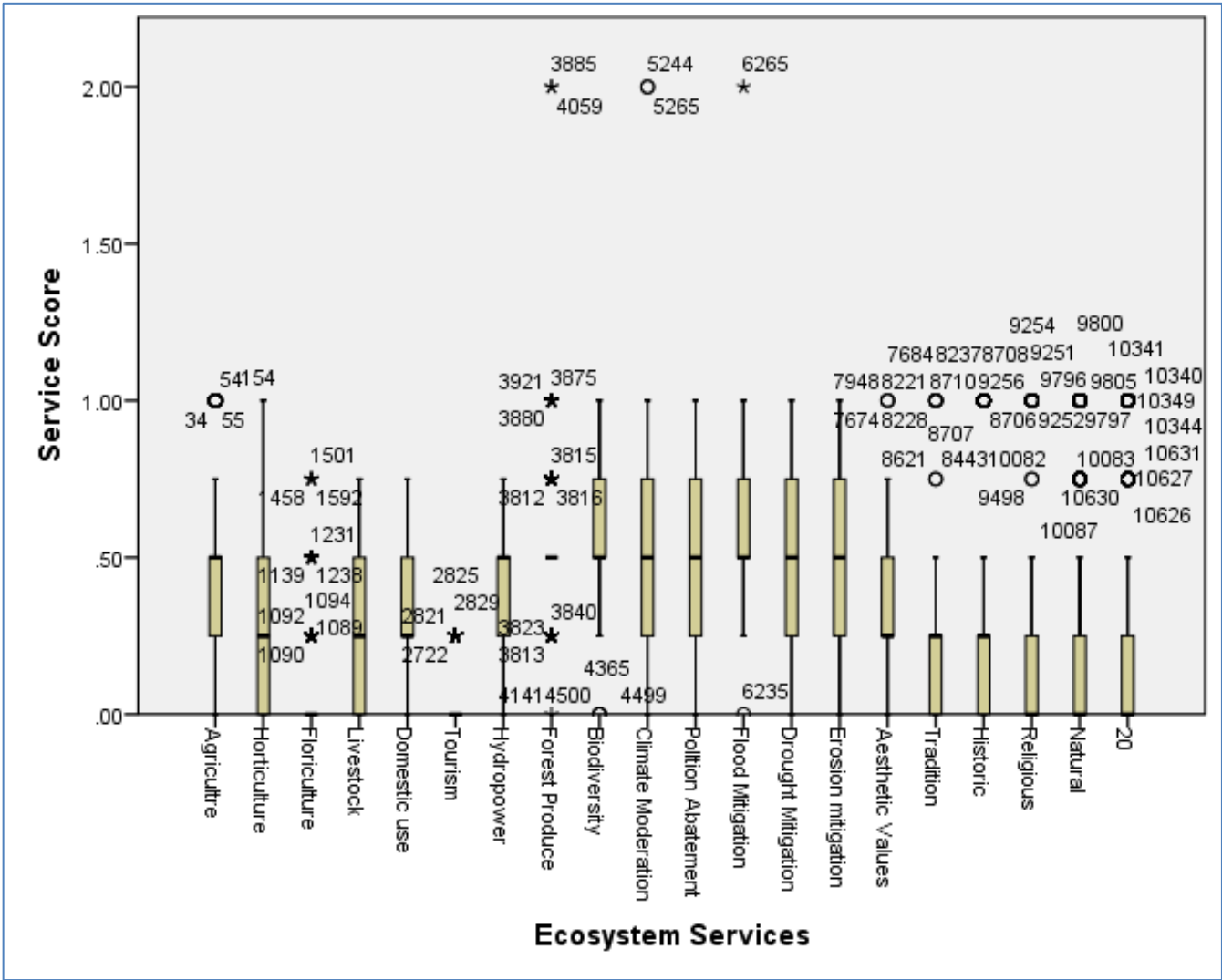
Close to 80 percent of the community members taken as sample for the survey, turned out to be farmers, indicating that the main occupation in the region is farming and dependence on agriculture for income is extremely high.

Yet another striking point was that the dependence on other occupation like own business or private sector was minimal indicating that options for diversification of occupation is quite limited in the region.

The communities identified 19 ecosystem services (9 provisioning 5 regulating and 5 cultural services) as being derived from the watershed. According to 67% of surveyed population there has been a significant change in settlement in the area, increasing demands on natural resources. Communities depend on forests for limited collection of fuel wood, timber and non-timber products and are highly dependent on agriculture for their needs, and dependency on horticulture produces is because of more income in short period.

The rankings ascribed to provisioning services is mapped with the occupation categories like farmer to the provision of water for irrigation. Communities which have a lesser direct dependence on the watershed for livelihoods (such as business owners, Government servicemen and private sector employees) ranked the regulating and cultural services higher. Scores for disaster risk reduction

*The Communities identified 19 ecosystem services (9 provisioning, 5 regulating and 5 cultural services) as being derived from the watershed.*



functions and select cultural services (religious values, aesthetic values, and education values) were rated high. Therefore as seen in the graph above, agriculture, horticulture and livestock were attributed by the communities to be the most important use of ecosystem services.

### 5.2.1. Gender Specific analysis

Gender specific analysis highlighted distinct perception regarding watershed ecosystem services. Men scored provisioning services higher than the women (95% significance), whereas women scored cultural services higher than the men. Similarly, the male respondents felt that the impact of watershed ecosystem degradation on economy and health would be higher than the females.

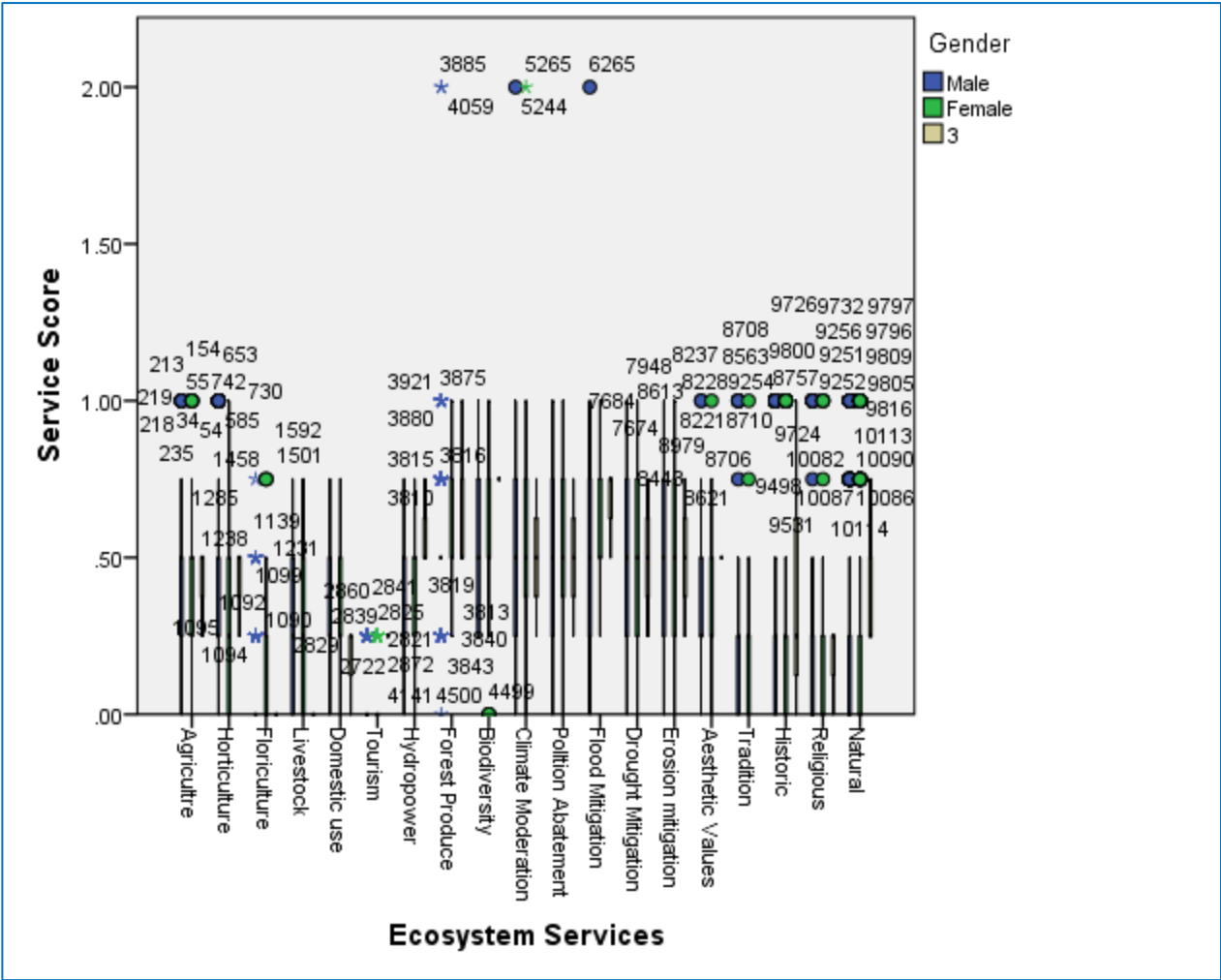


FIG 24: GENDER SPECIFIC RANKINGS BASED ON ESSVA ASCRIBED TO PROVISIONING SERVICES IS MAPPED

A more closer study of the provisioning services and Gender specific analysis, indicate that both men and women rank horticulture higher than any other provisioning services indicating thier dependence on ecosystem for horticultural is high and majority of them have horticulture as major source of income.



Statistically, no major difference was observed in the ranking of threats to the watershed ecosystems by the respondents. Almost all mitigation measures including pollution abatement, flood mitigation, drought mitigation, erosion mitigation biodiversity and climate moderation were perceived to be equally essential.

The cultural services or cultural importance associated with the watershed systems ranked the least among all provisions of the ecosystem.

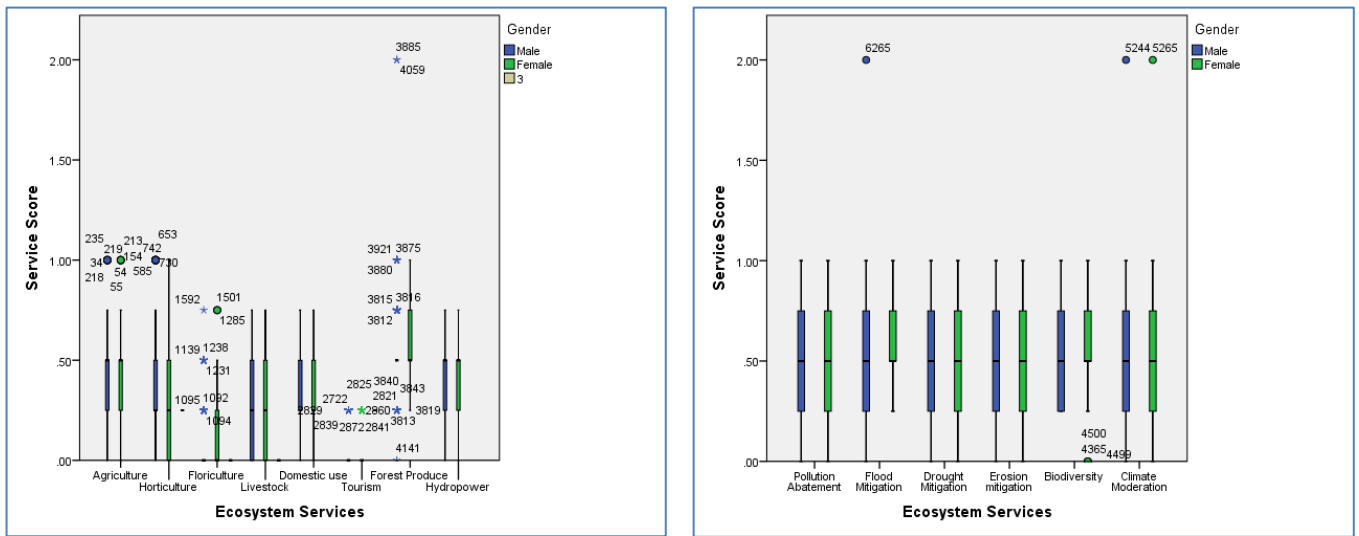


FIG 25: RANKING OF SERVICES BASED ON GENDER SPECIFIC PREFERENCE

### 5.2.2. Education specific

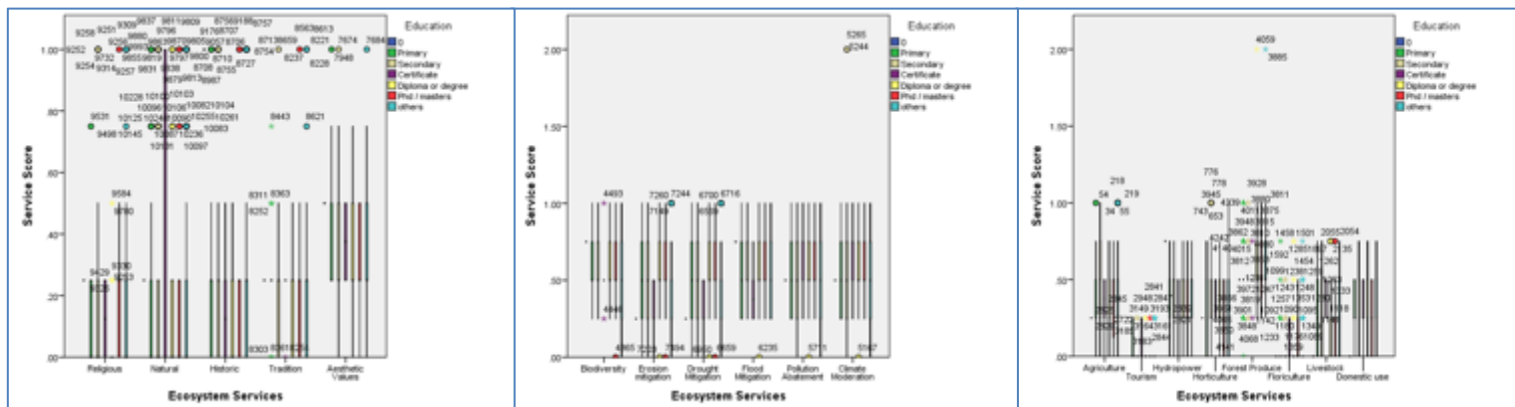
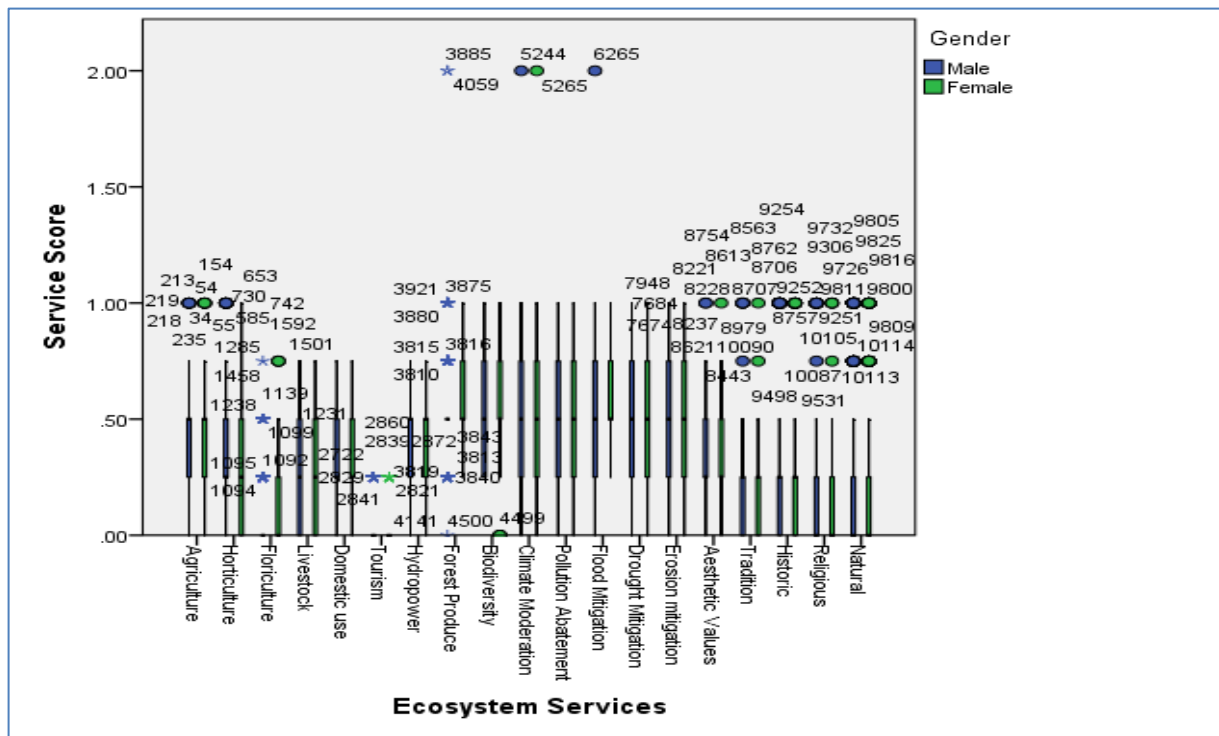


FIG 26: RANKING OF PROVISIONAL SERVICES BASED ON LEVEL OF EDUCATION OF RESPONDENTS

Beyond the gender specific analysis ESSV analysis in Naugaon also attempted to study the preception of provisions based on level of education of the respondents.

The study reveals that Agriculture and forest produce have been ranked the highest by almost all. However, respondents with secondary education consider the natural provisions of ecosystem as high. They also rank agricultural services are most important provision. All mitigation provisions were found to considered equally important by all the respondents irrespective of thier education. A significant observation was that the respondents with certificate level and above considered forest produce as important provisions from ecosystem. Also only a few respondents with certificate level education perceived tourism and floriculture as a provision from ecosystem. This depicts lack of awareness and knowledge among people towards diversification of occupation towards other sectors beyond traditional horticulture and agriculture for enhanced income.



**FIG 27: RANKING OF PROVISIONAL SERVICES BASED ON LEVEL OF EDUCATION OF RESPONDENTS AND**

### 5.2.3. Based on Occupation

In study of provisioning services based on occupation, agriculture was ranked high by almost all respondents. An obvious inference considering Naugaon primarily being an agricultural economy and most families being dependent on agriculture as their main source of income. Those respondents who had their own business ranked forest produce higher. Floriculture was ranked only by private sector respondents. The perception towards services other than Agriculture and

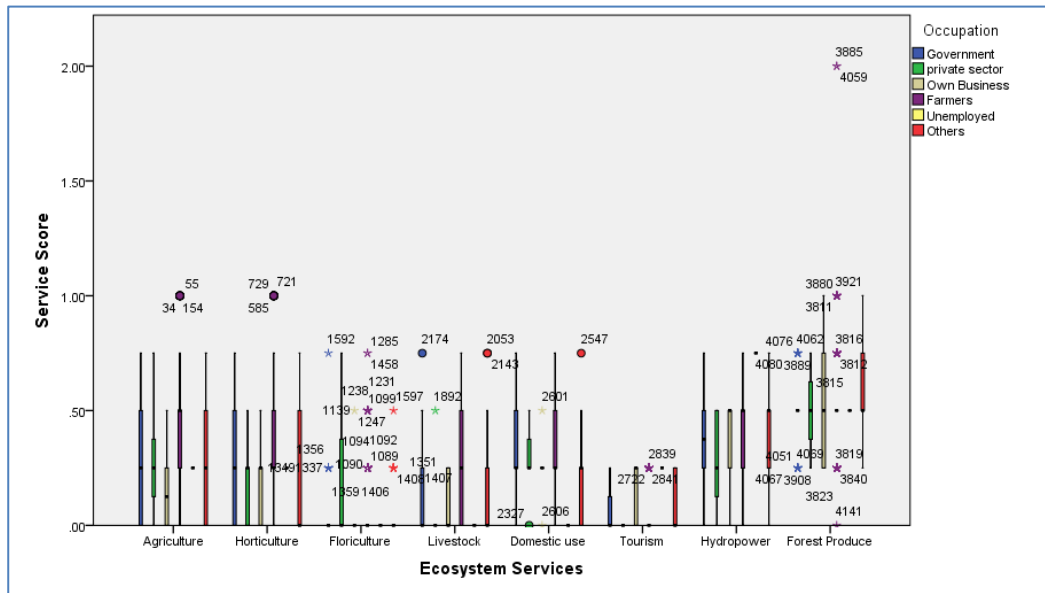


FIG 28: RANKING OF PROVISIONAL SERVICES BASED ON OCCUPATION

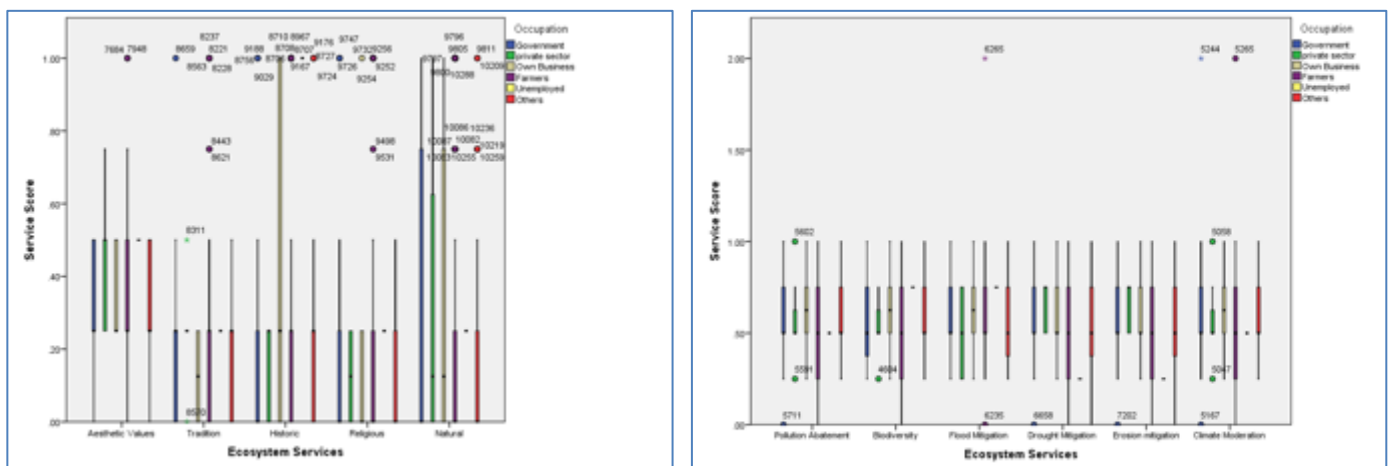


FIG 29: RANKING OF ECOSYSTEM SERVICES BASED ON OCCUPATION

Horticulture has been skewed among the respondents, indicating a lack of knowledge on supporting services provided by ecosystems.

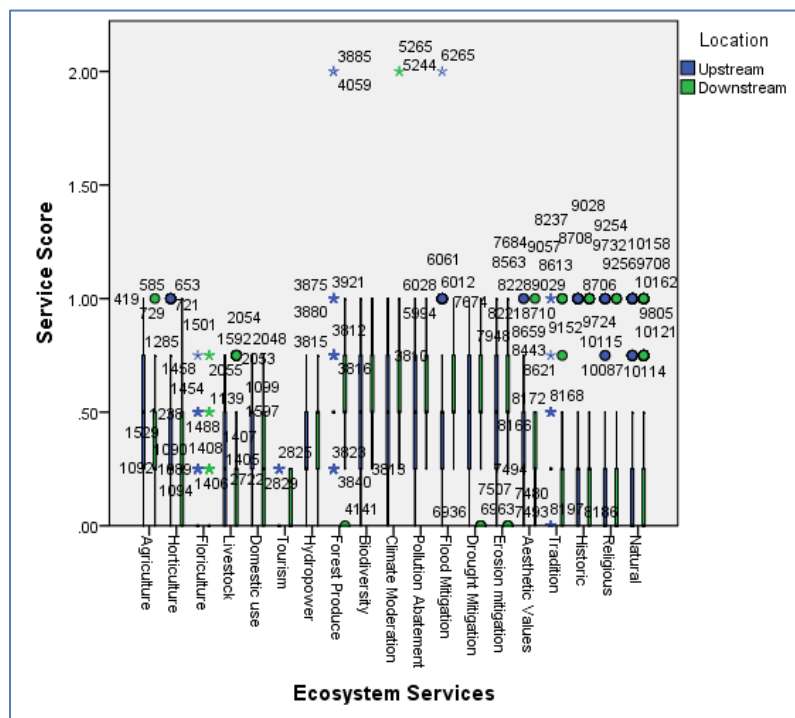
In terms of cultural services higher value was placed as watershed's preference as natural aspect followed by historic and aesthetic value. Respondants with own business seems to have high perception of the watershed as natural and historic as compared to others like farmers and Government servicemen who placed almost same preference for all cultural services.

In case of regulating services, as has been the case in other aspects, irrespective of occupation, all regulating services were given equal preference.



### 5.2.4. Location Preference

While respondents from upstream placed higher preference to agriculture, livestock in provisioning services, the respondents from downstreams placed ranked horticulture the most. In terms of regulating provisions, the downstream laid increased emphasis on flood mitigation services of the watershed when compared to upstream, indicating that floods are more of a concern downstream as compared to upstream. There was equal preference for all cultural provisions by both upstream and downstream respondents.



**FIG 30: RANKING OF PROVISIONAL SERVICES BASED ON LOCATION OF VILLAGE**

### 5.3. Conclusion

ESSV results indicate the watershed continues to be the considered the most crucial for its provisional services followed by regulatory and asthetic services. In terms of provisional services, Watershed's service for agriculture and horticulture was the highest, followed by others. Tourism and floriculture was the least ranked services. This indicates a lack of diversification of occuptions and lack of knowledge of the same.

Regulatory sevices were all considered equally important and ranked equally. The inhabitants do understand and value the importance of watershed in terms of the role in plays in regulating the phenomena and thereby concious to its conservation for future. The watershed holds relevance naturally, asthetically, traditionally, religiously and historically in terms of cultural services and therfore high belongingness exists among the inhabitants.

Tools such as ESSVA highlight the social factors which have a bearing on the perceptions, preferences and attitudes towards ecosystem services. They help dive deeper into factors which define the relationship communities have with

watershed ecosystem services and use the assessment outcomes to develop a shared view of ecosystem services, trends therein and possible restoration options. ESSVA was used as tool to further build capacities of communities to understand regulating and supporting services especially for their role in disaster risk reduction and the need for sustainable ecosystem services use for risk reduction.



FIG 31: HOUSEHOLD SURVEY UNDERWAY IN NAUGAON



## Chapter 6: Problems Identification and Analysis of Issues

*Inappropriate development policies and programmes; constraints of livelihood; rampant poverty; unplanned development; and increasing frequency and severity of natural hazards and disasters and the resultant risks of food and livelihood insecurity have accelerated the livelihoods and environmental risks during the recent years.*

State of Uttarakhand has an exceptionally fragile landscape that by origin is susceptible to natural calamities. Recurring disasters, extreme weather and ever increasing impact of natural calamities, has revealed the extreme vulnerability of the state. Floods in June 2013 was a wakeup call for the entire country with state witnessing the most disastrous floods in its history. These disasters lead to substantial loss of life, livelihoods and community assets, which not only threatens the pace of socio-economic development, but also undo hard-earned gains.

The Himalayan Watersheds are under constant threat of mass wasting and erosion caused by depletion of forest cover, unscientific agronomic practices, hydrologic imbalances and natural calamities.<sup>11</sup> The ever increasing population, the need to provide a better quality of life to the people and the pressure on natural resources are further compounding the problem.

Changes in the climate are sabotaging efforts towards realization of the three pillars of sustainable development- economic, social and environmental. Climate change also poses a threat towards the achievements of the Sustainable Development Goals (SDG). Climate Change would have its impact on water resources, forest, bio-diversity and agriculture and food security of the rural people. The productivity of the crops is adversely affected by variability in precipitation, temperature changes, changes in soil properties and distributions of pests. The extent of adversity increases with the increase in the altitudes as rise in temperature is also expected to push up the snow line higher.



FIG 32: LADIES FROM VILLAGE PARTICIPATING AT A FOCUSED GROUP DISCUSSION

*Naugaon watershed is one of the catchment area in Uttarakhand that has been bearing the wrath of the rising temperatures (climate change) and natural calamities. The watershed lies in the upper part of catchment area of River Yamuna. The region is extremely vulnerable to disaster by virtue of its geographical setting and complex development dynamics.*

The problems are further compounded by unplanned development, environmental degradation and rising temperatures. Haphazard construction with a myopic view of gains from increased tourism demands is a major concern. Exploitation of the fragile mountain ecosystem makes communities vulnerable to risks of extreme weather conditions and disasters. The problems are exacerbated for marginalised and families with limited capacities to adapt to the changing climate and increasing disasters. The impacts of climate change are wide ranging from receding glaciers and upwardly moving snowline, together with depleting natural resources and erratic rainfall patterns have put a stress on biodiversity and livelihoods. The increase in invasive species such as pine trees and drying up of perennial streams, illustrates the complexity of problems the people face. The shifting in cultivating zones of apples and other horticulture crops, advancing cropping seasons have further put their livelihoods under stress. Decreasing produce from farming is to an increase the migration of population to urban centres for increased income.

Inappropriate development policies and programmes; constraints of livelihood; rampant poverty; unplanned development; and increasing frequency and severity of natural hazards and disasters and the resultant risks of food and livelihood insecurity have accelerated the livelihoods and environmental risks during the recent years. Both the proportion of agricultural land as well as the farm-productivity has declined steadily and significantly. As result, the household level income from agriculture is much lower than the total household income contributed by rural off-farm sectors, which clearly indicates that people are practicing agriculture in highly compelling circumstances in the absence of other viable means of livelihood. It also shows that the conventional land based economic sectors, specifically, crop-animal husbandry combination is not capable of generating adequate surplus to meet the needs of growing population and a livelihood above subsistence level in watershed, particularly keeping in view, the ongoing process of land use intensifications and resultant depletion of natural resources and the impending threat of changing climatic conditions therefore calls for looking beyond the traditional agricultural system and generation of rural employment opportunities in off-farm and non-traditional sectors in the region. Increasing trend of out-migration has affected the overall quality of rural life by increasing the responsibilities, hardship and workload of rural women; and retarding the process of development.

Existing trends of underlying vulnerabilities, resulting in skewed access to resources, services and institutions, will only see a rise with future climatic changes or climate induced events, and as extreme weather events are predicted to increase so will the implications on water availability, health and livelihood opportunities of the people living in watershed regions<sup>12</sup>. These implications coupled with changes in demographic and socioeconomic changes might further aggravate the underlying vulnerabilities.

Naugaon watershed is one of the catchment area in Uttarakhand that has been bearing the wrath of the rising temperatures (climate change) and natural calamities. The watershed lies in the upper part of catchment area of River Yamuna. The region is extremely vulnerable to disaster by virtue of its geographical setting and complex development dynamics. Landslides, forest fires, cloudbursts and flash-floods occur with great regularity every year between April and August. Unplanned development of infrastructure such as roads have made the region further vulnerable.



Springs are a vital component of the ecosystem that provide essential services to people and landscape in the region. As Naugaon watershed is located in the upper Yamuna catchment area, some of villages can't access piped water supply from the river and hence they are dependent on natural water stream for their water requirement whether it be drinking, bathing, washing or irrigation. According to a water streams discharge survey carried out in the Naugaon watershed, the water discharge rate of 19 water springs, has been decreased among them only 3 flows throughout the year, with much of the reduction happening during summer months (May-June). This has led to vulnerability of farmers, through an inability/difficulty in watering cash crops in the area which then results into economic loss. Severe water crises especially during summers is a growing concern among the community in the region.

Further a lack of discharge is leading to water crises in the lower areas of Yamuna basin as well. Downstream communities, use mules or horses for logistics services during the season of "Char Dham yatra", or open shops/stalls on the way of national highway which is seasonal income source for these people. Apart from this, hotels which lie on national highway also get affected if tourists influx gets slow down because of these events, later affecting people's income.

Taking into account the critical situation affecting the rural communities inhabiting the region, Himalayan Action Research Centre (HARC) started need and landscape specific interventions based on the Integrated Risk Management approach promoted by the Partners for Resilience: Strategic Partnership programme, to support vulnerable communities of Naugaon to become more resilient in face of climate change and enhanced risk of disaster events.



**FIG 33: A STREAM IN NAUGAON WATERSHED**

## Chapter 7: Proposed Programmes - Strategies & Activities

*HARC demonstrated the integrated approach enabling inclusive participation of local community and government agencies enhancing relevance, effectiveness, and sustainability of activities with effective and sustainable outcomes. The approach was implemented in Naugaon watershed region reaching out to the 10 Gram panchayats and 1 Nagar Panchayat, covering a total of 1963 households.*

Partners for Resilience (PfR) strategic programme implementation in India is focussed on water-mediated risks which constitute a majority of disasters in the country and where application of IRM is expected to leverage change by connecting actions across various development and conservation sectors and at multiple scales. HARC being the technical and implementing partner for PfR in Uttarakhand, as part of the programme has been undertaking interventions to attain the objective of strengthening the community resilience through integrating ecosystem management and restoration and climate change adaptation into risk reduction approach into the development plans at various levels.

HARC demonstrated the integrated approach enabling inclusive participation of local community and government agencies enhancing relevance, effectiveness of the activities with effective and sustainable outcomes. The approach was implemented in Naugaon watershed region reaching out to the 10 Gram panchayats and 1 Nagar Panchayat, covering a total of 1963 households.

The intervention took a three pronged approach whereby activities were undertaken in the ambit of three clusters namely - Engagement with policy and decision making at different levels, Capacity building and Knowledge and Evidence building.

### 7.1. Capacity Building

HARC over the period of 5 years also undertook various capacity building programmes on various themes that enhance community knowledge and skill sets on individual and community preparedness towards resilience. Activities included techniques of spring Water rejuvenation, apple grafting, DRR orientation, Mock drills etc. Continuous interaction with PRI members, community leaders and members and organising trainings and awareness workshops at regular intervals aided in enhancing the knowledge of community towards Integrated watershed management through DRR. As a result, villages in the area have DRR committees formed and operations, which was earlier non-existent. Additionally there is increased awareness among people about disaster response and preparedness.

#### 6.1.1. Risk Management

Focussed on mitigating risks, trainings and orientation were imparted to different stakeholders by HARC. Some activities include:

1. Capacity building and training of CSOs and PRI members on IRM
2. Training of application of ESSVA (Ecosystem Service shared value assessment tool)
3. Training on emergency preparedness and disaster response with community members:
  - a) Search and Rescue
  - b) First Aid
  - c) CPR
  - d) SERV- Social Emergency Response Volunteer
  - e) Fire Hazards and Safety



*Creating an enabling environment for implementation of the watershed Management programmes require training and capacity building of different stakeholders based on their respective roles.*

4. Mock drill exercises on “Safe Evacuation and safe disposal in fire incident” with 5 schools of Naugaun watershed , more than 1000 students and teacher participated in the exercise from each school
5. Capacity building of community on participatory gram Panchayat development planning in 10 villages of Naugaun watershed
6. Capacity building of community on Hazard Risk Vulnerability Capacity Assessment

#### 6.1.2. Livelihoods

Focussed on reaching out to the most vulnerable, livelihood stood core to the IRM program in Naugaon by HARC. Stakeholders including famers, PRI members, Community were trained and oriented on activities which would enable them to become adapt to the climatic changes and minimize losses. Some activities included:

1. Training of PRIs on understanding weather forecast.
2. Establishing linkages between the government authorities and communities through workshops for example, A workshop namely, “A talk on- Agro-meteorology advisory: a boon for farming communities to reduce livelihood risks” was conducted for capacity building of community members of Naugaun watershed which was facilitated by representatives of Agromet advisory services division, Indian Metrological Department, Delhi, Directorate of Watershed, Uttarakhand .
3. Training by resource persons from agriculture department to PRIs and community members on practicing climate resilient livelihood
4. Orientation of PRIs on watershed management to reduce disaster risks and Need for practicing resilient livelihoods.



FIG 34: A WORKSHOP ON IRM IN MATIYALI VILLAGE

*Sustainable interventions require, activities, interventions, policies and plans, be prepared with due consideration to local contexts and prevailing situations. A knowledge base on watershed is a must for supporting the future plans and defining expected outcomes.*

### **6.1.3. Integrated Risk Management for Watershed Management**

Creating an enabling environment for implementation of the watershed Management programmes require training and capacity building of different stakeholders based on their respective roles. HARC organised multiple training and orientation sessions for different stakeholders like PRI members, community members etc. to create awareness and build their knowledge towards the program. Some of these activities included:

1. Capacity building programme on “Sustainable Planning of Naugaun watershed using IRM measures to support integrated watershed management” of Nagar (Naugaun) Panchayat members.
2. Capacity building programme with PRI members of watershed on” understanding GIS findings for village development planning
3. Training of Community members on their role in watershed management
4. Orientation of communities on development schemes that can be accessed for implementing GPDPs
5. Plantation activity in parts of Naugaun watershed like Matiyali village, Kwari, Bingsi, Kandaun, upper forest areas in coordination with Upper Yamuna catchment forest department Naugaun, Uttarkashi
6. Meeting with Van Panchayats Committees in Naugaun watershed for developing micro-plan, implementing environment conservation actions etc.
7. Workshops/ orientation sessions with Van Panchayat members on revision of Van Panchayat Manual.

## **7.2. Building Trust in Government Institutions and PRIs**

For ensuring that Panchayat Raj Institutions (PRIs) or Village level authority and Municipal Corporation integrates watershed management as a risk reduction measure in Gram Panchayat Development Plans and Nagar Panchayat Plans, activities were planned and conceptualised based on participatory risk analysis undertaken in the region by HARC.

HARC regularly conducted meetings with community members at ward level, carried out discussions with different community based organizations like market associations, parent teacher association, vegetable and fruit supply chain cooperatives, women help groups etc. on ascertaining their needs and possible solutions that would enable them to sustain the process of occurring development and which will maintain the ecological balance. Thus, taking a participatory approach to defining the activities.

Workshops and meetings were held with PRIs on introducing the concept of Integrated Risk Management into watershed. Interactions and continuous dialogues over the period of three years has led to increasing number of PRI members to consider the approach of integrated Watershed management in their development planning. Currently, 10 GPs in the region have already incorporated it in their plans.

A notable achievement in line with the above said outcome is the agreement with State Urban development department was on amendment of Nagar Panchayat Act and integration of watershed management actions into Naugaun Nagar Panchayat, agreement with SDMA to review Uttarkashi DDMP based on integration of watershed management and Agreement with State forest department to acknowledge the proposed changes in Van Panchayat manual incorporating Eco-DRR. Clearly the agreements by state, district and village authorities to integrate watershed management as a risk reduction measures to



*Based on participatory risk analysis the needs and the problems of the communities in the region were ascertained and the Eco-based interventions proposed, which were implemented using government funds for development.*

the plans and manuals implies their trust to rely on the integrated approach for building community resilience in the region.

Participatory Risk Assessment of communities and surveys of water springs in the Naugaon region provided insights indicating great need to rejuvenate water springs, as they were the primary and essential source of water in the proximity. After continuous advocacy with the authorities, the state forest department, included “Spring Rejuvenation” as a sub- programme, under one of the main intervention of the Compensatory Afforestation Fund Management and Planning Authority (CAMPA). Based on findings of various institutions or organizations along with witnessing of drying conditions of natural water streams of Uttarakhand hills, CAMPA steering committee of Uttarakhand decided to rejuvenate 560 springs, which have been identified in different districts of Uttarakhand under this programme in the state of Uttarakhand. Under the scheme water streams shall be rejuvenated, maintenance of pipe lines and irrigation channel shall be done. The aim is to enhance watershed management, water health and community livelihood by leveraging funds from developmental schemes, continuous engagement with policy influencers and decision making authorities at different levels and capacity building activities were undertaken. A detailed proposal was prepared by the steering committee with representative from HARC proving inputs and guidance to the state government. The development funds were leveraged and utilised undertaking training and implementing the programme in Naugaon.

HARC also proposed some prevention and risk reduction measures in the whole watershed, to be included under the state forest departments CAMPA programme. These includes plantation of more than 7500 plants on landslide prone terrain in Bingsi, Kimmi, Naini and Matiyali villages, soil conservation by retaining proposed wall and stone wall, rain water harvesting (by contour trenches and water holes), treatment of landslide area by diversion of streams and stabilization of slopes/embankments using geo- jute and vetiver root system . Naugaun Nagar Panchayat is a newly elected Panchayat ( which had recently come under the jurisdiction of urban development department), hence regulations for the panchayat had changed and therefore development plans for the area had to consider the urban perspective. HARC extended support to the new members of Naugaun Nagar Municipal Corporation in developing development plan, which included incorporating eco-based disaster risk reduction measures into development planning, that would help community people to mitigate impact of potential hazards, and secure their livelihoods. In the Nagar panchayat plan draft, prepared during a meeting between HARC and the members of the Municipal Corporation, among the various activities considered for watershed management, was construction of four water harvesting structure in the Municipal Corporation. HARC also suggested construction of water harvesting system as potential activity in micro planning.



FIG 35: A MULTI – STAKEHOLDER MEETING UNDERWAY

*HARC reached out to over 250 Panchayati Raj members and Nagar Panchayat members across 10 Villages and 1 Nagar Panchayat during the 5 year period encouraging and enabling them to develop Development Plans incorporating appropriate watershed management practices based on informed and inclusive decision making.*

### 7.3. Building a knowledge base

However, sustainable interventions require, activities, interventions, policies and plans, be prepared with due consideration to local contexts and prevailing situations. A knowledge base on watershed is a must for supporting the future plans and defining expected outcomes. The three year pilot programme entailed developing maps, evidences and reports through detailed analysis of Naugaon area. These include identifying physical vulnerability of Naugaon watershed through GIS mapping, status reports of water springs of 19 villages, Identification of recharge sites upstream, Soil report cards. Integrated risk assessments of the villages in the watershed area, Geo-informatics systems – NDVI, NDWI, Land surface temperature, hazard mapping, soil maps, database of types of vegetation, Hazard vulnerability assessment of villages, Comparative analysis of water discharge of well, GIS maps for the region etc. Currently, these details are available at the block level, which was missing three years earlier when the programme was initiated by HARC.

The methodology adopted by HARC for generating this knowledge database is involves use of scientific process being validated at the ground level through rigorous surveys and participatory mapping process.

In order to ensure that enough knowledge and evidence is available and localised parameters are well considered, in many cases, maps were also developed at the village level. For instance, the hazard zonation maps were prepared each of the 11 villages and accessible to the respective panchayat to ensure informed decision making during the preparation of development plans at the panchayat level.

#### List of Maps prepared

- Base Map
- Drainage Map
- Geomorphological Map
- Landslide Map
- Land Use/ Land Cover Map
- Digital Elevation Model
- Soil Map
- Recharge structure
- Village Map
- Agroclimatic zone

### 7.4. Implementing Watershed Management Activities

The interventions for application of IRM for Watershed Management in Naugaon by HARC was designed to leverage change by connecting actions across various development and conservation sectors and at multiple scales. Given below are activities undertaken by HARC bringing about the significant shift in the watershed management practices in the region:

#### Gram and Nagar Panchayat Development Planning

Mainstreaming the IRM based watershed management activities requires its integration into the Village/Nagar Development plans. HARC initiated the intervention with engaging with PRI members at village level and authorities at district and state level to review the existing Gram Panchayat Development Plans and understanding the prevailing issues. This was followed by numerous sessions with PRI members on understanding the existing issues & needs and orientation on concept of Integrated Risk Management into watershed etc. Interactions and



*Currently all 10 villages and Nagar panchayat has a DRR committee in place, which was formed as part of GPDP. The members are trained and oriented in basic emergency response skills. This has led to increased knowledge among communities to the threats and risks they face and has increased their capacities on life saving and safe evacuation techniques. HARC also reached out to more than 1000 children across five schools in the region, increasing awareness about the calamities and how to respond during crises.*

continuous dialogues over the period of five years, has yielded the much anticipated result of PRI members acknowledge, invest and integrate Watershed Management measures in their development plans. Increased capacities and knowledge has encouraged members of Gram Panchayat avail funds from Government development schemes to implement many of the activities for Watershed management based on IRM. HARC extended handholding support to each Village in the Nauagaon, review its existing plans, understand the gaps and provide framework based on participatory risk analysis in each village, to have village specific development plans.

Naugaon Village, which was earlier a gram panchayat. During the intervention period, the village was transitioned to Nagar Panchayat. As a result, the development plans had to be revised with regard to consideration to the guidelines for Nagar Panchayat. HARC also conducted numerous workshops with new elected members of Nauagaon Nagar Panchayat, appraising them of the Nagar Panchayat Guidelines, support in formulating the Development plan in line with government guidelines etc.

HARC reached out to over 100 PRI members, community members and representatives of community institutions during the 5 year period encouraging and enabling them to develop Development Plans incorporating appropriate watershed management practices based on informed and inclusive decision making.



**FIG 36: MEETING WITH PRI ON REVISION OF GPDP**

## Assessments

To build a strong knowledge base for ensuring informed decision making by authorities and community members, HARC undertook various assessments including HVCRA, ESSVA, GIS mapping etc. to generate information pertaining to risks, threats, existing capacities, preferences, conditions etc. The assessments were conducted at village level, such that all 10 villages and 1 Nagar panchayat were covered. For HVCRA, 150 households were covered and for ESSVA, 545 households were reached in the region. This ensured participation by over 35% of households in the assessments.

The assessments were also designed and identified such that each kind of stakeholder is considered, especially the most vulnerable ones. Multiple tools including household survey, Focussed group discussions, one to one interviews, stakeholder specific meetings like with teachers, self help groups, Business men etc. were used by HARC to assess and validate the information. The scientific data was also validated through on-ground assessments.

HARC also undertook workshops to enable the PRI members to understand the importance and relevance of the findings and capacity building to take appropriate actions in this regard. For example two day awareness workshop on understanding analytical findings of geo hazard mapping, land use and land cover mapping of Naugaun watershed was undertaken with 30 PRI members from different villages. The results thereby generated enabled the community members to take informed decision while developing their GPDPs.



**FIG 37: PARTICIPATORY RISK ASSESSMENT THROUGH VILLAGE MAPPING**



### Capacity building for DRR

Based on the risk profiling and hazard vulnerability assessment, a clear need of Emergency preparedness and disaster response systems at the local level was evident. HARC focussed on developing the capacities of the communities towards the disaster response in order to keep the losses at the minimum. During the five year period HARC organised various orientation sessions, training and awareness workshops with community members including Orientation Programme for the community about the need of first responders, First Medical Responders/First Aid training, training on light search and rescue, Training on emergency preparedness and disaster response with community members, Mock drills and orientation session at schools etc.

As a result, currently all 10 villages and Nagar panchayat has a DRR committee in place, which was formed as part of GPDP. The members are trained and oriented in basic emergency response skills. This has led to increased knowledge among communities to the threats and risks they face and has increased their capacities on life saving and safe evacuation techniques. HARC also reached out to more than 1000 children across five schools in the region, increasing awareness about the calamities and how to respond during crises.



**FIG 38: TRAINING & CAPACITY BUILDING OF COMMUNITY MEMBERS**

## Ecosystem restoration and management

To promote restoration of the ecosystem and its management, it was important to increase the existing knowledge of the community about their environment. An efficient management system calls for increased participation of communities and therefore activities towards building awareness and sensitivity of the communities towards the issue was extremely crucial. Additionally, promotion of livelihood options that are in sync with the ecosystem is essential for sustained livelihood and wellbeing of the communities.

HARC undertook numerous workshops and orientation sessions with the communities in Naugaon watershed, at village and Nagar Panchayat level. Some activities included – Village level Workshop on identification of measures for safeguarding ecosystem conducted across the 10 villages, Workshop on Promoting livelihoods by innovation in temperate horticulture crops in Garhwal and Kumaun regions, conducted at block level, Promotion of Agro- Advisory services through Weather station, Plantation programmes, Workshop on orientation of Insurance schemes for horticulture etc.

As a result increased knowledge of the communities are reflected as most of the communities are now resorting to locally available material for fencing agriculture and horticulture land. Plantation activities in the area has increased. Maintaining cleanliness and fire lines in forest areas to prevent loss from forest fires is being practised across the region.

In a survey conducted by HARC in Naugaon watershed to calculate discharge rate of perennial and non-perennial streams, it was found that water discharge rate has declined in almost 10-12 springs out of 31 surveyed springs. Possible solution to the problem is to restore spring sheds and even augment groundwater recharge to increase the amount and duration of spring discharge. HARC being a part of steering committee meeting of CAMPA (State Forest Department, Uttarakhand) voiced out the community concern to rejuvenate and restore the drying natural springs and rivers that are source of living to communities around the globe, and augmented with studies conducted by various CSOs on discharge rate of perennial and non-perennial streams. As a result the State forest department initiated the “Stream Rejuvenation and restoration programme” in 2018 for treatment of catchment of 57 springs with the help of plantation, creation of contour trenches, recharge structures and recharge pits etc. HARC conducted a pilot on spring rejuvenation to address the issue of water recharge in the springs considering different aspects of geology and hydrological settings. HARC provided trainings on the concept of hydrogeology and water management to community members. Later, community members with support of forest department and under MGNREGA programme created contour trenches and recharge pits in the eroded areas and at high reaches of watershed.

## Capacity building on climate change adaptation and livelihoods

The impact of climate change was evident in the assessments and therefore increased sensitivity of communities towards it and also knowledge of practices and options that enable climate change adaptation was crucial in the region. HARC intended to increase awareness among the community on importance of weather advisory and early warning information systems, adopting climate resilient and disease control, thermal resistant varieties of crops and promote Rain harvesting structures, check dams and solar energy etc.

HARC organised workshops such as Orientation programme on climate and disaster management at Naugaon, attended by 108 people including community

*HARC also organised workshops and training sessions for farmers in Naugaon on various aspects like climate resilient cropping, Agro-Climate advisory, orientation on Government Insurance Schemes, Marketing strategies for vegetable and fruit producers etc. HARC reached out to over 200 farmers in the region through the above said activities.*



members, PRI members, Block officers etc. This aided in increasing awareness and acceptance among the community members towards climate change and need to focus on adaptation measures especially in livelihoods.

HARC also organised workshops and training sessions for farmers in Naugaon on various aspects like climate resilient cropping, Agro-Climate advisory, orientation on Government Insurance Schemes, Marketing strategies for vegetable and fruit producers etc. HARC reached out to over 200 farmers in the region through the above said activities.

HARC focussed its intervention on two major deliverables– Climate resilient cropping and increased access to reliable & authentic information to minimize livelihood risks of agricultural economy through automated weather station.

With support from Block Development office and State Disaster Management Authority, an automated Weather Station was established in the block development office of Naugaon watershed, the weather station provides agro-advisories to the farmers in the region based on the climate forecasts through text messages on their cell phones. This is expected to reduce the crop loss in case of extreme weather event, or planting of crops based on the expected forecasted to avoid losses and increase income for the farmers and their families.

Government funds were also utilised at the village level in other Eco-based DRR practices as at the panchayat level planning like Vermi compost pits under MGNREGA, Reconstruction of irrigation channel, Drip Irrigation, Solid Waste Mgt Unit, MGNREGA (flood control and protection/rural sanitation/land development), Solar lights, Socio-economic security (Widow/Old age-12000/person; Kanyadhan 50000) etc. Each of these activities was focussed on either enhanced and sustained livelihoods or reducing risks in the region or both.

Multiple climate resilient crop varieties were identified and the scientific package of practices in farming of these crops was imparted to the farmers in the region. By applying the knowledge of scientific package of practices in farming, farmers can increase the production of crop and also improve the soil health. Increased yield is expected to increase income and thereby increasing purchasing power of the households.



FIG 39: APPLE ROOTSTOCK CULTIVATION IN A POLY HOUSE IN NAUGAON



The process was initiated with organising Soil health awareness camp across 20 villages with participation by 433 people.

Different crops that were demonstrated and produced by farmers in Naugaon, based on training and recommendation from HARC, as part of the three year intervention and undertaken using the government funds. Refer to Annexure for more details.

Reduced soil health in the region was a major concern considering that agriculture is the primary source of income in the region. HARC focussed a part of its intervention on enabling farmers in the region improve the soil quality of the region, thereby increasing the yield. The process was initiated with organising Soil health awareness camp across 20 villages with participation by 433 people. Soil Samples were collected from different parts of the watershed and tested. Soil health cards were then prepared based on test results and recommendations to the farmers to maintain soil health, other crop options appropriate to soil conditions etc.



FIG 40: SOIL SAMPLE COLLECTION FOR TESTS

FIG 42: SOIL HEALTH CARD (OUTSIDE COVER)

**मृदा स्वास्थ्य कार्ड**  
**SOIL HEALTH CARD**

कार्ड संख्या 2aH/WK/U-03

नाम विशना रावत

पिता/पति का नाम मनोज रावत

गाँव मुब्बाना

ब्लाक मोगांव

जिला उत्तरकाशी

राज्य उत्तराखण्ड

### भौगोलिक परिस्थिति

मोबाइल नंबर

अधिक जानकारी हेतु सम्पर्क करें:-

मृदा परीक्षण प्रयोगशाला

हिमालयन एक्शन रिसर्च सेन्टर (हार्क)

नौगाँव, उत्तरकाशी, फोन न० : 01375-245272

[illegible]

**FIG 41: SOIL HEATH CARD (INSIDE)**



## Van Panchayat

Yet another focus of HARC's intervention was focussed on Forest cover in the region. The forest plays a very crucial role in maintaining the ecosystem in the region and therefore, HARC worked closely with the Van panchayats in the region. HARC organised capacity building program for the Van Panchayat Samitis & Gram Pradhans on Role of Van Panchayat in addressing Climatological Risks through Sustainable Planning. Further, HARC also supported the bodies in developing plan specific to forest, water and soil conservation under CAMPA programme for Naugaun watershed.

HARC through participatory assesments, workshops and meetings, enabled integration of Watershed Management Practices in the Van Panchayat Manaul. The Van Panchayat manual of the region was revised with inputs from the community and officials, and in congruence with the watershed management plans of the villages.

## 7.5. Conclusion

The interventions for enhancing watershed health and community livelihoods in the region were conceptualised based on intergration of the watershed management practices in the Gram Panchayat development Plans. Based on assesments and participatory risk analysis the needs and the problems of the communities in the region were ascertained and the IRM based interventions were collectively determined in the GPDM. These were then implemented using government funds for development. The technical guidance was imparted to the CSOs and community members by HARC.

Clearly, increased knowledge and capacities of communities and PRIs on watershed management plays a crucial as part in Community development planning. Integrated approaches which give due consideration to Disaster Risk Reduction, Climate Chance Adaptation and Ecosystem Management and Restoration ensures sustainable development.



**FIG 43: AWARENESS CAMP ON SOIL HEALTH AND NUTRITION BEING HELD IN NAUGAON**

## Chapter 8: Way forward

Essentially, the Watershed management approach adopted by HARC through IRM based activities were driven by the objective of Disaster Risk Reduction, Climate change adaptation and Livelihood enhancement, and focussed on the most vulnerable communities. It did have substantive impact with least stress on the existing fragile environment. The focus on DRR and climate change has ensured that no future risk are created and the existing stress is reduced to some extend. HARC's five-year intervention in Naugaon indicates high feasibility for up-scaling the approach and also replicability of similar approach in watershed in alike terrain.

For future, while IRM approach with dynamic multi sectoral approach can remain the core of the watershed management strategy, the activities must be driven by the objective for enhanced of livelihood and income in the region with due consideration to vulnerability of the region. Some recommendations are as under:

*Naugaon doesn't have any big industrial setup or any secondary sector that provides employment. Therefore diversification in occupation is a challenge for the population. Low household incomes over a period of time has also led to increase in migration of local inhabitants to cities in search of better income, better education for their kids and to ensure secure source of income for future.*

### 8.1. Mountain livelihood

Agriculture and livestock rearing is the primary occupation of the communities in the region. This has made people more dependent on their immediate environment for ensuring productivity. Recurrent water crises in the region owing to increasing temprature and changing climate, has been a major concern for farmers. Agriculture is the only source of income for most families residing in the region. Streams are the mainsource of water for irrigation, but with these streams drying up and the looming water crises, making the ends meet has become a struggle for the farmers. Further, in the past years there have been instances of heavy rains, floods and landslides causing severe destruction to the standing crops. The situation is extremley precarious for most farmers. Diversified livelihood options are the call of the hour for most families to survive.

Naugaon doesn't have any big industrial setup or any secondary sector that provides employment. Therefore diversification in occupation is a challenge for the population. Low household incomes over a period of time has also led to increase in migration of local inhabitants to cities in search of better income, better education for their kids and to ensure secure source of income for future.

However, lately the security of migrants and their livelihoods in citiies threatened owing to emergency situations like Covid pandemic, in cities. Most are back to their families in Naugaon but low income issues and unemployment situated has aggravated.

The diversified livelihood options which still remains unaddressed largely, need a dynamic approach encompassing investement and development of holistic policies. The focus of investment into the region and the policies must not only be limited to provisions of employment, education and improved health but also on creating diversified livelihood options and food security for the people. Development policies must have a multi-sectoral approach.

Over the last few years, HARC has been able to bring about small but significant changes in helping the farmers in the region increase their income. Farmers have been loosing income owing to Changes in weather and climate which reduced the agricultural yield. With increased awareness and training, there have been increasing number of farmers resorting to farming of seasonal vegetables, which has led to increase in their disposable income. These vegetables are being

*Current Covid -19 Pandemic too created a crises situation with limited access to community to distant markets owing to lockdown and fear of spread of virus. In such situations self sustained provisions of food is essential for such far flung communities. Food security is be defined as the new approach for farmers in the region to accept and promote climate resilient cropping,*

exported to Delhi through local cooperative societies. The Mother Dairy in Delhi is the largest marketing agency for these cooperative societies where they sell whole farm produce. Apart from this, farmers of Naugaun watershed are shifting to floriculture as they able to find market for flowers, main flowers grown by farmers in the valley are Lilium and chrysanthemum. Hence, diversification of livelihood options provides farmers of watershed a sense of economic security.

## **8.2. Food Security**

The introduction of climate resilient cropping must be promoted as way forward. This aspect needs more emphasis in the future, for a more coherent approach to improve local food security and reduce food shortages while reversing degradation trends and improving soil fertility on sloping lands in upstream areas. Areas that need to be maintained for local food security, e.g. home gardens, community forestry woodlots or fish ponds, to ensure healthy, nutritious and diverse food for current and future. Since area is extremely prone to recurrent disasters like heavy rainfall, landslides, floods; food security is an important element to be considered as part of future development plans. Current Covid -19 Pandemic too created a crises situation with limited access to community to distant markets owing to lockdown and fear of spread of virus. In such situations self sustained provisions of food is essential for such far flung communities. Food security is be defined as the new approach for farmers in the region to accept and promote climate resilient cropping, especially of crops with higher shelf life or those which do not require huge land holdings but can be encouraged at household levels in kitchen gardens.

## **8.3. Green development**

**Considering the vast forest cover and the fragile environment, there is a need to manage and preserve the environment along with the development so that ecosystem services are maintained yet the livelihood continues to grow. HARC suggests incorporation of the green growth and development in future plans and initiatives in the region.**

According to Thirteenth Finance Commission Report(India), Green growth involves rethinking growth strategies with regard to their impact(s) on environmental sustainability and the environmental resources available to poor and vulnerable groups. It means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.

Some of the reccomendation in this regard to be considered in the future plans include:

- Initiatives towards conservation of environment especially the forests.
- Climate friendly agricultural development plan specially for mountains.
- Increased livelihood diversification strategies and plans so that people are better able to adapt to climate change.
- Restore and maintain ecosystems as they are lifelines for mountain people.
- Landscape based development planning with less grey development so as to increase green economy.

#### 8.4. Spring Water management

Surveys reveal that water discharge rate of 18 out of 31 streams in the region has gone down leading to lesser water level in 3 perennial streams that creates water crisis, and puts community's livelihood activities on hold. Communities are dependent on natural spring water for domestic and livelihood needs like drinking water and irrigation. Community faces water shortage in summer season and poor quality water in monsoons. While the current interventions are planned with minimum future risk, measures must be adopted to manage quantity of water being drawn from the springs.

Measures must be adopted that stop exploitation and reduces stress on the springs. These may include water security planning, monitoring supply and demand service of water, waste water treatment and rejuvenation of water springs etc.

HARC is providing technical and non-technical support to the block level forest department for rejuvenation of three springs in Naugaon watershed. These were identified based on water discharge rate survey of water streams, risk assessment and transect walk carried out with the participation of local community members to identify degraded natural water streams. A total of 10 streams were identified to be degraded releasing less than the required amount to sustain continued supply to households.

In total three springs were restored in Naugaon watershed which will provide sustainable access to water for 593 households.

*The way forward demands a community managed biodiversity conservation based practices and investments in the region. It is recommended that a model could be developed which would be ideal for similar contexts and development plans through landscape-based development planning could be set in Naugaon block.*

#### 8.5 Landslide prevention by plantation of native species in run-off zones

Naugaon region is a landslide prone area, with the risk of damage to assets and livelihoods, especially during monsoon season. The frequent landslides not only destroy lives but also destroy crops, reduce soil fertility and disrupt the natural ecosystem. Based on pre and post satellite data analysis, eight landslide prone areas have been identified in Naugaon watershed. To reduce the risk of landslide, HARC has proposed prevention measures in the whole watershed, to be included under the state forest departments CAMPA programme. This includes plantation of more than 5000 plants on landslide prone terrain in Bingsi, Kimmi, Naini and Matiyali villages, soil conservation by retaining proposed wall and stone wall, rain water harvesting (by contour trenches and water holes), treatment of landslide area by diversion of streams and stabilization of slopes/embankments using geojute and vetiver root system. Since these activities are seasonal, resource dependent and still in the inception stage, the tangible results are not yet visible. However, these activities are a first step in the right direction on the path to developing climate resilient communities. Native flora such as Banj Oak (*Leucotrichophora*) Aldre tree (*Utish*), Salacca (*Salak*), Vitex, (*Synax*) and locally endemic grass like (*Magar*, *Baans*, *Kaans*, *Mooj*).

#### 8.6. Renewable sources

HARC had promoted a few renewable sources like solar lights as part of pilot project in Naugaon watershed. However, use of more such renewable sources and alternate energy sources or technologies much be considered in future plans. The technologies identified should be low cost and must have least or no negative impacts on the current fragile ecosystem of the region. Low cost solutions must



be encouraged to ensure that the focus of interventions and plans continues to be marginalised and most vulnerable population.

### **8.7. COVID Challenges**

Like in most parts of the country, Naugaon too witnessed a reverse trend during lockdown period owing to covid. A large number of population who had migrated to urban centres of the country, returned to their homes. Almost all of them engaged in the informal sector or low paying jobs in the urban centres, have lost their jobs in the period, now plan to stay back with families. As primary occupation in the region is agriculture, most of these people are expected to resort to farming. Hence it is crucial that new technologies and solutions for cropping be adopted which increases the income and employment prospects in the region in farming.

### **8.8. Conclusion**

Clearly, the way forward demands a community managed biodiversity conservation based practices and investments in the region. It is recommended that a model could be developed which would be ideal for similar contexts and development plans through landscape-based development planning could be set in Naugaun block. The plan will address the climate induced ecosystem or disaster issues identified in Naugaun watershed which underlines the need for restoration of ecosystem services through sustainable utilization and conservation of critical natural resources, particularly, land, water, forests, and biodiversity; engaging stakeholders like scientific institutions/experts, decision makers, and investors etc. to provide alternatives for energy consumptions, water security and food-economic security; and further evolving effective climate change adaptation and disaster risk reduction strategies with the knowledge of community who are curators of the landscape; and mainstreaming it into the overall process of development programmes /policies, particularly at watershed level is the crucial need of hour.

## Annexure: Details of increasing incomes through watershed management

**Table 5:** Different crops that were demonstrated and produced by farmers in Naugaon

Name of the variety	Characteristics	# of Farmers who have demonstrated in Naugaon	Production days	Land required for cultivation per farmer	Crops Replaced	Crop yield (kgs/nali)	Increase in income
<b>Cabbage Varun and Golden</b>	<ul style="list-style-type: none"> <li>High yielding</li> <li>Suitable for different climates</li> </ul>	209	60 to 75 days	0.02 Ha	pulsed and leafy green vegetable	400-500 kg/nali.	Rs 3250 more income from same covered area.
<b>Tomato Himsona</b>	<ul style="list-style-type: none"> <li>High yielding</li> <li>Suitable for different climates.</li> <li>Durable for long transportation</li> <li>Resistant to heavy rain and diseases.</li> </ul>	209	90 to 120 days	0.04 Ha	Naveen, Naveen 2000+, sonam etc.	250-350 kg/nali.	Rs 2100-4500 more income from same covered area.
<b>Capsicum YI Tanvi</b>	<ul style="list-style-type: none"> <li>High yielding</li> <li>Suitable for different climates.</li> <li>Enhanced shelf life</li> <li>Resistant to heavy rain and diseases.</li> </ul>	210	60 to 90 days	0.02 Ha	Traditional Capsicum & Cucumber other varieties like Sonali, Chitra & subhi, etc	800-1200 kg / nali	Rs 1000-12000 more income from same covered area
<b>SL onion</b>	<ul style="list-style-type: none"> <li>Kharif crop. long shelf life Higher market demand</li> </ul>	212	160-170 Days	0.04 Ha	Traditional onion	180-220 kg/nali.	Rs 1000-1500 more income from same covered area
<b>French Makhmali &amp; Golden</b>	<ul style="list-style-type: none"> <li>Green and long shaped variety.</li> <li>Suitable to the climate</li> <li>High market demand</li> </ul>	675	80-90 Days	0.02 Ha	Other vegetable Brinjal, green leafy Local varieties	110-150 kg/nali	Rs 11200-2260 more income from same covered area
<b>Cucumber Sardar 108</b>	<ul style="list-style-type: none"> <li>Green and cylinder long shaped variety</li> <li>Higher yield</li> </ul>	21	80-90 Days	0.02 Ha	Other Local varieties	110-130 kg/nali.	Rs 500-900 more income

Peas GS 10	<ul style="list-style-type: none"> <li>• High market demand</li> </ul>				of cucumbe r		from same covered area
	<ul style="list-style-type: none"> <li>• Four time more Yield</li> <li>• Suitable to climate</li> <li>• Higher quality</li> </ul>	450	60- 90 days	0.02 Ha	Tradition al Peas	140-160 kg/nali.	Rs 900-35000 more income from same covered area
	<ul style="list-style-type: none"> <li>• Spicy crop</li> <li>• Alternate source of Income</li> <li>• Improves soil health</li> <li>• Medicinal value</li> </ul>	450	150 to 180 days	0.02 Ha	Pulses	200-250 kg/nali	Rs 8400-10000 more income from same covered area
Turmeric Pratibha	<ul style="list-style-type: none"> <li>• Alternate source of Income</li> <li>• Improves soil health</li> <li>• Medicinal value</li> </ul>	3	200 to 240 days	0.02 Ha	Chillies	120-140 kg/nali	Rs 2400-4400 more income from same covered area
Kala Bhat	<ul style="list-style-type: none"> <li>• Variety of Millets</li> <li>• rich nutrient value crops</li> <li>• Alternate source of Income</li> <li>• Improves soil health</li> </ul>	115	150 – 180 days	the 0.02 Ha	Soya bean	20-22 kg/nali	Rs 480-520 more income from same covered area
Chrythensimu m Promina & Yellow star	<ul style="list-style-type: none"> <li>• Variety of flower crop</li> <li>• Improves soil health</li> <li>• Good Market demand</li> </ul>	76	150 – 180 days	0.02 Ha	Unused land	300-350 kg/nali	Rs8700-10000 by introduc ing the crop
Paddy VL 85	<ul style="list-style-type: none"> <li>• Variety of paddy.</li> <li>• Resistant to blast.</li> <li>• Double yield than traditional variety.</li> <li>• Diseases Resistant</li> <li>• High shelf life.</li> </ul>	346		0.02 Ha	Tradition al paddy	40-45 kg/nali	Increased food stock for household consumption.



## References

- 1 FAO. 2017. Watershed management in action – lessons learned from FAO field projects. Rome.  
<http://www.fao.org/3/a-i8087e.pdf>
- 2 IRI, Roorkee. 2018. A Report On State Specific Action Plan for Water Sector Uttarakhand by IRI Roorkee, National Water Mission India  
[http://nwm.gov.in/sites/default/files/Report\\_Draft\\_SSAP\\_Uttarakhand.pdf](http://nwm.gov.in/sites/default/files/Report_Draft_SSAP_Uttarakhand.pdf)
- 3 Sharma, Mridula. 2017. Climate change, population Drift and Violent Conflict over land Resources in Uttarakhand. India  
<http://www.iosrjournals.org/iosr-iestft/papers/vol11-issue%202/Version-1/L1102017682.pdf>
- 4 Water for Welfare, An Uttarakhand State Government Initiative  
[https://www.iitr.ac.in/wfw/user\\_group\\_watershed.htm](https://www.iitr.ac.in/wfw/user_group_watershed.htm)
- 5 Joshi. 2018. Recent Trends of Rural Out-migration and its Socio-economic and Environmental Impacts in Uttarakhand Himalaya. India  
<https://core.ac.uk/download/pdf/222961853.pdf>
- 6 WWF. WWF Water Security Series 4, Understanding Water Risks, A Primer on the Consequences of Water Scarcity for Government and Business.  
[https://d2ouvy59p0dg6k.cloudfront.net/downloads/understanding\\_water\\_risk\\_iv.pdf](https://d2ouvy59p0dg6k.cloudfront.net/downloads/understanding_water_risk_iv.pdf)
- 7 NITI Aayog. 2018. Report of Working Group I Inventory and Revival of Springs in the Himalayas for Water Security. India  
[https://niti.gov.in/writereaddata/files/document\\_publication/doc1.pdf](https://niti.gov.in/writereaddata/files/document_publication/doc1.pdf)
- 8 ACWADAM. Hydrogeology in Watershed Planning. Pune. India  
<https://www.indiawaterportal.org/sites/indiawaterportal.org/files/GW-mapping.pdf>
- 9 Central Ground Water Board (CGWB), GOI. District Groundwater Brochure, Uttarkashi District, Uttarakhand. India  
[http://cgwb.gov.in/District\\_Profile/Uttarakhand/UTTARAKASHI.pdf](http://cgwb.gov.in/District_Profile/Uttarakhand/UTTARAKASHI.pdf)
- 10 Prasad, Badrinath & Eaturu. 2008. Effects of precipitation, temperature and topographic parameters on evergreen vegetation greenery in the Western Ghats, India  
<https://rmets.onlinelibrary.wiley.com/doi/pdfdirect/10.1002/joc.1662>
- 11 Lexer & Bugmann. 2017. Mountain forest management in a changing world.  
<https://link.springer.com/article/10.1007/s10342-017-1082-z>
- 12 District Disaster Management Authority - Uttarkashi. 2019. Uttarkashi District Disaster Management Plan. India
- 13 Water for Welfare, An Uttarakhand State Government Initiative. Webpage  
<https://rb.gy/kgq8tt>
- 14 Kelkar, Narula, Sharma & Chandna. 2008. Vulnerability and adaptation to climate variability and water stress in Uttarakhand State, India.  
<http://water.columbia.edu/files/2011/11/Kapil%202008%20Vulnerability.pdf>

