

Climate Change and Agricultural Sector in Uttarakhand

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ABSTRACT

The relationship between climate change and agriculture is not a new phenomenon. In last fifty years, there has been a lot of academic focus on dealing with the issues of climate change in the field of agriculture. Climate change is believed to affect agriculture by inducing changes on farmer behaviour, quantity, quality, cost of production; changes in production, consumption, prices, and trade patterns; changes in market responses at global and local levels and these changes not only depend on the domestic and global adaptive capacity their economic impacts also vary by region, by sector, and by stakeholder groups. Climate change is a major global environmental problem and also an issue of great concern to all countries irrespective of their size or level of development. It is established that adverse impacts are likely from increased frequency of extreme weather, floods and droughts and submergence of coastal areas due to sea level rise and extreme climate variability. It is considered that mountain regions are vulnerable to climate change and it will have direct impacts on livelihoods as most of the economic and livelihood sectors are vulnerable to the impacts of climate change.

Key Words: *Climate impact, agriculture in Uttarakhand, climate change and agriculture, agricultural production in Uttarakhand*

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Introduction:

There is evidence that the world's climate is changing and threatening the world's environmental, social and economic development, including the agricultural sector (Mall, Singh, Gupta, Srinivasan, & Rathore, 2006). The Earth's climate is constantly changing as a result of natural processes. The atmosphere has an effect like a greenhouse on the Earth's temperature. It has been observed that the increase in frequency and intensity of weather extremes, including high temperatures leading to long time drought and inconsistent rainfall patterns are the results of climate change and increased weather variability. This changing weather patterns makes it difficult for farmers in the country to predict, that which type of weather is better for different kind of crops using the traditional knowledge. These changing weather patterns have come with challenges

such as tropical storms, wildfire, soil erosion, pests and diseases which are causing devastating loss to farmer's yields. Villagers are also facing a continuous failure of winter crops for the last two years. This is happening due to absolute lack of rains during critical winter period. Duration of wheat crop has reduced by 15 to 20 days due to the rise in temperature, which has resulted in suitable climatic conditions for the crops to risen (Chijioke, Haile, & Waschkeit).

Sometimes there is continued rainfall during the dry seasons and pronged dry spell occurred during rainy seasons making it difficult for farmers to plan for cultivation. In the olden days the rainfall patterns were timely and it was easier for farmers to follow the traditional planting trends but now the extreme frequency with prolonged dry spells and heavy rains resulting into flooding which leads to poor yields and

the disease burden on the agriculture. A farmer who depends completely on proceeds of his or her crop as well as animal husbandry therefore meet unexpectedly loss leading to hunger, starvation, limited pasture and also the low production due to the climatic changes, because the production of the crops, vegetables and fruits etc. totally depends on favourable climate conditions. A greenhouse gas emission raises the earth's temperatures (Aydinalp & Cresser, 2008).

The consequences include melting glaciers, more precipitation, more and more extreme weather events and shifting seasons (Nelson, et al., 2009). More changes in climate combined with global population, threatens food security everywhere. Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops. Changes in precipitation patterns increase the likelihood of short-run crop failures and decline the production in long-run.

The relationship between climate change and agriculture is not a new phenomenon. In last fifty years, there has been a lot of academic focus on dealing with the issues of climate change in the field of agriculture. Climate change is believed to affect agriculture by inducing changes on farmers' behaviour, quantity, quality, cost of production; changes in production, consumption, prices, and trade patterns; changes in market responses at global and local levels. These changes not only depend on the domestic and global adaptive capacity but also their economic impacts also vary by region, by sector, and by stakeholder groups (Walthall, et.al 2012). Box-1 provides a brief account of possible impacts of climate change on some selected agricultural crops.

Box 1 Differential Impacts of Climate Change on Different types of crops

- Corn: high night-time temperatures, high temperatures during pollination, water stress
 - Soybean: water stress, high temperatures
 - Wheat and small grains: extreme events, frost during flowering, water stress
 - Rice: temperature extremes during pollination, water management
 - Cotton: high temperatures during boll fill Pasture and rangeland: water stress
 - Fruit trees: chilling requirements not met, high temperatures during fruit development
 - Specialty crops: water stress, high temperatures
- Source: Excerpts taken from Walthall, C.; Hatfield, J.; Lengnick, L.; Marshall, E.; Backlund, P and Walsh, M (2012)'Climate Change and Agriculture in USA:Effects and Adoption', USDA

Table:-1 shows the various physiographic zones of the Uttarakhand are classified into different soil types, crops produced, district wise, along with the rainfall distribution in these zones.

Not only that the events related to climate change affect the agricultural crops they also result in economic loss due to extreme climatic conditions. Figure-1 gives an account of the increase in temperature at the global level over last 150 years. The temperature increase may also lead to some major implications for rainfall, agricultural productivity and so on. Again, the temperature increase may also have an impact on agriculture and life in Uttarakhand. Figure -2 gives a brief account of

the human loss happened in Uttarakhand due to some of the extreme climatic conditions in the state. Such events will only increase in frequency and magnitude with the climate change.

Climate change is a major global environmental problem and also an issue of great concern to all countries irrespective of their size or level of development.

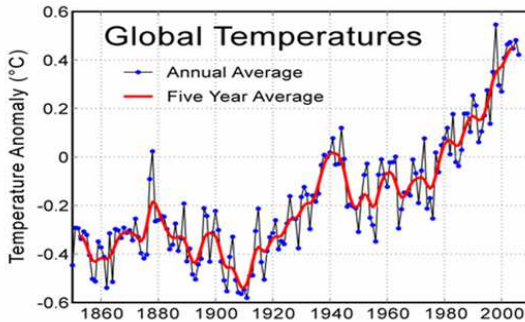
It is established that adverse impacts are likely from increased frequency of extreme weather, floods and droughts and submergence of coastal areas due to sea level rise and extreme climate variability. It is considered

that mountain regions are vulnerable to climate change and it will have direct impacts on livelihoods as most of the economic and livelihood sectors are vulnerable to the impacts of climate change.

If we consider the mountain state such as Uttarakhand, it is more sensitive and more affected by climate change. Climate and weather determine food security of the hill communities, who depends on agriculture and animal husbandry for their subsistence needs. Temperature, precipitation and their associated seasonal patterns are critical components of agricultural production. The agriculture sector uses only 13 % of the geographical

land; it provides employment to almost half of the workers in the State (Mohanty & Singh, 2014).

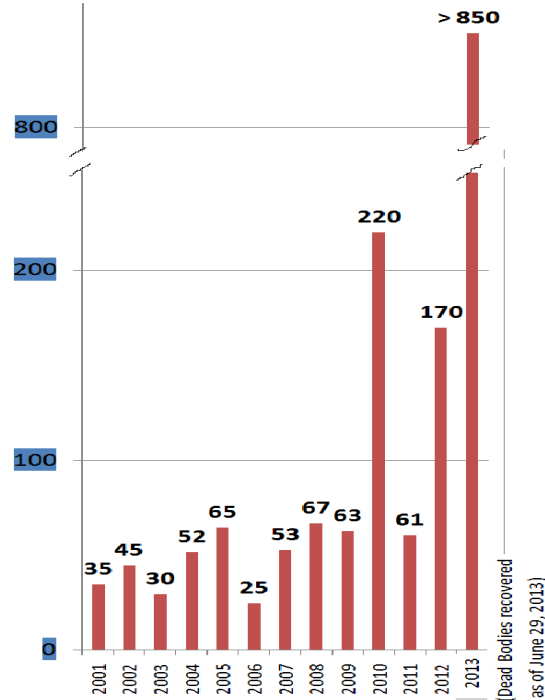
Figure: 1 Increase in Global Temperature in last 150 Years



Source: Source: Global Warming Art, http://www.globalwarmingart.com/wiki/Image:Instrumental_Temperature_Record_png
 Compiled by the Climatic Research Unit of the University of East Anglia and the Hadley Centre of the UK Meteorological Office.

Rising temperature associated with climate change will likely have a negative impact on crop production. Changing seasonal patterns and Increase in frequency and patterns of extreme weather events will affect the stability and the access of food supplies. These continuous changes in the weather have resulted in the overall decrease in the quantity of available water in all the water sources of the region. The area under irrigation is gradually decreasing due to lack of sufficient water for irrigation, resulting in low production of crops. Crop productivity also has been reduced because of low soil fertility. Not only crop production, there have been also a negative impact on the orchard land due to climate change. Due to no rain in most areas of Uttarakhand, the trees have not borne fruits. The litchi production has been decreased and prices of litchis have now touched all time high because of the shortfall in the production. Also people from older generation view that the rosy aroma that used to be an integral part of fruits like litchi is no more available now-a-days. Many people with traditional knowledge of agriculture and also scientists identify such changes in crops productions with rapid changes in climatic conditions that have been witnessed in the hilly regions and valleys of Uttarakhand.

Figure 2: Loss of Human Lives in Uttarakhand due to Extreme Climatic Conditions



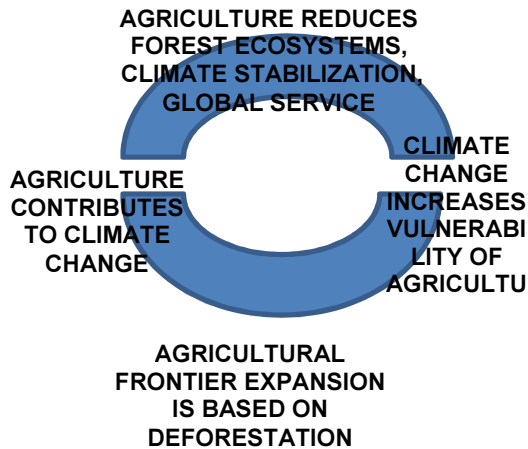
Source (Seismic retrofitting of lifeline structures in Uttarakhand, 2012), (Figures for 2013 taken from News Reports)

It is believed that agriculture and climate change work in a vicious circle. An increase in the intensity of agricultural practice reduces the sustainability of forest an ecosystem, climate stabilization etc. and contributes to the climate change.

On the other hand, climate change also increases the vulnerability of agricultural practices. Figure-3 presents this vicious circle in a perspective. This vicious circle is an important aspect of our study in the present context.

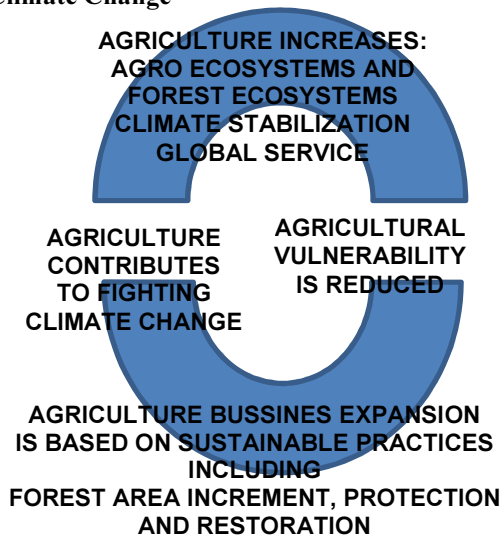
But there also exist a virtuous circle between agriculture and climate change that is necessary to discuss when we are dealing with the climate change impacts on agriculture. Figure-4 shows the virtuous circle of agriculture and climate change and it is in his context that we are more interested in while discussing the issues in relation to climate change in Uttarakhand.

Figure 3: Vicious circle of Agriculture and Climate Change



Source: (Rodas)

Figure 4: Virtuous Circle of Agriculture and Climate Change



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While the major objective of the present study is to assess possible impacts of climate change in Uttarakhand, we need to focus on policies that may lead to the establishment of this virtuous circle as well.

The present study seeks to highlight some of the inter-linkages between the changing climate patterns and agricultural outcomes in the state of Uttarakhand. Since, the issue of climate change is an emerging field and there has not been much work done on the state of Uttarakhand, such a study is expected to present some interesting ideas for the policy makers while undertaking planning exercises for the agricultural sector in the state.

A Critical Appraisal of State Agricultural Policy of Uttarakhand vis-à-vis Environmental Sustainability

In Uttarakhand rainfall pattern differ from district to district and also with altitudes and slopes, the average annual rainfall experienced in Uttarakhand is 1500 mm. Table: 2 shows the patter of variation of the rain in the State. The most of the area of hill being fully rain fed, the monsoon behaviour cast great effect on crop production.

As per the Annual report of Uttarakhand Organic Commodity Board it has been found through analysis of rainfall pattern during last many years that:-

1. Rainfall in monsoon is generally efficient and erratic over the years.
2. Peak rainfall is shifting from the mid July to mid-August.
3. The total number of rainy days is shrinking.
4. During Rabi Season, rainfall was erratic/ negligible over the years.

5. Peak rainfall in Rabi season is shifting towards harvesting season.

agriculture for livelihood. Agriculture in Uttarakhand is already constrained due to mountainous terrain, low temperatures and short growing seasons, with

Box:2 Possible Impacts of Climate Change on Agriculture through different types of Changes

Temperature Related Changes

Longer frost-free period (high)
Higher average winter temperatures, both daily maximum and daily minimum (high)
Fewer extreme cold temperatures in winter (high)
Fewer extreme high temperatures in summer in short term but more in long-term (medium)
Higher night-time temperatures both summer and winter (high)
More freeze-thaw cycles (high)
Increased temperature variability (high)

Rainfall Related Changes

More (~10%) precipitation annually and during the growing season (medium)
Most of the increase will come in the first half of the year (wetter springs, drier or little change in summers) (high)
More water-logging of soils (medium)
More variability of summer precipitation (high)
More intense rain events and hence more runoff (high)
Higher episodic stream flow (medium)
Longer periods without rain (medium)
Higher absolute humidity (high)
Stronger storm systems (medium)
Snowfall increases (late winter) in short term but decreases in long run (medium)
More winter soil moisture recharge (medium)

Other Changes

Reduced wind speeds (high)
Reduced solar radiation (medium)
Increased tropospheric ozone (high)
Accelerated loss of soil carbon (high)
Faster plant growth and development to maturity (high)
Weeds and vines grow more rapidly under elevated atmospheric CO₂ (high)
Weeds migrate northward and are less sensitive to herbicides (high)
Plants have increased water-use efficiency (high)
Combinations of conditions and pathogens more favourable for development of toxins (medium)

Source: IOWA (2012), Climate Change and Agriculture, IOWA State University

The rivers in the region originated from the Himalayan glaciers. Between 2006 and 2008 a series of floods and droughts were experienced with change in the rainfall pattern in the area, which effected crops, animals and people's livelihoods extensively (**Mele**).

Changes in critical variables such as temperature and rainfall can unfavourably impact the snow and ice cover, glacial flows and hence impact life and livelihoods of communities downstream, table:-3 shows the variation of the temperature in Uttarakhand. In India, it is estimated that a temperature increase of 2°C could lower the produce of basic crops such as wheat and rice by 10% and decrease farm revenues (DFID, 2006). A large population in Uttarakhand is dependent on

climate change compounding these factors.

The majority of State agriculture is rain fed and there is not much production beyond a subsistence living. Uttarakhand is mostly rain fed, irrigation facilities are minimal, and land holdings are small and uneven.

In the Kharif Season about 66% of the area is rain fed of the total area major area is under cereal and pulse productions. As area under cereal production is the maximum of which 66% is rain fed the yield in rain fed area is 15 qt. per ha which is very less compared to irrigated areas where it is 21qt. per ha. The overall yield from all the major crop in the rain fed area is 14 qt. per ha. compared to the yield in irrigated area which 21 qt. per ha (Table: 5). And in the Rabi season, cereal cultivation area is 60 per cent and 40 % irrigated from the other sources and the gap

between the irrigated and rain fed area is very high, the overall productivity of rain fed area is just 11 (q/ha.) and productivity of irrigated area is 33 (q/ha.).

This may have happened due to lack of irrigation facilities or may have been occurred due to unexpected heavy rainfall. Improvement in the irrigation facilities and increase in organic farming may have resulted in better productivity.

Conclusions and Policy Suggestions:

With the help of some relevant data related to agricultural crop we drew graphs and through these graphs we can conclude that there are some possible inter-linkages between climate change and agricultural sector. Present study shows that climate change affect the productivity which in turn the agriculture as a whole.

In this study we have taken Cereals, Pulses, Oilseeds and some other crops from two different seasons such as kharif and Rabi. By the help of all different graphs we can see that there are some major differences in the production of these different crops which may have happened due to the change in the climate.

The major policy suggestions are,

- The most of the Uttarakhand agriculture is rain fed and there is not much production. As a result most of the persons have migrated to other places in search of employment. Only women are left in the hills and they have started looking after the farms. The challenge is to change this structure and create employment through agriculture. This could be done by diversifying the agricultural pattern so as to create alternative income and better living standards.
- Suitable mitigation strategies should be followed by the policy makers to lower the emission from the agriculture sector.
- It is important to assess inter linkages between ecosystem services and food production and how ecosystem based adaptation will add to food security.
- By taking the adaptation and mitigation strategies to make agriculture sustainable on the face of global warming and improve livelihoods of farmers.
- By assessing the effects of global climate change on agriculture might help to deal with the farming system and to maximize agricultural production.

- Senseless felling of trees and destruction of ancient forest which is the result of human activity should be stopped.
- Adapting the climate, people must have started cultivation of crop varieties that required less water.
- It is observed that chemical fertilizers have severely affected soil health which is continuously deteriorating. To maintaining the crop yield through sustainable agricultural practices, it should be considered to promote organic farming methods, combining modern technology with traditional farming practices.

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Table 1: Physiographic zones of Uttarakhand, their attributes, major produces and livestock

S.no.	Zone	Farming situation	Soil	Rainfall (mm/year)	Districts	Principal farm produces and Livestock
1	Zone A up to 1000 m	Tarai irrigated	Alluvial	1400	U.S.Nagar, Haridwar	Rice, wheat, sugarcane, lentil, chickpea, rapeseed-mustard, mango, litchi, guava, peach and plums. Livestock: Buffalo and cattle.
		Bhabar irrigated	Alluvial mixed with boulders and shingles	1400	Nainital, Dehradun and Pauri Garhwal	Rice, wheat, sugarcane, rapeseed-mustard, potato, lentil, mango, guava, and litchi. Livestock: Buffalo and cattle
		Irrigated lower hills (600-1000 m)	Alluvial sandy soil	2000-2400	Champawat, Nainital, Pauri Garhwal, Dehradun, Tehri Garhwal	Rice, wheat, onion, chillies, peas, potato, radish, cauliflower, pulses, oilseeds, soybean, mango, guava, plums, and peaches. Livestock: Buffalo and cattle
		Rain-fed lower hills (600-1000 m)	Residual sandy loam	2000-2400	Champawat, Nainital, Pauri Garhwal, Dehradun, Tehri Garhwal, Bageshwar	Finger millet, maize, rice, wheat, pulses, mango, guava, plums, and peaches. Livestock: Buffalo, cattle and goat
2	Zone B 1000-1500m	Mid hills south aspect (1000-1500 m)	Sandy loam	1200-1300	Champawat, Nainital, Almora, Dehradun, Tehri Garhwal, Bageshwar	Rice, finger millet, wheat, potato, tomato, peas, Cole crops, pulses, peach & plums. Livestock: Cattle, sheep & goat
3	Zone C 1500-2400m	High hills (1500-2400 m)	Red to dark	1200- 2500	Pithoragarh, Almora, Chamoli, Bageshwar	Amaranth, finger millet, French beans, Cole crops, potato, peas, peaches, plums, pear, apple, stone fruits. Livestock: Cattle, sheep and goat,
4	Zone D >2400 m	Very high hills	Red to dark Black clay	1300	Pithoragarh, Chamoli, Uttarkashi	Amaranth, buckwheat, peas, Cole crops, apple and potato. Livestock: Sheep, goat

Source: (Uttarakhand State Perspective and Strategic Plan 2009-2027)

Table – 2: Rain In Uttarakhand

S.no.	District	Rain (millimetre)		
		2009	2010	2011
1	Dehradun	1624.7	3253.5	2688.5
2	New Tehri	521.8	1526.2	1228.5
3	Pant Nagar	1013.5	1984.9	1968.5
4	Mukteshwar	1315.1	1701.3	1487

Source: (Statistical Diary 2011-12)

Table- 3: Temperature (centigrade) In Uttarakhand

S.no.	District	2009		2010		2011	
		Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.
1	Dehradun	41.9	3.7	41.9	3.7	37.9	2.6
2	New Tehri	42	0.8	42	0.8	39.5	0.3
3	Pant Nagar	30.3	-1.7	30.3	-1.7	27.8	-4
4	Mukteshwar	34.4	1.6	34.4	1.6	32	18

Source: (Statistical Diary 2011-12)

Crops	Table-4 (a) Area and Yield of Major Crops in Irrigated / Rain fed Conditions during Kharif Season						Table-4 (b) Area and Yield of Major Crops in Irrigated / Rain fed Conditions during Rabi Season					
	Area (ha.)			Yield (q/ha.)			Area (ha.)			Yield (q/ha.)		
	Total	Irrigate d %	Rain fed %	Irriga ted	Rain fed	Aver age	Total	Irrig ated %	Rain fed %	Irriga ted	Rain fed	Ave rage
Cereals	507003	34	66	21	15	17	421446	40	60	33	11	20
Pulses	39164	4	96	7	9	9	22607	41	59	10	4	7
Oilseeds	16845	40	60	16	9	12	14373	48	52	9	4	6
Others	3270	25	75	8	4	5	12986	100	0	33	0	33
Total	566282	32	68	21	14	16	471412	42	58	31	11	19

Source: (Uttarakhand State Perspective and Strategic Plan 2009-2027)