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Traditional Practices for Survival in Resource Depleted Himalayan Region: Challenges Put Forth by Climate Change and Response of Local Communities

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ABSTRACT

Based upon the strength of their traditional farming and resource management strategies the people living in the Niti, Bhagirathi, Byans and Johar valleys of Higher Himalaya in Uttarakhand Himalaya (India) have been managing good livelihood standard despite constraints put forth by physiography, climate and resource availability. Evidences suggest that the masses have started to experience impact of changing climate that is generally manifested in the form of changes in hydrology, phenology, agricultural productivity, faunal and floral population. Perceived adverse impact of these on life and livelihood strategy of the people has forced them lately to introduce many changes in their traditional life support pursuits. Acknowledged as being adaptation strategies these are documented but are analysed as being short of what is required. To be successful these are required to be better engineered and innovated with amalgamation of traditional knowledge and promoted aggressively to speed up the adaptation process.

Keywords: *Himalaya, Uttarakhand, Bhagirathi, Niti, Byans, Johar, Traditional Knowledge, Climate Change, Phenology, Adaptation, Coping Mechanisms.*

1. INTRODUCTION

Resources in the higher reaches of Himalaya have always been scare. The challenges put forth by climatic and physiographic conditions further make human survival difficult in this terrain. Based on traditional knowledge of generations the people living in this region however fine-tuned and developed resource management practices that ensure optimal utilisation of the available resources. Recent changes in climatic conditions however pose a threat to the sustainability of agriculture and allied sectors in the Himalayan region besides depleting natural resource availability.

Besides documenting resource management practices of the people living in the valleys of Higher Himalayas that are highly sensitive to changes in climatic parameters this study is an attempt to assess the impact of these changes on life support strategy of the people and to document the efforts being made by them to cope up with this impact.

Habitations located in the northern frontier of the Uttarakhand state that are largely populated by the people of Bhotiya tribe are taken up for the present study (Fig. 1), with specific focus on 73 villages of Johar, Byans and Niti valleys together with upper reaches of Bhagirathi valley. Of these 26 are located in the upper reaches of Bhagirathi river valley in Bhatwari subdivision of Uttarkashi district (Fig. 2). 16 are located in Niti valley in Joshimath subdivision of Chamoli district that is drained by Dhauliganga river (Fig. 3). 24 villages are located in Johar valley in Munsyari subdivision of Pithoragarh district that is drained by Goriganga river (Fig. 4). Another 07 villages are located in Byans valley of Dharchula subdivision of Pithoragarh district that is drained by Kali river that marks the boundary between India and Nepal (Fig. 4).

Fig. 1. Location of the four valleys taken up under the present study.

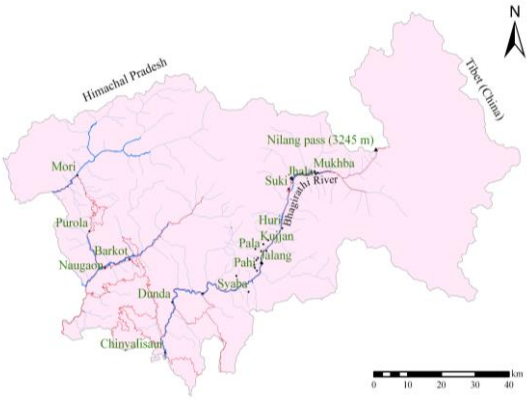

Fig. 2. Location of the villages covered under the study in Bhagirathi valley of Uttarkashi district.

Fig. 3. Location of the villages covered under the study in Niti valley of Chamoli district

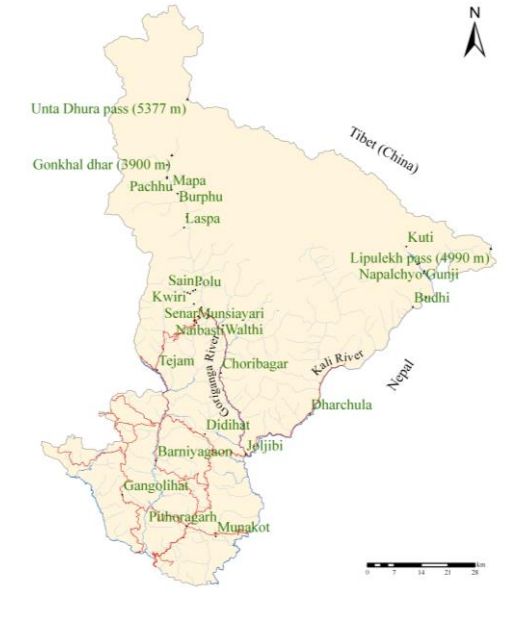

Fig. 4. Location of the villages covered under the study in Johar and Byans valleys of Pithoragarh district.

Bhotiya tribe constitutes majority population of the study area. Trans - Himalayan trade used to be their traditional pursuit until the same was closed after Sino – Indian conflict of 1962. For transporting various tradable commodities from terai, in the foothills of Himalaya that used to be their abode during harsh winter months, to Tibet traversing high-altitude passes and rugged Himalayan terrain they maintained large animal herds. On their way they bartered tradable commodities with the local inhabitants and ensured variety in the economy of the region besides infusing new vigour into the economy of this region.

Closure of cross border trade forced the people to pay attention towards settled agriculture for supplementing their income from trade. Lipulekh pass of the study area is first Indian border post to be opened for trade with China in 1992. This was followed by the opening of Shipki La in Himachal Pradesh in 1994 and Nathu La in Sikkim in 2006. Presently,

Lipulekh pass is open for cross-border trade every year from June through September and people of the area still engage in traditional cross border trade. Their ethnic characteristics and linguistic skills together with traditional acumen to traverse difficult terrain that is still largely traversed on foot help them dominate this trade.

Most people of the study area still resort to seasonal migration and live at high altitude in summer (May - June to October - November) and migrate to lower altitudes around November till April.

The present study is an attempt to take stock of changing climate from the perspective of the inhabitants of the study

area. An objective methodology is evolved to identify and quantify climate induced changes through interaction with the community members. The response of the masses is recorded using a specially designed semi-structured questionnaire and recourse is also taken to focused group discussions, in-depth interviews and key informant interviews.

Responses of 871 persons from 73 villages of the four identified valleys are recorded and besides this, recourse is taken to focused group discussions, in-depth interviews and key informant interviews. Special care is taken to select elderly people for response as they have memories of longer time span. Gender balance is resorted to in the responses. Proportions of male and female respondents are 46 and 54 percent respectively. The age profile of respondents is; 35 - 40 years 24 percent, 41 - 45 years 14 percent, 46 - 50 years 11 percent, 50 - 55 years 13 percent, 55 - 60 years 11 percent and > 60 years 27 percent (Fig. 5).

2. TRADITIONAL PRACTICES RELATED TO AGRICULTURE

People traditionally living in this resource deficient region, based on their experience and accumulated knowledge of generations devised various practices that ensured optimal and prolonged resource utilisation. Details of some of these are gathered from the area during the course of the present study.

2.1. Terrace farming and bunding

Contour aligned terraces is the product of the quest of the people of the region to maximize agricultural area in the mountains. It is practiced in many hilly or mountainous regions of the world for transforming landscape in to stepped agro-systems [1]. According to a responder in Barsu village of Bhagirathi valley, "The quest for bringing more area under agriculture would have led people to level the hill slopes. It would not have been possible to level large area in the mountainous slopes and therefore they would have started to build terraces on slopes". Pointing out the benefits of terracing he added, "It is useful for checking soil erosion and this structure is an effective measure for it and still practiced in the region."

Besides conserving water these at the same time provide stability of the fragile slopes that are prone to mass wastage. In order to conserve rainwater and to reduce soil losses from surface erosion agricultural fields are tilled perpendicular to the slope direction. Furrows and crop rows aligned across the slope improve rainwater retention, thus permitting increased infiltration and more uniform distribution of the moisture. Apart from this contour aligned dry stone walls are also utilised for checking soil erosion. These also prevent stray livestock from sneaking into farmlands.

Contour aligned bunds are traditionally constructed at the outer edge of the agricultural fields and these are planted with grass that acts as soil binder. These also help in reducing surface runoff and soil erosion. Grasses growing on the bunds are regularly trimmed and used as livestock feed and mulch. Grasses have the advantage of getting easily established, although these could compete for moisture in water deficient situations. The people through their experience however know that the water being stored behind the bunds has to be managed and excessive stagnation of water can lead to failure of the terrace. Bunds are therefore not constructed in far flung terraces that are hard to manage during monsoon period. Bunds are also observed in non-agricultural areas like the area above the habitations as also around pastures. In these places these help in moisture retention and growth of pastures.

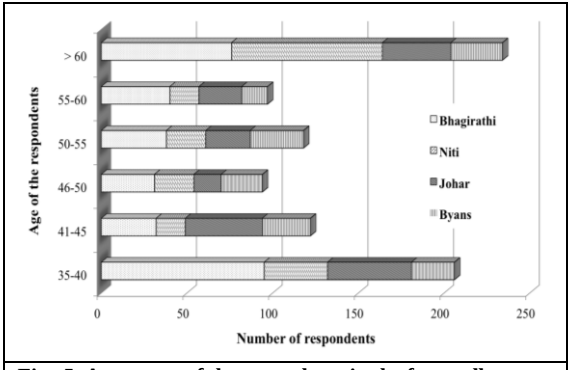

Fig . 5. Age group of the repondents in the four valleys.

2.2. Water diversion for irrigation

Even though gifted with ample rainfall steep topography of the region promotes quick runoff and most area of the region is still rain fed. The people of the region traditionally used to divert water of the subsidiary streams from a relatively higher elevation through a network of unlined channels, called *gool* in local parlance. Gravity driven flow of water through these ensured minimal moisture levels in the agricultural terraces. The rights over water were regulated by tradition and customary rules framed for sharing the same. This ensured that there are no conflicts related to water.

2.3. Mixed cropping

The practice of mixed cropping is reported to be common in the area. In the event of some particular crop being damaged, this practice assures return from other crops. This is, at the same time, perceived to maintain soil fertility and productivity and conserve soil. *Barahanaja*, meaning twelve crops, is the traditional practice of mixed cropping of the area. In this a combination of twelve different crop varieties chosen from amongst various cereals, millets, pulses, oilseed, vegetable, spices, and fibres are sown together in terraced fields. Traditionally this combination consists of i) 3 – 4 cereals chosen from amongst mandua (finger millet, *Eleusine coracana*), ramdana (*Amaranthus* sp.), kuttu / ogal (buckwheat, *Fagopyrum esculentum*), jwar (*Sorghum sp.)* and makki (corn, *Zea mays*), ii) 3 – 4 pulse varieties from rajma (*Phaseolus vulgaris*), lobia (*Vigna unguiculata*), ragadwas, tor (*Cajanus sp.*), bhatt (*Glycine max*), gehat (*Macrotyloma uniflorum*), local cow pea (satrangi / riyans / naurangi), urad (*Vigna mungo*) and mung(*Vigna radiata*), iii) 2 – 3 types of oilseeds from amongst til (sesame), bhangjeer (*Perilla fruiticense*) and bhang (*Cannabis sativa*), iv) a combination of vegetables that include kheera (cucumber) and spices like jakhiya (*Cleome viscose*) and v) fiber plants that include sann or patsan (*Hibiscus cannabinus*) and bhang (*Cannabis sativa*).

In this system the crops provide favourable conditions for each other and thus improve productivity. The crops at the same time grow at different heights and thus utilise multiple levels of space on the same terrace. This provides protection against total crop failure and is an effective instrument of food security.

Diversity, in the form of barahanaja plays a significant role in maintaining long-term stability by minimising crop loss due to insect pests and improving soil fertility by ensuring legumes in the chosen combination. It also inhibits or suppresses weed growth, produces a varied diet and preserves soil from erosion on steep slopes. The *Barahanaja* system also provides wide ranging food options along with diverse types of fodder and straw for livestock.

The practice of raising multiple crops helps in maintaining right nutrient balance in soil, which depletes at fast rate in monoculture and thus hence requires heavy doses of fertilisers that keep on increasing with subsequent crops.

2.4. Crop rotation

Crop rotation refers to the practice of growing different crops in the same plot of land for maintaining fertility of soil and maximising productivity. The farmers of the area reportedly divide entire arable land of the village into two portions locally known as sari. Crop are then grown in a pattern that paddy (*Oryza sativa*), barnyard millet (*Echinochloa frumentaces*) and other secondary crops are cultivated in one portion while finger millet, (*Eleusine coracana*), amaranth (*Amaranthus oleracea*) and pulses are grown on other portion.

Paddy or barnyard millet is sown in April and after harvesting it in early October, wheat (*Triticum aestivum*) and oil seeds are sown subsequently. Immediately, after harvesting wheat and other accompanying crops in early May, finger millet (*Eleusine coracana*) and other twelve grain crops and pulses are sown in the same portion. After harvesting finger millet and other secondary crops in October, the land is left fallow for about 5 months and in month of April, paddy and other crops are sown in it. In this way every crop repeats itself in the same land after one and half year. In this unique pattern farmers reap three crops in two years. Under this system the land is left fallow by rotation and every farmer raises common crops by following a common cultivation and harvesting schedule. This has a unique advantage in the mountains, where arable land is scarce and land holdings are scattered. The practice of leaving arable land fallow for about four to five months in winters, when scarcity of fodder is acute, provides suitable grazing ground for the animals. Animals graze on the stems (remnants of harvested crop especially of finger millet which is rich in nutrient content) and subsequently manure the fields. The traditional pattern of crop rotation is thus an effective instrument of conserving soil, maintaining bio-diversity and ensuring food security.

2.5. Local crop varieties

As reported by the people the local crop varieties are better adapted to withstand the rigors of harsh climatic conditions and provide optimal output. These are able to sustain on minimal water and withstand long dry spells. Millets like mandua (finger millet, *Eleusine coracana*), malkauni (jowar or *Sorghum sp*.), bajra (pearl millet, *Pennisetum glaucum*) and jhingora (*barnyard millet*, *Echinochloa frumentacea*) and oilseeds like bhang jeera (*Perilla fruiticense*) and til (*Sesame*) are reported to be drought-resistant and can thrive well in marginal to excessive rainfall conditions. Jakhya (*Cleome viscose*), tor (*Cajanus sp*.), san (*Hibiscus cannabinus*) and kulath (*Macrotyloma uniflorum*) are also perceived as being drought-resistant crops.

People of Salang village of Bhagirtahi valley described traditional varieties of wheat called misri (biggest in size amongst local varieties), chayoni (medium sized) and bhami (small in size) as well as barley as being resistant to frost and snow. It was however qualified that these varieties are no longer grown in the area. Bhami variety of wheat is however still grown in Siyabba village of Bhagirathi valley.

Traditional varieties that include *jhedu* (long panicle), *kalaayun* (black coloured), *jadkya* (pink coloured, aromatic), *lathmar*, *khimanand ki ghodi* and *kanguri* are also described as being drought resistant. It is asserted that these varieties can also withstand hailstorms. It is added that jhedu is not attacked by animals and birds. Being thorny, it is left alone and not touched by animals such as boars, monkeys and others.

The people in the study area usually cultivate leguminous crops like pulses, lentils and beans on sandy soil. On relatively more fertile lands buck wheat or *amarathus* is grown with cannabis on the borders.

2.6. Weed management

Traditionally weeding is done manually using a locally made small hand held tool with sharp pointed tip. Heavy labour input is thereby involved in de-weeding operations. Intercropping and crop rotation practices are perceived to be effective for weed management.

Planting a variety of crops with different characteristics reduces the likelihood of specific weed species being adapted to the system and becoming problematic. Moreover different crops involve different agricultural practices, which disrupt growth cycle of weeds and, as such, prevents selection of the flora towards increased abundance of problem species [2].

Though the use of herbicide was reported in Bhagirtahi and Dhauliganga valleys, crop rotation naturally puts varying selection pressure on weeds, preventing any one weed species from becoming problematic, and slowing the development of herbicide resistance in weeds.

2.7. Farm manure

For preparing green manure, green leaves from local trees that include banj (*Quercus*), burans (*Rhododendron sp*.), *Artemisia spp*. and the like are collected from the forest and stored near the house. These leaves along with farm residue, leaf litter, left over forage and feed are used as bedding material for domestic animals. These are spread and added at various intervals, generally once a week, to keep the shed dry. In the presence of moisture, dung and urine this material decomposes into manure.

In this system, the whole process of farm manure preparation takes place within the animal shed or at a place near the shed. This is subsequently used as manure in the fields. Some properties of these leaves in combination with the animal urine are perceived to make this manure particularly effective for pest control as well. Farm manure is still used especially in areas where the fertlisers have not reached.

Natural fertilizers in the form of dung and forest litter are thus used in these areas to replenish soil fertility. This is perceived to be the best way to adapt to the changing environmental conditions and is still being used by the farmers in the area.

2.8. Mulching

Mulching is another common method adopted by farmers in the study area for moisture conservation and weed control. On decomposition the mulch helps in maintaining soil fertility. Mulching materials, such as weeds, fallen leaves, crop residues, fodder leftovers, and decomposed twigs, supply the soil with plant nutrients.

2.9. Storage practices

People of the area resort to various practices of storing seeds and food grain. These include storing grains in specially designed containers (bhagar or kothar in local parlance) that are placed at particularly dry places. These are commonly made from deodar (*Cedrus deodara*), Kataunj (*Castonopsis tribuloides*), bamboo (*Dendrocalamus strictus Roxb.*), ningal (*Thamnocalamus spathiflora trinius*), cheura (*Diploknema butyracea*) and tooni (*Cedrella toona*).

The storage bins made of bamboo and ningal are locally called topare or doke. Inner and outer surfaces of these bins are plastered with a specially prepared paste main constituents of which include cow dung, mud, mustard cake and carbon from tawa (chapati baking iron plate). These items are mixed in cow urine for preparing a paste, which is plastered on the storage bins on both sides and is subsequently sun dried. This mixture is reported to act as insect and pest repellant. This is one of the indigenous practices of storing grains in Uttarakhand.

For storing seeds ash, cow dung ash, cow dung with cow urine, mustard oil is added. These protect the seeds from infestation and increase their shelf life.

2.10. Religious and cultural mechanism for sustainable agriculture

Communities in Uttarakhand have elaborate religio-cultural practices in the forms of festivals, which enable people to make joint assessments related to climate and exchange their knowledge regarding agriculture. Most of these festivals begin with the worship of local gods and goddesses, with offerings of produce to main deity of the village. These practices promote seed preservation and conservation of biodiversity. These cultural practices follow Vikram Samvat calendar. Few cultural practices promote testing of different seeds promoting crop diversity and conservation. Harela festival, which is celebrated on the Sankranti of Assar month (Vikram Samvat), is specifically related to seed testing of different species. Culturally, every family has to participate in three testing. Harela stands for first, followed by two testing in each occasion of both Navaratri festivals. During Navratri, community members sow minimum seven types of grains and pulses in their households or in temple on the bed of soil collected from their fields. This is a symbolic cultural reflection of seed conservation, crop rotation and mixing.

Similarly festivals of Phool Dei and Ghee Sankranti have a relation with nature and people pray for abundant crops and general well being of their families. Phool Dei is celebrated on the first day of Chaitra or in mid March and shows the advent of spring. Young girls go to every house in their villages with plates full of rice, jaggery, coconut, green leaves and flowers and put forward their good wishes for the prosperity of the household .They sprinkle auspicious flowers and rice on the doorsteps. Ghee Sankranti on the first day of the Bhado month (mid August) of the Hindu lunar calendar. This is a very significant festival of the farming community. A variety of agricultural tools are swapped on this day. It is throughout this point in time that the yield is abundant and green and vegetables grow in profusion.

2.11. Climate prediction

Agricultural practices in Himalayan region are closely related to nature and seasonal cycle. A shift in the pattern of precipitation can affect the crop cycle and production, especially in rain-fed farming of Uttarakhand. However, local communities addressed this issue with developing capability of climate prediction based on various sings and variable. This technique is still practiced by traditional farmers in remote areas of Himalayan region.

3. CLIMATE CHANGE IMPACT AS PERCEIVED BY PEOPLE

Based upon the interaction with the people in the identified valleys attempt is made to reconstruct the scenario of changing ground realities and to put together how these are affecting life and livelihood of these people.

3.1. Meteorological parameters and glacial retreat

Respondents universally perceive increase in average temperature together with change in precipitation regime. Both duration and amount of rainfall is reported to have changed significantly. Other important observations include i) change in the timing of rains, ii) rains having become intense and erratic.

The respondents in the study area invariably reported occurrences of heavy rainfall that were earlier unknown in high altitudes. This is lately reported to result in flash floods causing loss of infrastructure and property. This is attributed to observed temperature increase that results in enhanced evaporation from land and water bodies.

Major proportion of precipitation is presently perceived being received as rain rather than as snow. As the snowfall is less and it stays for a shorter duration, chances of its compaction and conversion into ice are thus reduced (Fig. 6). This is deduced to be responsible for reported negative mass balance of the glaciers and their fast recession.

Winter conditions in the study area are reported to traditionally prevail between November and February – March. This period has reportedly shortened drastically over the previous 10 to 15 years. The winter season has reportedly become short and snow has lately started to melt early which is perceived have adverse impact on agro - horticultural operations.

3.2. Hydrological regime

Besides rainwater main sources of water for the people in the study area include glaciers, rivers, lakes, streams (of all sizes) and springs. The study shows a mixed response on the level and availability of water. The discharge of the streams and springs is reported to have fluctuated and the main reasons cited for change in water availability include i) increase in temperature or dry spells, ii) glacier recession, iii) earthquake shaking, iv) monsoonal variability, v) irregular rainfall or less or heavy rainfall, vi) landslides, vii) climatic changes, viii) reduced snowfall, ix) construction of dams, x) deforestation, xi) appearance of ground fissures and xii) land subsidence.

It is reported that reduced supply of water has not yet started affecting quality of life or life support strategy of the people. It is however agreed that in times to come the same could become a serious problem. Hardships faced by the people due to reduced water availability include i) difficulty in managing water for household use, livestock and irrigation, ii) long distances to be negotiated for fetching water, and iii) long queues for water collection implying prolonged waiting time for water collection.

Hydro-geologic response to earthquakes is well known and there are reports of wells and springs becoming turbid or dry or beginning to flow after earthquakes [3]. The same is reported from the area that lies in seismically active zone. Change in the discharge and drying of some sources is reported from Dwari, Siyabba and Raithal villages of Bhagirathi valley after 1991 Uttarkashi Earthquake. The problem is not alarming but scarcity is reported from some villages including Kaamar in Bhagirathi valley.

3.3. Impact on agriculture

Climate change is known to affect the two most important agricultural inputs; water and temperature [4]. Agriculture in the study area is observed to be of subsistence type and highly dependent on atmospheric precipitation. Snow is an important source of soil moisture and essential for agriculture and growth of pastures.

Moreover optimal productivity of majority of agro-horticultural crops of the area is dependent on persistence of relatively low temperatures for appreciably long duration. In this period plants remain in a dormant stage and come out of it when the conditions are suitable for growth. Due to reduced winter period, dormancy of the plants is broken relatively early and this is reflected in early flowering of these plants.

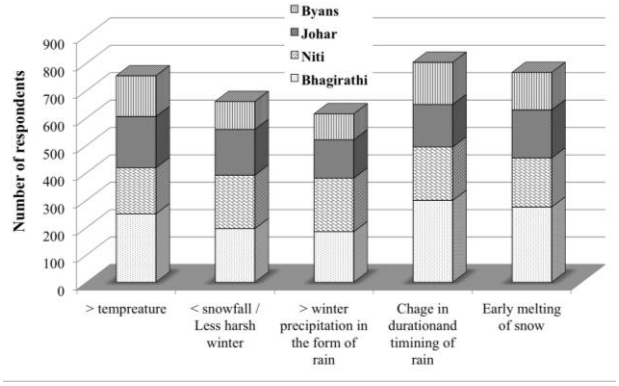

Fig. 6. Change in the precipitation pattern as perceived by the respondents

The plants thus flower at a time when weather conditions are not favourable for their growth and survival. Hailstorms that are common during this period result in major losses.

To add to it plants start to bloom even before local pollinators are active. This reduces fruiting and thus productivity. Production of apples is reported to be particularly affected by this. The situation is further exacerbated by the use of pesticides that wipe out useful insects along with the harmful ones.

Phenological response of plants, particularly the early flowering ones, is considered a prominent biological indicator of climate change [5] and the same is being witnessed in the area.In the present study an overwhelmingly large proportion of the respondents (65 percent) agreed that the timing of flowering and fruiting of plants has changed. Early flowering in almost all agricultural, horticultural and wild species is reported to be a common observation, particularly so in *Rubus sp*., apples and rhododendron. This change is attributed to increase in temperature, shortened and less harsh winters and early onset of summer. There are reports from Johar valley of *Prunus sp*. fruiting twice in a year. To combat these changes the farmers of the area are resorting to early sowing.

3.4. Change in cropping pattern

Agriculture in the area is reported to have undergone major changes in recent times. Traditional subsistence agriculture in the area is reportedly being replaced by cash crops and thus monocropping is fast becoming common. Three types of agricultural fields are commonly observed in the area; i) traditional fields that are reduced in size, poor in organic matter, and are without irrigation; ii) vegetable gardens that are often localized within or near the home, and rich in organic matter; and iii) fields within the village ruins. *Fagopyrum tataricum* (Phaphar) and durum wheat used to be the traditional crops of the region that were supplemented by indigenous vegetables and niche plants like thoya (*Carum*

carvi) and jambu faran (*Allium stracheyii*) which are grown within the safety of the crumbled walls .

With shortened winters people have started to stay in their summer homes for longer duration. Traditionally they used to return by the end of May but presently they usually return in March and stay there till October. Even though this duration is right for crop cultivation traditional crops are not being grown, mainly because of their reduced demand but sometimes also because of changed climate. Today, cereals and pulses are virtually absent in Johar valley. Prior to 1962, durum wheat was produced on large scale as the same was used as sattu (a type of flour that is eaten after mixing it in water). Similarly, growing potatoes has no longer remained profitable due to high freight charges.

3.5. Changes in animal behavior

Respondents said that they have observed changes in the population and behavior of wild animals and others in the forest around their villages. It is reported that the wild animals have lately started to come very close to the habitations. Climate induced changes have both direct and indirect impact on habitat, distribution limits and food availability for wild animals. Search of food is perceived to drive wild animals towards habitations. Climate change is put forth as one of the reasons for random movement of Himalayan black bear towards habitations. Acorns and nuts of the previous year are the main food of this species, when availability of these decreases due to unusual weather events they are reported to wander around for other foods. Many other animals might be victim of such events.

It is also reported that wild animals have lately shed fear of human presence. This is qualified by increased instances of wild animals being sighted close to habitations and agriculture fields. Incidences of bear and leopard killing animals even in cattle sheds are reportedly rising. The aggression is also observed in apes and monkeys. Responders acknowledge that the wild animals attack humans due to sudden encounter and some time due to hunger. Human encounter with animals is on the rise due to increasing population of wild animals. People perceive that some animals including ape, monkey, bear, boar and leopard have lately started to reproduce more or survival rates of their progenies have increased significantly. This is held responsible for rapid increase in their population. An old women from Siyabba village in Bhagirathi valley shared that earlier it used to snow a lot and when the village women used to go for fuel wood collection in the forest, they often used to find bodies of dead wild boars. She continued that with reduced snowfall population of boars has increased due to greater survival rates of progeny.

People also reported increase in the incidences of crop damage by wild animals that include monkey, boar, deer, bear and rodents due to increase in their population. The variation in the distance between farm and forest boundaries and number of neighboring farms is put forth as a reason for increasing vulnerability to crop-raiding by wildlife [6]. Other reasons of this include increase in wildlife population and forest degradation and depletion resulting in less food availability in forest. The situation is observed to be the worst in the Bhagirathi valley. People of Siyabba and Kaamar that were well known for potato production have stopped growing potatoes due to increased menace of wild animals. There are similar stories of increased animal attack from Hurri, Kyarakh, Banadarani, Raithal. Farmers universally complained of attack on crops by monkeys during the daytime and the losses by wild boars during the night. Intentional release of the monkeys captured from other areas by the Department of Forest is also reported to be responsible for this problem.

3.6. Changes in honey bees and bird population:

In agro-ecosystems, wild and domesticated pollinators (bees, wasps, flies, beetles, moths and other insects, as well as birds and bats) are essential for orchard, horticultural and forage production, as well as for the production of seed of many root and fibre crops. Pollinators such as bees, birds and bats affect 35 percent of the world's crop production and a decline in their population can cause significant declines in quantity of produce, quality of fruits and seed set. The study area shows an impact n the population of bees and birds.

Impact on bird population due to climate change is reported in the form of shortened breeding period or failure to make nests and reproduce due changes in plant phenology, food availability and habitat alteration. Long dry spells fail to induce flowering and fruiting of plants together with emergence of insects [7] that results in low food availability. Bees and butterflies are considered to be indicators of ecosystem change and are used to predict various environmental alterations [8]&[9]. Their specific survival related ecological requirements that include temperature, humidity; food plants and egg laying habitats make this most vulnerable to global climate change [10] & [11]. Reduced nectar availability due to dry spells and drought together with phonological changes are perceived to be responsible for their reduced population.

Similarly the habitat of the bees is also perceived to have changed due to rising temperatures and growth of modern infrastructure that have little scope of accommodating these. The use of insecticides is also perceived to have taken serious toll of the honeybees. Mono-cropping that is become prevalent in the area reportedly requires pesticide use to control various pests and diseases. Besides reducing diversity of food sources of the pollinators it also kills many pollinators. Both diversity and abundance of pollinating insects has thus been greatly reduced in the study area.

The bee hives re also under threat from the attack by Himalayan yellow-throated marten (*Martes flavigula*) .It feeds on honey and the broods. After eating all the combs and brood, it urinates on the hive probably to mark their territory and locals tell that honey bees do not form the hives at that same for subsequent years.

Traditional be keeping has also reduced due to change in housing structure and lack of interest. Traditional bee hives were made in the traditional wooden houses with the help of local available resources.

3.7. Increased infestation in crops

Growing incidences of crop infestation are reported from area due to change in climatic conditions and increased use of chemical fertilizers. In the area around Malari, where herbicides and pesticides were reportedly introduced by organized system of the state government, insects are perceived to have gained resistance against these. It is a general perception that chemicals cause loss of soil fertility and bring forth changes in soil structure. This is reported to result a hard upper crust in the soil which is hard to break and requires a heavy plough for tilling. This is also perceived to reduce porosity and water holding capacity of the soil.

There are reports of increased infestation in crops from the study area. Insects being poikilotherms, temperature is probably the single most important environmental factor influencing their behaviour, distribution, development, survival, and reproduction [12],[13]&[14]. Major drivers of climate change i.e. elevated carbondioxide($CO_{2)}$ levels, increased temperature and depleted soil moisture therefore affect population dynamics of insect-pests and thus significantly enhance the extent of crop losses. The reasons given by the respondents for the same include i) change in frost-thaw cycle, ii) use of fertilizers and pesticides, iii) increase in temperature and iv) less treatment of soil before sowing.

3.8. Impact on pastoralism and on pastures

In the region the number of families using the alpine pastures has declined substantially due to market oriented cash economy. The size of herds and intensity of high altitude grazing has and continues to decline. More and more people are resorting to other sources of income. In fact families/owners are now hiring labourers to accompany livestock to the grazing pastures. Traditional norms like designated areas for selected group of animals ,time of grazing and restriction on grazing in some areas existed in the region was followed by the entire community. In the absence of younger generations to graze and manage the livestock and hired labourers doing the task, the traditional norms and rules are disrupted.

However some of the grazing areas have become protected after their declaration as biospheres and sanctuaries which is again a threat to survival of the livestock. The inhabitants are denied the right of pastoralism by forest official and often they have to pay regular grazing taxes.This wsa opposed a lot in Niti valley in Nanda Devi Biosphere reserve in the form of the *Chheno-Jhapto Andolan*" ("grab and take away") in 1998 by villagers of Lata under the guidance of some NGOs from Dehra Dun and the local pradhan, Dhan Singh Rana. The villagers were banned from entering the biosphere reserve and the promised alternate grazing land was never given. The protest was meant to enter the reserve forest and take over the grazing pastures for grazing and collection of medicinal herbs.

4. ADAPTATION MEASURES

Adaptation generally refers to actions that help in better coping with the circumstances or ground realities. This generally refers to changes in livelihood or survival strategy so as to reap better returns under changed conditions. Adaptation related actions include cropland, pasture or grazing land and water management, use of organic manure, thoughtful land use and agro forestry.

Traditional farming practices show fine assimilation of these practices and these are all the more relevant today in the changing climatic scenario. To combat the negative impacts of the changing climate people in the region are observed to resort to various measures, some of which are described below.

4.1. Early sowing and crop selection

With increasing temperature, shortened and less harsh winters farmers of the area have started to sow early. People have at the same time started to cultivate crops that are favoured by changing climatic conditions. Production of off-season vegetables around Harsil together with production of cash crops throughout the Bhagirathi valley is part of the strategy of the people to maintain the livelihood.

4.2. Crop diversification

The area has the niche advantages in the form of temperate climate that is favourable for growing plants of medicinal value. These crops fetch high prices and there exists a large and ready market for these products. People of the area have lately started to cultivate jambu faran (*Allium stracheyi Baker*), kala jeera / thoya (*Carum carvi*), sea buck thorn (*Hippophae rhamnoides*) in large areas.

People of the study area are observed to change their farming practices according to the changed climatic conditions. In the Byans valley people have reportedly started to get good production of garlic in the previous 6-7 years that could previously not be grown in the area due to harsh climatic conditions. Increase in the production of potato is also reported from the alpine meadows of all the valleys.

Apart from the other fruits changing climate has enabled apple production in new areas. As it generates more money and has ready buyers, in places like Harsil more and more people are observed to plant apple orchards replacing traditional crops.

4.3. Organic farming

There is a vast potential of organic farming in the hills and people have lately started to adopt this farming practice with crop varieties that can flourish in the area and fetch good returns. On site availability of the buyers ensures high return and this has encouraged farmers to maintain fertility of the land through organic manure.

4.4. Millets, pseudo cereals

Lately people of the area have slowly started to grow some of the traditional crops, which suit the climate well. This is largely attributed to growing global demand of some of these crops that include buck wheat.
These crops are of short duration and fit the climatic conditions of high altitude temperate zone. These are at the

same time particularly adapted to very poor, badly-tilled land which can scarcely produce anything else. Buck wheat for example is one of the quickest growing crop that takes only 4–5 weeks from seeding to flowering and thus suppresses weeds and prevents soil erosion due to intensive runoff. The crop at the same time has multiple usages; the young leaves are eaten as vegetable and the stalk is an important source of cattle feed. Since it matures quickly, it escapes early autumn frost injury. It is also a good green manure crop and improves soil texture, and also increases nutrient status of the soil, particularly phosphorus and micronutrients in the root zone, which is beneficial for the succeeding potato crop and other cash crops like apple and razma.

8. CONCLUSION

The study brings forth various traditional practices of the area that ensure optimum crop productivity. These ensure that adequate attention is paid on preparation of farms, selection of crops, replenishing soil fertility and moisture conservation. The people at the same time are aware of various storage practices together with nutrient and medicinal value of plants available in their vicinity. The people use this knowledge judiciously for sustaining in resource scare area despite adverse climatic conditions.

In the recent past the area is however witnessing changes in temperature and precipitation regime. Both duration and amount of rainfall having changed significantly, most precipitation is received as rain rather than as snow. These changes are having differing impact on resource availability and life support strategy of the people. Besides changes in hydrological regime and agricultural productivity, phenological changes in wild and cultivated crops are common observation. Changes in floral and faunal population and type together with changed animal behaviour are also observed.

Changing climatic conditions are resulting in loss of livelihood capital, changing agro-livestock conditions and emergence of invasive species. The biggest impact is perceived to be on the agricultural sector that accommodates highest proportion of the workforce of the state. The impact has already started to show up and is evident from the fact that the share of agricultural sector in Gross State Domestic Product (GSDP), at constant prices, has declined from 16.7 percent in 2004 – 05 to 7.8 percent in 2012 – 13. Though fast pace of migration from the region is held responsible for this, climate change is sure to have adverse impact on the livelihoods based on forestry, agriculture, livestock husbandry, NTFPs and medicinal plants.

Communities are observed to react positively to changed situation and taking advantage of the niche of their area and improvising on their traditional knowledge they have started to grow commodities that are better suited to the changed scenario and has ready market. They are also taking advantage of reduced duration and harshness of winters for growing new crops. Organic farming that is observed to gain ground in the area is perceived to stabilise the population of the pollinators and also control infestation of weeds.
The efforts of the people are certainly short of what is really required for coping up successfully. The impacts have therefore to be studied in detail so as to devise adaptation strategy that improvises upon traditional practices of the people by dovetailing elements of modern science and technology in the same. Popularisation of these strategies though appeal to the little tradition of the masses would ensure their acceptability and sustainability.

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