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Effect of Climate Change in Himachal

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ABSTRACT

Although the understanding of the impact of climate change continues to improve, it is as yet difficult to identify the specific regional impact with any precision. This uncertainty remains a key constraint and major challenge in both, formulating and implementing policies related to adaptation. Climate change represents a loss of information; the value of historical data in guiding water resources decision-making is degraded and future conditions are subject to a high level of uncertainty. With the very high variations of topography and rainfall, projection of future climate trends will be especially difficult for Himachal Pradesh.
Keywords: Climate Change, Physical and Biological Systems, Anthropogenic Warming Influence

I. INTRODUCTION

Warming of the climate system is unequivocal as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Many natural systems on all continents and in some oceans are being affected by regional climate changes. Observed changes in many physical and biological systems are consistent with warming.

Anthropogenic warming over the last three decades has likely had a discernible influence at the global scale on observed changes in many physical and biological systems.

Climate data coverage remains limited in some regions. In many parts, there is a notable lack of data on observed changes in natural and managed systems. Analyzing and monitoring changes in extreme events including drought, tropical cyclones, extreme temperatures, the frequency, and intensity of precipitation is more difficult than for climatic averages as longer data time-series of higher spatial and temporal resolutions are required.

Effects of climate change on human and natural systems are difficult to detect due to ongoing adaptation and non-climatic drivers. Difficulties remain in reliably simulating and attributing observed temperature changes to natural or human causes at smaller than continental scales. At these smaller scales, factors such as land-use change and pollution also complicate the detection of anthropogenic warming influence on physical and biological systems.

II. GLOBAL OBSERVATIONS AND PROJECTIONS

While global projections can give guidance, the specific impacts on Himachal Pradesh are however, less clear. Despite significant advances in modeling, different models continue to show some conflicting results and it is not easy to prepare definitive assessments of future climate situations. Climate warming observed over the past several decades is consistently associated with changes in parts of the hydrological cycle and hydrological systems such as changing precipitation pat terns, intensity, and extremes; widespread melting of snow and ice; increasing atmospheric water vapour; increasing evaporation; and changes in soil moisture and runoff. There is however, significant natural variability on inter-annual to decadal timescales in all components of the hydrological cycle, often masking or making interpretation of long-term trends quite difficult.

There is still substantial uncertainty in trends of hydrological variables because of large regional differences, and significant limitations in the spatial and temporal coverage of monitoring networks. IPCC reports provide a good overview of the various projections on global climate changes. Most of these would be applicable to Himachal Pradesh. A broad summary is presented below.

2.1 Temperature:

The best-estimate linear trend in global surface vtemperature from 1906 to 2005 is a warming of 0.74°C (*likely* range 0.56 to 0.92°C), with a more rapid warming trend over the past 50 years. Future projections depend very much on international actions to reduce emissions, presently targeted at less than 1.5° to 2.0°C.

2.2 Average Rainfall:

The consensus is that globally, rainfall has and will increase primarily due to increased evaporation due to higher temperatures. There are however, many anomalies. For example, over much of northwest India, the period 1901 to 1925 shows increases of more than 20 per cent over the 100 year period, but the same area has shown significant decreases since 1979. This trend is now apparent in some parts of Himachal Pradesh.

2.3 Potential Evaporation:

This is projected to increase globally due to increase in the water-holding capacity of the atmosphere from higher temperatures and non-marked change in relative humidity. Water vapour deficit in the atmosphere increases as a result, as does the evaporation rate. Actual evaporation over open water is projected to increase with spatial variations in surface warming. Changes in evapotranspiration over land are controlled by changes in precipitation and radiative forcing, which would in turn, impact on the water balance of runoff, soil moisture, water in reservoirs, and the ground-water table.

2.4 Extreme Rainfall Events:

Globally, it is considered *very likely* that heavy precipitation events will become more frequent. The intensity of precipitation events is projected to increase especially in areas which experience increases in mean precipitation. In most tropical and mid-latitude areas, it is estimated that extreme precipitation will increase more than mean precipitation. Widespread increases however, in heavy precipitation events (e.g., above the 95th percentile), have been observed even in places where total amounts have decreased. These increases are associated with increased at mospheric water vapour and are consistent with observed warming.

2.5 Droughts:

There are linkages between intense precipitation and droughts. The projected increase in the risk of intense precipitation and flooding is associated with the risk of drought.

Increased precipitation is projected to be concentrated in more intense events resulting in longer periods of lower precipitation in between. Intense and heavy episodic rainfall events with high runoff amounts are likely to be in trespassed with longer relatively dry periods with increased evapotranspiration, particularly in the sub-tropics. Depending however, on the threshold used to define such events, an increase in the frequency of dry days does not necessarily mean a decrease in the frequency of extreme high-rainfall events. Another aspect of these changes is related to changes in mean precipitation; the projection is that in general, wet extremes will become more severe in areas where mean pre capitation increases, and dry extremes, more severe where mean precipitation decreases. Multi-model climate projections for the 21st century show increases in both, precipitation intensity and number of consecutive dry days in many regions. Precipitation intensity will increase almost everywhere, particularly at mid and high latitudes where mean precipitation also increases.

2.6 Changes in Surface Water Resources:

There have been many studies globally to assess trends in river flows. However, no homogeneous pattern has been observed. Difficulties were found in assessing trends and differentiating these from increases in abstraction over time and changes in the catchment conditions. At a global scale, there is more coherent evidence of changes in annual runoff with some regions experiencing an increase and others, a decrease. For Himachal Pradesh, the very high levels of hydroelectric and other infrastructure development in rivers and lack of long-term records make estimates of trends difficult.

2.7 Glaciers:

The linkages between trends in climate and trends in glacier extent (length, area, volume, and melt volumes) are of key concern to the future water resources of Himachal Pradesh as well as of downstream states. The consensus is that glaciers around the world are shrinking primarily because of global warming; the precise rate of melt is still not well re searched. Orlove describes that the linkage between glacier extent and temperature is not quite as direct and immediate as many studies suggest.22 The effects of warming can be influenced by other variables such as topography and cloud cover, both of which affect exposure to sunlight; and the nature of the glacier bed, which can favour or delay the flow of ice. Changes in precipitation associated with climate change can influence accumulation in the upper portions of a glacier and ablation in the lower portions.

Moreover, since many glaciers are large, it can take a long time for them to respond to shifts in temperature. Although warming takes place on their surfaces, their interiors can remain cold for some time. Orlove however, concludes that nonetheless, in simple terms, ‘the glaciers are melting because temperatures are rising’. It is estimated, that for some areas, a temperature increase in 1°C would require of the order of 25 per cent extra precipitation to offset the increased rate of ice melt.

III. EFFECTS OF CLIMATE CHANGE IN HIMACHAL PRADESH

The scope of the study does not allow a full and comprehensive analysis of the water sector parameters under climate variability in Himachal. Some indicators include:

3.1 People’s Perception

It is evident that farmers are now observing the impact of climate change. Rural knowledge of the changes is in many ways, quite advanced through the day to day seeing and feeling of the changes. Observed parameters include movement to higher altitudes of apple orchards, loss of various tree species, drying of traditional water sources, changing of bird types and populations, reduction of crop yields, and increased vulnerability of crops due to drought and delays in planting. Hopper burn in rice was first reported in the Kangra valley during 2008. Other previously unknown pests are now becoming apparent.

3.2 Observed Changes

The mountain ecosystems harbour a wide range of natural resources and are particularly sensitive to change. Regional changes in climate have already affected a number of the physical and biological systems in the mountains. Analysis of temperature trends in the Himalayas and its vicinity shows that temperature increases are greater in the uplands than the lowlands.

3.3 Glacier and Snow Changes

The glaciers can provide a very useful measure of temperature trends–especially relevant in Himachal Pradesh. There are differing assessments of the rates of retreat and longevity of the glaciers. Further research is very important to make more definitive assessments. Less well defined is the percentage of dry season river flows that is attributable to the glaciers. Nineteen glaciers in the Baspa basin were monitored over a period 1962 to 2001. The investigation showed that all the glaciers were receding and overall, 19 per cent deglaciation was observed in the period. Glaciers at around 5000 m elevation showed 24 per cent loss compared with 14 per cent loss for glaciers above 5400 m. The mean glacier terminus has moved vertically about 88 m. Change in the snowfields is less conclusive and is influenced by the annual cyclical variations of rainfall. An extensive analysis of rainfall and temperature patterns at different elevations is required. Assessments of glacier change are complex and should be based on a study of the mass balance and the location of the equilibrium line.

IV. CLIMATE ASSESSMENT IN HIMACHAL PRADESH

Studies by the Himachal Pradesh Agricultural University give some indications of higher than average impacts of climate change in the Himachal Pradesh uplands than on the lowlands. From the studies covering over 30 years of records, average air tem peratures were found to be 0.7 to 2.4°C higher than that in the 1980s, as against the global average of 0.5°C; the Himachal Pradesh trend indicates an increase of 0.06°C per year. An analysis of rainfall data over the period 1976 to 2006 show increasing trends of rainfall in Lahaul, Spiti, Chamba and Kangra but decreasing trends in Solan and Kinnaur. Other districts showed no significant trends. Crops are showing shorter periods of flowering and maturity.

Table.1.1. Indicative Climate Impacts on Water Resources

Phenomenon and trend direction	Likelihood	Broad impacts on Sectors			
		Water resources	Agriculture/ Irrigation	Other	Adaptation Strategies
Increased frequency of heavy precipitation	Very likely	Increased runoff and higher levels of sediment loading. Reduced groundwater recharge.	Damage to crops and increased soil erosion.	Increased sedimentation will affect hydropower and potable water. Shut-down of hydropower may become more frequent.	Soil and water conservation. Storage to reduce sediment levels. Groundwater management.
Increase in extreme rainfall intensity	Very likely	Increased flood flows.	Damage to crops and severe economic loss for farmers.	Disruption and damage to settlements, roads, infrastructure, and risks to human life.	Soil and water conservation. Insurance. Flood management and protection. Disaster preparedness and management. Changes to design criteria for dam and other water structures. Sustainable urban drainage and land use planning.
Increased variability in rainfall patterns	Very likely	Erratic river flow patterns.	Major impact on non-irrigated crops.	Reduced hydro power production.	Soil and water conservation. Water harvesting, irrigation, and improved agriculture technologies. Improved seed varieties.
Increased likelihood of water shortages/ drought	Very likely	Reduced dry season flows. Drying up of some minor tributaries and springs.	Major impact on rainfed cropping. Some impact on irrigated cropping.	Reduction in water availability for some hydro power, irrigation, and water schemes. Loss of some perennial sources of potable water.	Soil and water conservation. Water harvesting, irrigation, improved agriculture technologies, and new seed varieties. Move from annual to perennial crops including agro-forestry. Improve irrigation and water supply efficiencies.

Source: Report, Himachal Pradesh Agricultural University

Table.1.2. Indicative Climate Impacts on Water Resources

Phenomenon and trend direction	Likelihood	Broad impacts on Sectors			
		Water resources	Agriculture/ Irrigation	Other	Adaptation Strategies
Reduced levels of precipitation as snow	Likely	Increased winter season runoff. Reduced dry season flows. Drying up of some minor tributaries and springs. Reduced dry season flows to neighbouring states.	Irrigation and potable water schemes in snow-fed rivers and streams would have reduced summer flows.	Loss of some perennial sources of irrigation and potable water. Higher winter rainfall will increase erosion.	Soil and water conservation. Adjustments in cropping schedules.
Loss of glacier volumes	Likely	Initially increased dry season flows. Over the longer term, likely reduced dry season flows-time frame uncertain. Long term reduced dry season flows to neighbouring states.	Uncertainty in supply of irrigation, water and hydropower.	Loss of some perennial sources of potable water. Long term reduced hydroelectric power, irrigation and water supply.	Improvement in irrigation and water supply efficiency. Optimisation of hydropower cascade dams. Storage at selected hydro sites. Change of water sources for potable water.
Earlier snow melt	Very likely	Increased spring flows and reduced summer flows.	Irrigation schemes in snow-fed rivers would have reduced summer flows.	Loss of some perennial sources of potable water and irrigation.	
Increased temperature	Very likely	Increased river and lake temperatures.	Changes in suitability of crops at different altitudes - eg. apples. Possible impact on aquaculture.	Changes in aquatic ecologies-including balance of phytoplankton/ zooplankton balances in rivers and water bodies. Increased bacteria.	Application of land suitability analysis under new climatic conditions. Estimation of temperature changes and impact in rivers and lakes.

Source: Report, Himachal Pradesh Agricultural University

V. PROJECTIONS OF FUTURE CLIMATE CHANGES AND THEIR IMPACTS

With current climate change mitigation policies and related sustainable development practices, global greenhouse gas (GHG) emissions will continue to grow over the next few decades. For the next two decades, a warming of about 0.2°C per decade is projected. Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. The pattern of future warming where land warms more than the adjacent oceans, and more in northern high latitudes, is seen in all scenarios.

Anthropogenic warming and sea level rise would continue for centuries even if GHG emissions were to be reduced sufficiently for GHG concentrations to stabilize. This is due to the time scales associated with climate processes and feedback. Equilibrium climate sensitivity is very unlikely to be at temperature changes of less than 1.5°C. Some systems, sectors, and regions are likely to be especially affected by climate change. These include mountain ecosystems, water resources in some dry regions at mid-latitudes and in the dry topics, areas dependent on snow and ice melt, agriculture in low-latitude regions, and human health in areas with low adaptive capacity. Impacts are very likely to increase due to increased frequency and intensity of some extreme weather events. Recent events have demonstrated the vulnerability of some sectors and regions, including heat waves, tropical cyclones, floods, and drought.

Models differ considerably in their estimates of the strength of different feedback in the climate system, particularly cloud feedback, oceanic heat uptake, and carbon cycle feedback, although progress has been made in these areas. Also, the confidence in projections is higher for some variables (e.g. temperature) than for others (e.g. precipitation), and it is higher for larger spatial scales and longer time averaging periods.

Projections of climate change and its impacts beyond about 2050 are strongly scenario and model dependent. Improved projections would require improved understanding of sources of uncertainty and enhancements in systematic observation networks.

Impacts research is hampered by uncertainty surrounding regional projections of climate change, particularly precipitation. Understanding of low-probability but high-impact events, and the cumulative impact of sequences of smaller events, which is required for risk-based approaches to decision-making, is generally limited.

VI. CONCLUSION

Some planned adaptation is already occurring; however, more extensive adaptation will be required to reduce vulnerability to climate change. Unmitigated climate change would, in the long term, be *likely* to exceed the capacity of natural, managed, and human systems to adapt. Making development more sustainable by changing development paths can make a major contribution to climate change mitigation and adaptation, and to reduce vulnerability. Understanding of how development planners incorporate information about climate variability and change into their decisions is limited. This limits the integrated assessment of vulnerability.

Barriers, limits, and costs of adaptation are not fully understood partly because effective adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political, and financial constraints.

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