IMPACT OF CLIMATE CHANGE ON AGRICULTURE OF HIMACHAL PRADESH

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Abstract: *Summer water scarcity has become a regular feature in the north Indian HimalayanState of Himachal Pradesh. One reason may be increased local anthropogenic activity accounting for increased population growth in the state over the decades and another may be the global climatic impact affecting this region. Himachal Pradesh is situated between 30°22'40''N to 33°12'40''N latitude and 75°47'55'' E to 79°4'20'' E longitude. It has an area of 55673 sq. km. which constitutes 1.69% of India's area and 10.54% of the Himalayan area. Monsoon dominates the climatic conditions as it receives rainfall from the southwest and the winter monsoons. The state receives an average annual rainfall of 1111mm but its intensity varies from place to place leaving many areas water-scarce. The rainfall varies from less than 500mm in Lahaul and Spiti to 3400mm and above in Kangra (State of Environment Report- Himachal Pradesh, March 2000). The past studies about the Himalayan region of which Himachal Pradesh is a part, warn about global climate change as there has been an increase in temperature over the last 100 years which is greater than the global average of 0.74° C (IPCC, 2007); a decrease in monsoon and overall annual precipitation during 1866-2006 and melting of glaciers at a faster rate compared to others. These important issues need serious concern as the impact of climate change on a region that is geologically and geomorphologically fragile could be manifolds that could devastate its ecology and economy. The state is not even able to produce enough to feed its own population, anda downturn in grain yields would have a high impact on the socioeconomic conditions of its people, especially where 23.87 percent of rural households are below the poverty line. The major future challenge for people and Government may be how to cope with the situation of water scarcity and declining grain production for a state where more than half of the cultivated area is rain-fed and the development of irrigation infrastructure is severely restricted by topography.*

In light of the above facts, this paper will try to establish a connection between global climatic change and its impact on agricultural production further aggravating related problems for the people of the state in the coming decades.

Keywords: *Climate change, agricultural diversification, productivity, agro forestry.*

Introduction

Climate change is not a recent phenomenon as shifts in ice caps towards the equator and poles have been going on during various glacial and interglacial periods in the geological time scale. The issue has widely attracted attention recently as the signs of climate change in the form of global warming and extreme weather events have started affecting human beings adversely. According to Dash (2007), 'among the suggested causes of climate change, across different time scales, are changes in solar radiation and the earth's orbit, continental drift, polar wandering, mountain building, volcanic eruptions, changes in the carbon dioxide (CO2) content of the atmosphere and changes in the heat stored by oceans'. The concentration of Carbon dioxide the

major greenhouse gas or the major cause of Global warming has increased from approximately 277 parts per million volumes (ppm) in 1744 to 384 ppm in 2007 (Agenda on Environment Protection, HP). The major increase is due to the use of fossil fuels and deforestation. Greenhouse gases accumulate in the atmosphere gradually and over a period of time affecting temperature, precipitation and soil moisture conditions. This further initiates phenomena like the melting of ice caps, and glaciers, the rise in sea level, the occurrence of floods and droughts, soil erosion, landslides, changes in species composition and distribution, etc. Sea ice is an effective insulator and maintains climate naturally by maintaining the temperature as it reflects a lot of solar radiation back into space and decreases the amount of heat lost from the oceans to the atmosphere (Dash, 2007). On average, the global temperature rose by 0.74°C over the last hundred years (1906-2005), with more than half of this rise, 0.44°C, in the last 25 years (ICMOD, 2009). The current projections show further global average temperature increases of between 2.5° F and 10.4° F by 2100 and warming in India is expected to be still higher (Agenda on Environment Protection, HP). The impact of this climatic change can be felt both in ecological and socio-economic domains. The weather elements affecting agricultural productivity are temperature, precipitation, sunshine, soil moisture content and soil types, etc. Slight changes in these elements may affect agricultural productivity creating problems related to food and livelihoods in the world which is already facing food insecurity in many parts. The onset of the summer monsoon is projected to be uncertain under the climate change scenario. It has a direct influence on rain-fed crops. In the case of the failure of monsoons, water quantity will be affected leading to pressure on irrigation and further affecting agriculture. Increased soil temperature will increase evaporation and upward movement of groundwater. Both rice and wheat yields could decline (IPCC 1996 and 2001 quoted in Dash, 2007). Anderson (1981) noted that people of the world are either facing or soon will face three interrelated food problems: malnutrition, undernourishment and rapid dietary change though many countries in the third and fourth world like Bangladesh and African Sahel are facing all three in the current context. The intensity of these problems will be greater for poor and marginalized people all over the world.

Effect of local Anthropogenic Activities and Global Climatic Changes on Himalayan Agriculture

Population explosion, rapid urbanization, industrialization and associated developments are considered to be the main reasons for global climatic change. The situation is excessively alarming in Asia, especially because of what the west achieved in 200 years in terms of urban-industrial growth, which most of the Asian cities have achieved in a few decades after World War II (IGES, 2001). High mountainous areas like the Alps, Rockies, Andes and the Himalayas, etc. are the ecosystems that are most vulnerable to climatic change (Beniston, 2003 in Bhutiyani, Kaleb and Pawarc, 2009). Pandey (2002) has referred to the environment of highlands in general and the Himalayas in particular as ecologically fragile[1]. Any alteration in the environment is likely to have cascading effects (Agenda on Environment Protection, HP). Hence, due to greater vulnerability, urbanization, industrialisation and associated developmental processes mean many things, which are otherwise not so relevant in other parts of the world. Though the fact is well known yet developmental processes followed the developmental patterns of plains. The degradation of the

1 Fragile ecosystem here is understood in terms of vulnerability and the increasing and irreversible stress on the physical environment that includes land, water, forest, air quality and so on. The frequency of hazards like mass wasting, large-scale erosion, landslides etc. also increase in the process of infrastructure creation. This can be devastating in case of Himalayas which are still undergoing changes and is not yet fully stabilize.

Himalayas is linked to various land-use patterns, like deforestation, overgrazing, wasteful agricultural practices and mismanaged developmental ventures.

Studies about the Himalayan region show that ecosystems absorb stress over long periods without much outward sign of injury and gradually over a period of time reach a disruption threshold at which the cumulative consequences finally reveal themselves leading to environmental discontinuities (Myers, 1996). A study of Almora which is a part of the Himalayan region by Sah and Pande (1987) shows that unplanned and haphazard growth along with the large-scale cutting of hill surfaces has led to environmental degradation like soil erosion and deposition of silt in streams which have abandoned agricultural activities in the adjoining plain areas. Any climate-induced changes will affect the flow of Himalayan Rivers as they are controlled by monsoon and winter precipitation. The rivers are a source of water for agriculture and any fluctuations in the volume of water will affect agricultural productivity and the livelihoods of a large population.

The IITM (Indian Institute of Tropical Meteorology) study suggests that "there will be a decrease in monsoon precipitation of up to 20% by the end of the century in most parts of south-eastern Afghanistan, the southern and eastern Tibetan plateau and the central Himalayan range. Increases in the range of 20-30% are projected for the western Himalayas, Kunlun and the Tien Shanranges" (IPCC, 2007). Warming could be as high as 3.5-4° C in the Punjab area, a large partof Afghanistan, Badakshan, the western Nepal Himalayas, Himachal Pradesh and the northern Tibetan Plateau. The temperature increase in the Himalayan region has been greater than the global average of 0.74° C over the last 100 years (IPCC, 2007). (Bhutiyani, Kaleb and Pawarc, 2009) in their study of the North Western Himalayan region have found a statistically significant decreasing trend in monsoon and overall annual precipitation during their study period 1866-2006. They have also noticed that temperature data also shows significant increasing trends in winter, monsoon and annual temperatures. The warming effect appears to be particularly significant during the winter season. Fluctuations in precipitation in North West Himalayas appear to be strongly affected by global teleconnections which appear to have weakened considerably in the last three decades i.e., after the late 1960s (ibid). This may be due to an increase in anthropogenic emissions of pollutants. According to Dyurgerov and Meier (2005), continuous warming has affected the Himalayan environment which can be noticed in the form of glacial retreats and the waning of snow fields. Himalayan glaciers are expected to melt at higher rates than glaciers in other mountain ranges. This will increase the volume of water in rivers for some time but its shortage afterward as the glaciers retreat. The effects will be felt more in dry or already water-scarce regions, especially in the dry season. Supplying water for drinking and agricultural purpose to its people will be a challenge for the government and municipal bodies in the future. Agricultural production will be affected due to flash floods, droughts, pests and diseases which may be a consequence of various climatological, geomorphological and hydrological changes. The geographic shifts may render areas suitable for the cultivation of staple crops unsuitable and the reduction of water availability may affect production (Aydinalp and Cresser, 2008). The impact of the change of climate on agriculture will be different for different areas of the world but agriculture that requires rainfall and irrigation will be most affected. This can further reduce the areas under rainfed cultivation. Crops are affected by changes in temperature and rainfall which may reduce their yield and if this happens for cereal crops shortage of food can cause "a number of health issues, including malnutrition, growth retardation in children and low immune system function" (Eriksson, Fang, and Dekens, 2008).

Status of Agriculture in Himachal Pradesh

The geomorphologic and climatic conditions of Himachal Pradesh have been responsible for making agriculture as the primary means of subsistence. This variation has also allowed agriculture to transform from subsistence centered to commercial horticulture based. Though more than 92% area in the state is still rural and agriculture is the mainstay, it has to depend on other states for its food and other requirements. The state is not even able to produce enough to feed its own population (total food grain production is 14 lakh tones which is not sufficient (scientific note, 2004), and a downturn in grain yields would have a high impact on the socio-economic conditions of its people. The area available for agriculture is less than 17% of the total geographical area of the state. Out of it only 5% is prime land in valleys and the rest which is scattered on high terraces faces extensive soil erosion and water scarcity (scientific note, 2004). The sub-montane and low hills sub-tropical zone which is 33% of the cultivated area receives about 150cm of the annual rainfall of which almost 75% is received in the monsoon period. The other months face water scarcity. Mid-hills sub-humid zone which is 53%of cultivated area is relatively less subjected to moisture stress (scientific note, 2004). Increased irrigational facilities have led to an increase in food production but have also shifted crop patterns. This is noticed in Himachal Pradesh also as a major shift has taken place from the cultivation of cereals to vegetables. During the 1940s agricultural production was restricted to the traditional Rabi and Kharif crops and in horticulture, some apples and stone fruits were produced (Pattern and Context of Rural Livelihoods in Himachal Pradesh, 2008). But diversification took place toward the cultivation of cash crops such as ginger, potato, off-season vegetables, kiwi, cherries, hops, apiculture and mushroom production (ibid). The per-hectare yield of apples i.e., 5.6 tons is only one-fourth of the world average (scientific note, 2004). Though traditional farming in other crops is getting diversified towards apples in some areas but even with the increased area of apples the per hectare production is much below the world average and at the same time a decrease in the production of other crops is resulting. Production of food grains increased from around 0.7 million tones in 1966-67 to about 1.4 million tones in the year 2003-04 due to increased irrigation schemes (State Water Policy) but at the same time, water requirements in other sectors like domestic, industrial, livestock and commercial have also increased which limits the availability of water for irrigation. The low agricultural productivity is due to the traditional system of agriculture, small land holdings, hilly and mountainous terrain, soil erosion, the occurrence of floods and dependence on rain. On one hand, the agricultural productivity and per hectare yield is low and on the other, its contribution to the gross state domestic product is declining over the years.

Table: Share of Gross State Domestic Product in the Economy of Himachal Pradesh

Year	Primary Sector	Secondary Sector	Tertiary Sector
1950-51	71.01	9.50	19.49
1960-61	63.14	9.71	27.15
1970-71	58.56	16.73	24.71
1980-81	50.35	18.69	30.96
1990-91	37.82	25.03	37.15
2000-01	25.87	34.62	39.51

Source: Pattern and Context of Rural Livelihoods in Himachal Pradesh, 2008

The share of the primary sector which used to be 71.01% in the 1950s has declined gradually in the gross state domestic product and came down to 25.87% in 2000-01 (Pattern and Context of Rural Livelihoods in Himachal Pradesh, 2008). The share of secondary and tertiary sectors has grown from the 1950s to 2001. The number of registered factories increased from 3 in 1951 to 598 in 1981 and 401 in 1993 (Environment Policy, Department of Science and Technology Government of Himachal Pradesh). Economic activities have also shifted from primary to secondary and tertiary sectors. People who used to earn their livelihoods from primary activities have also found their earnings in production activities with handsome returns. During the 1990s a large number of farmers got attracted to growing and marketing off-season vegetables when their demand in neighboring states was higher due to diminishing local stock. However, the production of off-season vegetables is only confined to irrigated areas as these require large quantities of water. The shift of the structure of the economy from a traditional agrarian to a diversified one has resulted from the shift of agricultural workers to secondary and tertiary sectors (Pattern and Context of Rural Livelihoods in Himachal Pradesh, 2008). This is evident in Census data as the workers engaged in agriculture have declined from 75.82% in 1970-71 to 68.65% in 2001 clearly implying a fall in per-worker productivity in the primary sector. This situation leads to the pursuit of multiple livelihood strategies in the context of Himachal Pradesh. Though the area under two major food crops rice and wheat and overall food grains has decreased decreasing the per capita food grain production the yield per hectare has increased from 1990-91 to 2006-07 increasing production. Per capita, food grain production has decreased from 282 in 1990-91 to 214 in 2006-07.

Table: Area and Production of Rice and Wheat

Year	Area of Rice (in 000 hect.)	Production of Rice (in 000 tones)	Yield	Area of Wheat (in 000 hect.)	Production of wheat (in 000 tones)	Yield	Area of total food grains (in 000 hect.)	Production of total food grains (in 000 tones)	Yield
1990-91	85	107	1280	376	602	1627	872	1453	1695
2006-07	79	124	1570	362	594	1650	765	1457	1905

Source: Socio economic Indicators of Himachal Pradesh other Major States and all India 2009 (Directorate of Economics & Statistics Government of Himachal Pradesh).

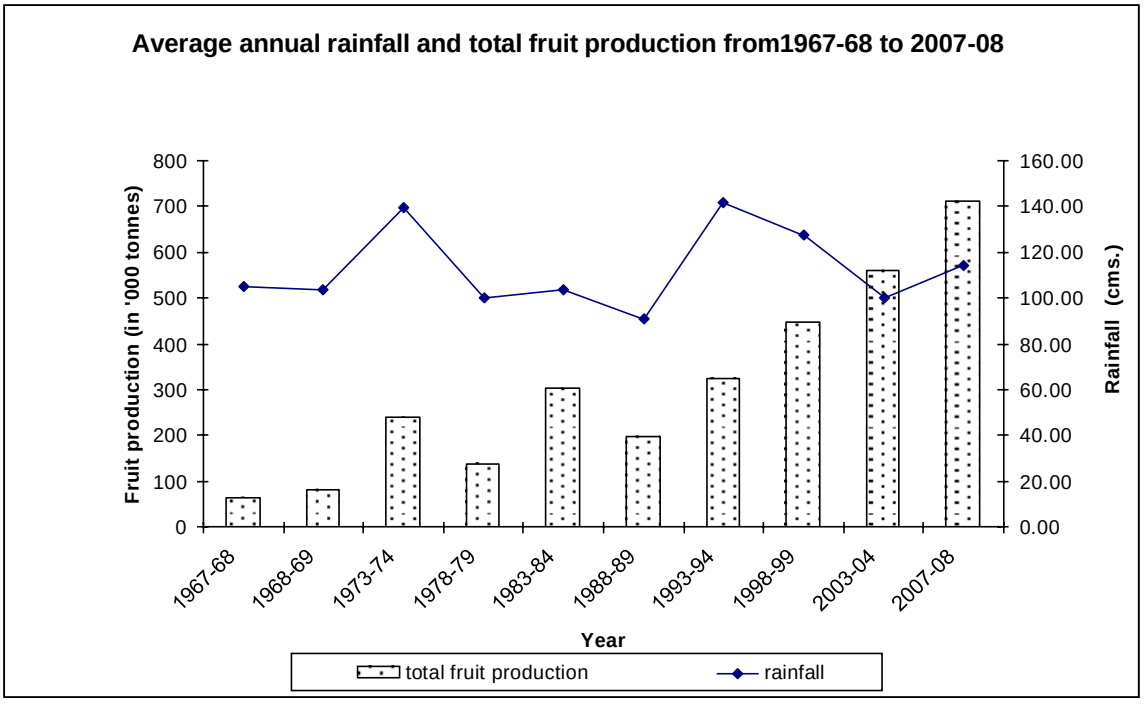
The area under off-season vegetables like peas, tomato, and exotic vegetables like Broccoli, Asparagus, Leek, Parsley, Brussels sprout is increasing as these are demanded in hotels and by foreign tourists. Strawberry, pomegranate, olive, kiwi and hazelnut have been identified as potential crops of the future. This will lead to more diversification and more pressure on the area and production of cereal crops in the coming decades.

Effect of Global Climate Change on the Agricultural Production and Implications

The state is vulnerable due to its topography and higher dependence on sectors that are sensitive to environmental vagaries and climatic changes such as agriculture, forestry, water sources, hydro-power and tourism (Agenda on Environment Protection, HP). The importance of rainfall can be felt as more than half of the cultivated area is rain-fed and the development of irrigation

infrastructure is severely restricted by topography. 18.7% of the total cropped area is irrigated and the rest 81% is still unirrigated. Indian Meteorological Data from 1900 to 2003 shows a declining trend in annual rainfall while Summer Monsoon Rainfall shows an increasing trend in Himachal Pradesh (Dash, 2007). Apart from it the usefulness of rainfall is greatly limited as during the larger part of the year evapotranspiration exceeds precipitation leading to dependence on irrigation. Any changes in the volume of water due to the melting of glaciers may affect agricultural production and shifts in cropping pattern towards drought-resistant crops when the availability of water decrease in the future due to retreating glaciers. Variations in monsoons and temperature due to climate changes may further aggravate the problems. The irrigation schemes involve the lift of water which is not cost-effective. Crops like maize, rice, pulses, potato and even off-seasonal vegetables could be affected by a decrease in rainfall and lesser availability of water due to glacial retreat. Apart from this the horticultural sector which is very important for the economy of the state will also be affected. On one hand, physical constraints like the availability of cultivable land and the amount of rainfall restrict agricultural activity and productivity and on the other, a reduction in per capita production of food crops due to diversification can make things miserable for the economy and health of the state as well as its inhabitants. Diversification and shifts in cropping scenario though may benefit economically but at the same time raises concern about food security as the major shift is from Cereal crops to vegetables. There is a decrease in area under wheat from 75% to 65% though the intensity of cropping in the state has risen from 158.41% to 170.3% over 28 years i.e., from 1966-67 to 1994-95 (scientific note, 2004). The article by Pratibha Chauhan "Global warming? Welcome to Lahaul-Spiti" in The Tribune (dated July 3, 2010 page 3) points about the possible socio-economic revolution for tribals as an effect of global warming as they have started cultivating apples in the cold desert of Lahaul Spiti. The areas which used to be the traditional producer of high-quality potatoes and peas till now are switching over to apple production like Lahaul and Kaza due to the rise in temperature. The government is also encouraging apple cultivation to make local people economically sound in Lahaul and Spiti. Potato grown in high hills is of good quality as compared to low hills, valleys and plains. A decrease in the production of potatoes was observed after the 1990s although Himachal Pradesh used to be the largest producer of quality of seed potatoes in India during the decades of the 70s and 80s. Livelihood strategies in the farm sector are highly vulnerable to the uncertainties of nature (Pattern and Context of Rural Livelihoods in Himachal Pradesh, 2008). Even a crop failure in one season devastates the economy of cultivators. This makes people adopt multiple livelihood strategies. The floods caused by excessive rainfall not only cause heavy loss to the agricultural and horticultural economy but leads to heavy erosion. In view of the limited agricultural land and small holdings, even a little variation in the climatic situation completely shatters the economy of the poor farmers. Every year state government has to incur expenditure of crores of rupees in the form of relief and rehabilitation works. The fluctuations in rainfall can vary the production of fruitsand at the same time can affect the economic conditions of people and the state which is to some extent dependent on the production of fruits a major part being apple production. The inadequate chilling in winter is the main reason for a reduction in apple crops in Kullu and Shimla districts recently and the shift of the apple belt to Lahaul & Spiti and Kinnaur districts (Aggarwal, ICAR). Early snow which strongly influences soil moisture is regarded as durable, long-lasting and full of nitrogen; late snow, on the other hand, is described as watery, transitory and considered to adversely impact pollination and apple fruit-bearing. Climatic changes alter the pattern of blossoming, bearing and, therefore, fruit yield and quality (Vedwan and Rhoades, 2001). Rise in temperature, long spells of drought during summers, and less snowfall during winters have

rendered large areas supposed to be marginally suitable for apple cultivation unfit for same forcing farmers to go for other cash crops e.g., in lower areas of Kullu and Mandi districts farmers have shifted to the cultivation of tomato and peas and in Rajgarh area to peach. 'According to horticulturists, global warming has caused loss of vigor, fruit-bearing ability, reduction in the size of fruit, less juice content, low color, reduced shelf life and increasing attacks of pests resulting in low production and poor-quality crop' (Indian Express). The rate of infection by the disease Canker which causes the decaying of trees has increased and an increasing number of sprays are now required for the routine control of pests (Vedwan and Rhoades, 2001).



Source: Statistical outlines from Economics and Statistical Department Himachal Pradesh, Shimla

Though the data on rainfall and fruit production shows a positive relationship there are no hard facts about the certainty of what will happen of the increases in the concentration of greenhouse gases within the atmosphere and hence the reliability of the predictions on climate change is uncertain (Aydinalp and Cresser, 2008). Variations in mountain climate can be noticed in the amount of precipitation received and its irregularity. Extreme events have also increased in this area (Dash, 2007). Flash floods and cloud bursts which are extreme events affect a large part, especially people living along river valleys (Pattern and Context of Rural Livelihoods in Himachal Pradesh, 2008). "Predicting the effects of climate change on the magnitude, frequency, timing and duration of extreme weather events is very difficult. Even a small change in the local weather of the fragile mountain ecosystems can bring about large-scale changes in the form of soil erosion, landslides and flash floods" (Dash, 2007). A number of human activities such as cutting of trees, construction of buildings and roads on hill slopes, construction of big dams for hydropower generation, wrong agricultural practices, overgrazing, etc., are some of the prominent activities that cause landslides and slips which further destroy agricultural land. Mountain tourism has also helped in degrading the ecosystem. There can be a forced diversification from more water-requiring crops to other crops further reducing grain yield.

According to (socio-economic indicators Himachal Pradesh-2007) out of a total of 1182926 Rural households in Himachal Pradesh, the number of households below the poverty line is 282370 i.e., 23.87%. The percentage of the population which is below the poverty line is quite large which can not be neglected and is highly vulnerable to changes.

The necessity of increasing forest area for diluting the effect of global climatic changes

Himalayas not only govern the ecological, economic and social conditions of neighboring areas but shape the climate, hydrology and soil fertility of much of South Asia. Therefore, the preservation of its components is not only important for its inhabitants but for the region as a whole (Agenda on Environment Protection, HP). One of the major components is forests as they not only maintain atmospheric balance by returning oxygen and absorbing carbon dioxide through the process of photosynthesis but are essential for the maintenance of the hydrological cycle, watersheds and controlling the hydrology of rivers which in turn have their socio-economic implications. A report submitted by the National Agriculture Commission in 1976 highlighted that the continued decline in the forest cover could cripple agriculture production because forests perform the protective function of recharging and conserving watersheds and basins on which agriculture depends (Dash, 2007). Since 1894 there exists a national forest policy, which was revised after independence in 1952. The national forest policy and Forest (Conservation) Ordinance, of 1980 lays stress on the protection, conservation, and development of forests in the country. The area of forests has increased in Himachal Pradesh due to plantation activities which started during the third Five Year Plan with the planting of fast-growing and coniferous species, soil conservation plantations, mainly of *Acacia catechu* under River Valley Project and later by schemes like integrated watershed development project (Kandi areas) in1990-91 and Indo German Eco-Development Project Changer (GTZ), launched in 1993. According to the National Forest Policy of 1988, which aims to maintain about two-thirds of the geographical area in hills of the country under forest the state is required to maintain about 66 percent of the geographical area. The actual forest cover in Himachal Pradesh is only 22.49%. Therefore, a massive afforestation program is needed to achieve 29.5% which is the maximum possible in Himachal ecologically within the legal forest area (Environment Policy Department of Science and Technology Government of Himachal Pradesh). For this, programs like social forestry and agroforestry should be encouraged which establishes a happy relationship between forest and society and meets ecological, social and economic goals by maintaining forest health, reducing pollution, controlling soil erosion and extension of deserts, meeting the requirement of forest and crops and improving economy by providing a solution to rural unemployment (Khosla and Khurana, 1987; Tiwari, 1983).

Suggestions:

- The forestry schemes should pay attention to the denudation of Himalayan forests.
- Check on the expansion of urbanization and industries on prime agricultural land.
- Promotion of agro-forestry with local people's participation.
- Water harvesting should be done to increase irrigation in the sub-montane, low hills sub-tropical region of the state which is 33% of the cultivated area to increase crop yield and thus help in food security.

- Traditional food crops and organic farming with great food value must be encouraged.
- To develop new varieties of crops which are capable of withstanding extreme weather, floods, dry spells, etc.
- Strategy should be not to use the area of other crops but to increase per hectare yield in the current area by scientific and biotechnological means and discouraging chemical fertilizers.
- A check on horticulture at the expanse of forest resources but its promotion on available cultivable wasteland.
- Assessment of the impact of industrial emissions and pollutants on agriculture.
- Per-worker productivity should be increased for the growth of the farm sector and more employment as the data shows that saturation in the tertiary sector has been reached and people have started to move towards the primary sector.
- Intensification by adopting technology suitable for small land holdings as the scope of extensification of cultivation is very limited in the northern high hills as a large proportion of land is already either under cultivation or has orchards or forests on it.
- Extensification in plains, valleys and low hills, if possible, for bringing more land under cultivation.

Conclusion

Climate change has and could affect water availability in the Himalayan region further causing water stress in the lean season or maybe throughout the year. A little change in weather elements could affect especially rain-fed agriculture severely and in turn the livelihoods of people who are dependent on it. Hence, timely intervention is required keeping in mind the future implications of climate change and necessary steps should be taken in advance so as to help agriculture, food security and related livelihoods of the people of the state.

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