Climate Resilient Green Growth Strategies for Himachal Pradesh

Towards an Inclusive Development Agenda

The Energy and Resources Institute

Global Green Growth Institute

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Towards an Inclusive Development Agenda

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FOREWORD

It is a matter of pride that The Energy and the Research Institute, (TERI) have taken up an important initiative on climate resilient green growth for the State of Himachal Pradesh. The State has always been conscious of the need to ensure sustainable development and to maintain ecological balance not only for the benefit of the people of the State but also for country as a whole. The report is therefore highly relevant and opportune and the State government will internalize many of these findings in the State policies for preservation of environment.

The research and analysis in the report, makes a strong case for climate resilient green growth which will need to factor-in impacts of future climate variability on natural resources which will have long-term implications for the development of policies of the State, besides other hill states.

Himachal was fast treading on the path of economic development and socio-economic advancement. Our government has taken pro-active measures to ensure that the growth of the State is socially inclusive and as well as environmentally responsible. Dealing with new emerging challenges as climate change requires leadership and environmental stewardship and Himachal is ready to take up such challenges.

I convey my heartfelt congratulations to all the institutes and agencies and the departments involved in this initiative including TERI and the Global Green Growth Institute.

I sincerely hope that with the help of this report, Himachal will also be the leader for responsible environmental leadership amongst the hill states.

(Virbhadra Singh)

Foreword

The importance of Himachal Pradesh for India's sustainable development is well established. With its lush green forests and associated flora, fauna, and diverse ecological pathways, the State is vital in terms of providing ecosystem services impacting large parts of the country. With its hydropower potential, the State plays an important role in terms of ensuring energy security for India.

However every development path comes with implications that need to be understood and carefully examined from time to time. Added to that, the implications of climate change need to be carefully understood. Climate resilient green growth for the State is not a luxury but a necessity. This initiative carries out an analysis to add to our knowledge in these matters. It uses a rich mix of analytical tools including a climate model, soil and water assessment, and energy analysis. Another component under this analysis is field insights from case studies of hydropower projects. In addition, a sectoral review lists challenges and opportunities related to environment and energy.

The Report finds that the overall climatic warming projected over the State in the near future increase by 1.3–1.9°C for 2021–50 relative to 1971–2000. It is also projected that nearly 11.61 per cent area of the State could face serious soil erosion while surface runoff is projected to increase for Beas and Ravi sub-basins. Through a state-specific energy model and on-ground case studies, the report identifies important issues and pressure points that it is felt are relevant for the energy and environment sectors.

The Department of Environment Science and Technology was happy to provide nodal guidance for this initiative which has been implemented by The Energy and Resources Institute (TERI) and supported by the Global Green Growth Institute (GGGI). The Directorate of Energy provided valuable facilitation for the field visits and the Directorate of Economics and Statistics provided insights on macro-level data. The State is already committed to green growth and inclusive sustainable development, and this report will further help the State in planning for further initiatives. The findings will now be analysed at the state level so that they can be inputs for changes in policy in relevant sectors.

I congratulate TERI and GGGI for their efforts towards the project activities. We value the partnership very much and hope that such initiatives bring about much needed science based policy change at various levels.

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Contents

Abbreviations

CSA	Critical Source Area
CUF	Capacity Utilization Factor
DEM	Digital Elevation Model
DPR	Detailed Project Report
ET	Evapotranspiration
GSDP	Gross State Domestic Product
HEP	Hydroelectric Project
HPERC	Himachal Pradesh Electricity Regulatory Commission
HPPCL	Himachal Pradesh Power Corporation Limited
HPSEB	Himachal Pradesh State Electricity Board
HRUs	Hydrological Response Units
IMD	Indian Meteorological Department
IPPs	Independent Power Producers
JJAS	June, July, August, and September
JNNSM	Jawaharlal Nehru National Solar Mission
LADF	Local Area Development Fund
MoEFCC	Ministry of Environment Forest and Climate Change
MRC	Master Recession Curve
MUSLE	Modified Universal Soil Loss Equation
NPK	Nitrogen (N), Phosphorus (P), and Potassium (K)
NSDP	Net State Domestic Product
PRECIS	Providing REgional Climates for Impacts Studies
SWAT	Soil and Water Assessment Tool
WBCs	Water Balance Components
WRIS	Water Resource Information System

Executive Summary

A forward-looking, unequivocal vision and policy signal is essential to translate the potential to real opportunities. Himachal Pradesh government merits special mention here. The state has recognized the importance of greener growth and has been at the forefront of environmental stewardship initiatives, which include the initiatives on climate change and disaster management, energy conservation program for promoting compact fluorescent lamps, enactment of a blanket ban on plastic bags, mandatory rain water harvesting in all newly constructed buildings, organic farming policy, payment for ecosystem services policy, ecotourism policy, and environment master plans.

With its progressive policies, the state is poised to take a leadership position among mountain regions in defining a future strategy of sustainable development rooted in sustainability of natural resources while ensuring future prosperity of its people.

The analytical framework included three models (climate modelling, Soil and Water Assessment Tool (SWAT), and energy modelling), field visits, and a review of sector-wise interventions in Himachal Pradesh.

The project approach was presented in a workshop and in a meeting engaging government officials and experts. Their feedback was used to refine the scope of the project, research questions, and data consistency. The analyses were conducted in consultation with various departments at the state level. In addition, the case studies component facilitated consultations at the district level and at the village level.

Climate

- A high-resolution dynamical model was used to simulate a baseline run from 1970–2000 and for near future (2030s: 2020–50) to arrive at future climate variability over the study domain area.
- Spatial variation is seen for precipitation projections for near future for different seasons. The climate model projects the percentage precipitation change for monsoon months between the range of –8 per cent and 12 per cent. This change for winter months of December to February shows a much larger variation from less than –10 per cent to over 30 per cent in some areas. The whole State shows a positive change for summer rainfall in the range of 5 per cent and 30 per cent. Post-monsoon season also shows a variation in the changes of precipitation percentage in the range of less than –15 per cent in some areas to more than 30 per cent in others.
- Overall warming projected over the State in the near future with respect to the baseline period is projected. Annual mean temperature projected to increase by 1.3–1.9°C for 2021–50 relative to 1971–2000.
- Mean Annual Maximum temperature (Tmax) over the State is projected to increase by 1.1–1.9°C. The Mean Annual Minimum Temperature (Tmin) also is projected to increase over the study domain area in the range 1.5–1.9°C. Increase in Minimum Temperature has many impacts not only over plants, crops but over human comfort as well.
- Extreme rain events are expected to increase for the State in the future time period of 2020–50 relative to the 1970–2000 time period.

Soil and Water Assessment

- In this integrated assessment, the SWAT model will take inputs from spatial analysis as well as the climate model. The model takes into consideration parameters like drainage network, land use and cover pattern, soils, elevation, and climatic parameters for simulating water balance (rainfall, surface and ground water quantity, evapotranspiration (ET), baseflow, and amount of water retained in soil), yield (crop and tree), and indicative soil and water quality of the region. The climate data used in ArcSWAT is output of Providing REgional Climates for Impacts Studies (PRECIS) model.

- Weather inputs for base period (1970–2000) and projected period (2030s) were taken from the PRECIS model. The range of water flow for base period and projected period were helpful in understanding the framework for water, soil, and energy inter-dependencies.
- As compared to 1970–2000, water yield in 2020–35 is projected to increase in sub-basins of Beas, Ravi, Chenab, and Yamuna. The water yield will decrease for Upper Indus and Sutlej. Development activities involving industry, power generation, and domestic sector will need planning accordingly.
- Water availability for irrigation purpose will vary sub-basin wise. Upper Indus, Sutlej Upper, and Chenab sub-basins might have decreased surface water availability. ET is expected to increase by 6 per cent to 8 per cent across all sub-basins. Considering the delivery, conveyance, and application losses, actual irrigation will be considerably more, depending upon the type of irrigation method. Hence, agriculture and horticulture activities in these sub-basins need attention.
- Apple has emerged as the leading cash crop among fruit crops. Based on the model results, it is predicted that as a result of climate variability especially increase in maximum and minimum temperature and decreased snowfall, apple productivity in Himachal Pradesh will decrease by 1 per cent by 2020 and 4 per cent by 2030.
- Soil formation is very slow process. It takes a thousand years for nature to make one centimetre layer of soil. Hence, even slight to moderate soil erosion is not desired. It was found that 11.61 per cent area of the state will have catastrophic soil erosion (more than 320 tonnes/hectare/year), 65.96 per cent area will have very severe soil erosion (80–320 tonnes/hectare/year), and 22.44 per cent area will have severe soil erosion (24–80 tonnes/hectare/year). Besides soil and water conservation schemes, catchment area development and catchment area development programmes continuous strengthening for long-term strategic planning.
- Based on model results, it is projected that as a result of climate variability, Lahaul and Spiti, Kinnaur, Shimla, and Sirmaur will be affected due to medium to high decrease in total annual surface runoff. As compared to this, blocks in Chamba and Kangra districts will have medium to high increased surface runoff. Hence, hydroelectric projects located in these regions need special arrangements to handle increased surface runoff.
- Surface runoff is projected to increase for Beas and Ravi sub-basins while it might slightly decrease or remain stable for Chenab, Upper Indus, Upper Yamuna, and Sutlej Upper.
- Aquifers in Himachal Pradesh are intermittent and scanty, which allows economic water harvesting for limited areas in few regions. Groundwater and subsurface water quantity is projected to increase for Beas, Ravi, Chenab, and Yamuna Upper sub-basins. A decrease in ground and sub-surface water quantity is projected for Upper Indus and slightly decrease for Sutlej sub-basins.

Hydropower

- The current exercise intends to project possible scenario(s) associated with Himachal Pradesh power sector. If the State realizes the capacity targets in the set time-line, the aggregate electricity availability in the State may reach 53,000 million units (MU) by 2032 at a compound annual growth rate of more than 11 per cent from the 2012 level. In terms of generation, 499 MU would be from solar.
- For the electricity demand scenario, the State is expected to witness twofold rise by 2032 from the 2012 level; the total electricity demand is projected to be about 14,400 MU with average per capita electricity consumption around 1,800 units.
- In a no outside State power purchase (from 2022) scenario, Himachal Pradesh may have potential to realize per annum inter-State sales to the tune of 18,000 MU in the Fourteenth Plan period (2022–27), which may reach 38,000 MU by 2032.
- Looking at the current hydro projects at different stages of development, a total of around 11 GW of hydro projects are in pipeline; however, investments for further 2,400 MW of hydro power are required. To realize the additional 2,400 MW, ₹29,000 crores would be required over Thirteenth to Fifteenth Plan periods (escalation in cost is accounted), 45 per cent

of which has to be tapped in the Thirteenth Plan period. On the other hand, the required investments to implement State solar power plans are estimated to be more than ₹2,000 crores over Twelfth and Thirteenth Plan periods.

- The analysis finds that the total revenue from sale of power exceeds total power purchase cost throughout the period (2017–32) if Himachal Pradesh continues purchasing power (~1,982 MU yearly) from outside at a rate of ₹3.21 per unit (this is as per the tariff guidelines). However, in a no outside State power purchase (from 2022) scenario, though Himachal Pradesh may save a part of the power purchase cost, a corresponding decrease in revenue is envisaged to outweigh the saving. Moreover, the study predicts a negative net monetary flow during Fifteenth and Sixteenth Plan periods in this scenario. This is assuming current tariff guidelines.
- The average power purchase cost is expected to increase by around 4 per cent annually till the Thirteenth Plan period compared to 2012 level (cost escalation accounted), largely because of greater share of new power plants, both hydro and solar, which will possibly have higher production tariffs. At this stage, solar power may not seem economically attractive, however, with the improvement in capacity utilization factor, this option may become competitive. Moreover, development of hydropower does entail aspects such as displacement of local population with corresponding compensation and procedures related to land acquisition. Hence, the State government can look to expand the ambition for solar power development in the State.
- The additional funds from hydro power projects in the State in the form of royalty would amount to approximately ₹30,000 crores over the next four Plan periods.
- The corpus for local area development fund (LADF) would be approximately ₹13,000 crores over the aforesaid period.
- It is found that the power output from a hydro power facility may decrease or increase by 6 per cent if mandatory minimum discharge level is raised to 20 per cent or reduced to 10 per cent, respectively. It is envisaged that if mandatory minimum discharge level is raised to 20 per cent, electricity generation from existing hydro power capacities may drop by about 2200 MU annually. Thus, the State may lose ₹1,869 crores in royalty over the next four Plan periods. The State can realize additional financial resource of similar amounts in case the required discharge level decreases to 10 per cent. This number however does not account for ecosystem services lost or generated upstream and downstream.
- An investigation into the possible consequences of climate change on the precipitation, it is observed that precipitation is likely to vary from –8 per cent to 12 per cent over different regions of Himachal Pradesh. It is also seen that 15–40 per cent of total rainfall will be concentrated within short duration of period. As a result of climate variability, the average flow rate observed in the base period (2.98–3.92 m3/sec) will be increased to 3.06–4.71 m3/sec in the near future (2030s). The performance of hydropower projects could be affected due to factors such as surface runoff and soil erosion, which could cause increase in silt transport.
- The loss from forestry sector and tourism sector, for every 1 GW hydro capacity addition, is estimated to be ₹123 crores. This valuation does not include aspects relating to riparian rights and aspects such as drinking water, health, and upstream and downstream livelihoods. This valuation also does not consider monetary valuation of biodiversity as the principle of incommensurability, used in ecological economics, applies. The National Environment Policy of 2006 also talks of entities with "incomparable value" that may be applicable to aspects involving biodiversity and rare species. Even so, it is worthwhile for the State to consider the various trade-offs (monetary and non-monetary) involving hydro-power, forests, tourism sector, livelihoods, and biodiversity.

Community perceptions

- A qualitative field research was undertaken by the study team at four hydro-electric plants in the State in consultation with the Directorate of Energy. The research included focused group discussions and key person interviews using a semi-structured questionnaire to interview hydro developers, villagers, and relevant government officials at State, district, and village level.
- Some of the major issues highlighted pertain to the LADF, employment, compensation, impact of blasting and tunnelling, and impact on the environment.

- The solutions for the issues identified in the case studies have implicitly or explicitly been mentioned in the Hydro Power Policy of Himachal Pradesh. However, inadequate implementation practices have led to some discontent among both the developer as well as the village communities. A lot of these issues need to be tackled on an individual basis rather than only formulating a policy change at a macro level.
- The case studies show that distribution and utilization of LADF is a major issue on both sides—the developer as well as villagers. At this point, it would be prudent to suggest an independent audit of the LADFs (district wise) by the State government with results being communicated via various mediums (one-to-one communication, group meetings, websites, etc.) to all the stakeholders involved. Moreover, it will also provide information on the development activities accruing from these funds carried out by the villagers.
- The government along with the developer could set up a website that would aid in documenting the impact of tunnelling and blasting activities. This website should be set up before tunnelling and blasting activities take place.
- The State government along with project developers can include skill training and livelihood development opportunities as part of the project plan. These skill building and employment opportunities should not only be centred around hydro-electric projects but should be aimed at facilitating local enterprise. This will help in sustaining socio-economic development of project affected communities as the HEP gets commissioned and employment opportunities dwindle.

1

Initiative on Green Growth and Development for Himachal Pradesh

1.1 Context

Himachal Pradesh is a mountain state with an area of 55,673 square kilometres nestled in the lap of the Himalayas. The State has a wealth of natural resources but is also ecologically fragile as it is situated in the Himalayan region. Himachal has performed well in socio-economic indicators with per capita income, human development index, health, and educational income higher than India's average.

In wake of climate change, socio-economic and ecological vulnerability increases and risk-based approaches become even more relevant. Thus, greener growth and sustainable development needs to take into account impacts of climate variability while strengthening policy interventions.

With 1.7 per cent share in country's total geographical area, Himachal Pradesh harbours approximately 7.32 per cent of flora and 7.4 per cent of fauna found in India. This shows the richness the State has in terms of biodiversity. The State also has a rich forest cover with 67 per cent of the geographical area being legally classified as forest area. However, at higher altitudes the tree and forest cover is limited as much of the area is barren because of prevailing geographical and climatic conditions. The State is home to major river basins (which drain into both the Arabian Sea and the Bay of Bengal) that provides ecological services and is critical to the livelihood of more than two hundred million people in Haryana, Punjab, Uttar Pradesh, and Rajasthan. Himachal Pradesh also has one of the main sources of clean energy—hydropower—for the country that can help address both the energy and peak shortages of the Northern Region.

Himachal Pradesh has rapidly evolved in terms of economic growth. The net state domestic product of the State and per capita incomes has shown a steady increasing trend. The secondary sector showed healthy signs of industrialization and modernization. Tourism is also contributing the economy as Himachal Pradesh has the natural capital and resources for being a tourist destination. The structural economy dynamics also has implications for the State's energy demand.

1.2 Motivation

The key engines of sustainable development for Himachal Pradesh include hydropower, horticulture, forestry, watershed management, industry, and tourism. In terms of hydropower and green growth, hydropower needs to be seen within a national green growth context rather than only looking at hydro-power as being important to development in Himachal Pradesh. In order to meet the objective of India's energy security and clean energy, hydropower will continue to play an important role.

A forward-looking, unequivocal vision and policy signal is essential to translate the potential to real opportunities. Himachal Pradesh government merits special mention here. The State has recognized the importance of greener growth and has been at the forefront of environmental stewardship initiatives that include the initiatives on climate change and disaster management, energy conservation programme for promoting compact fluorescent lamps, enactment of a blanket ban on plastic bags, mandatory rain water harvesting in all newly constructed buildings, organic farming policy, payment for ecosystem services policy, ecotourism policy, and environment master plans.

With regard to hydro power development in the State, the State Government has framed the Hydro Power Policy (2006). The policy sets separate guidelines for large (>5 MW) and small hydro (up to 5 MW) projects and deals with different aspects of hydro power development quite comprehensively. To promote small hydro in the State and encourage private investment in the sector, the government of Himachal Pradesh has designated Himurja as the nodal State agency. The government has also adopted the State Solar Power Policy in 2014.

With its progressive policies, the State is poised to take leadership position among mountain regions in defining future strategy of sustainable development rooted in sustainability of natural resources while ensuring future prosperity of its people.

Box 1.1 articulates green growth in the Indian policy context.

Box 1.1: What is Green Growth?
Green growth involves rethinking growth strategies with regard to their impact(s) on environmental sustainability and the environmental resources available to poor and vulnerable groups.
(Para 3.15, Thirteenth Finance Commission Report)

Climate change and resulting climate variability will have an impact on natural resources in the State. Given that the State's developmental activities are dependent on natural resources, for developing a climate-resilient green growth strategy, it becomes important to understand as to what will be the impact of climate variability on the soil and water parameters. In addition, for considering inclusive development aspects, it becomes relevant to understand developmental activities considering socio-economic aspects and perceptions of communities.

1.3 Approach

This report synthesizes the key analytical components for understanding aspects to inform decision making for:

- Climate Vulnerability
- Soil and Water
- Power Generation
- Sector-Wise Opportunities

The analytical framework included three models (Climate Modelling, Soil and Water Assessment Tool (SWAT), and Energy Modelling), case studies from field visits, and a comprehensive review of sector-wise interventions in Himachal Pradesh.

Climate modelling for Himachal Pradesh provides an analysis and evaluation of observed climatological information of Himachal Pradesh and assessment of near future climate variability over the State. Analyses methods include review of literature, obtaining the observed climatological data for the State, and its trend analyses. A high-resolution dynamical model is used to simulate (under A1B scenario) a baseline run from 1970–2000 and for near future (2030s: 2020–50) to arrive at future climate variability over the study domain area.

In this integrated assessment, the SWAT component takes inputs from spatial analysis as well as the climate model. The model takes into consideration parameters like drainage network, land use and cover pattern, soils, elevation and climatic parameters for simulating water balance (rainfall, surface and ground water quantity, evapotranspiration, base flow, and amount of water retained in soil), yield (crop and tree), and indicative soil and water quality of the region.

The analysis on Power Sector Scenario in the State intends to project a possible scenario associated with Himachal Pradesh power sector. This will inform the State into the possible implications of existing sector plans and policies on energy security and finance of the State. The analyses attempt to capture a broad range of aspects of the State's power sector, from technical to economic, which will aid in the planning and decision-making process of the State government for the coming plan periods.

The case studies component examines socio-economic aspects at hydroelectric project (HEP) sites in the State to further understand the concerns of the local people with respect to hydro power projects. This understanding aims to assist policy makers in evolving procedures with respect to project planning and implementation of HEP. To achieve the objective, a qualitative field research has been undertaken by TERI researchers at four hydro-electric plants in the State in consultation with the Directorate of Energy. The research involves focused group discussions and key person interviews using a semi-structured questionnaire to interview hydro developers, villagers, and relevant government officials at State, district, and village level.

A sector-wise review was undertaken as an additional analytical exercise to identify areas of policy interventions. The review included developing discussion papers for air quality, water, forestry, biodiversity, waste management, renewable energy, demand side management, transport, industry, agriculture, buildings, and climate change.

The project approach was presented in a workshop and in a meeting engaging government officials and experts. Their feedback was used to refine the scope of the project, research questions, and data consistency. The analyses were conducted in consultation with various departments at the State level. In addition, the case studies component facilitated consultations at the district level and at the village level. Figure 1.1 gives an overview of the approach followed in the project.

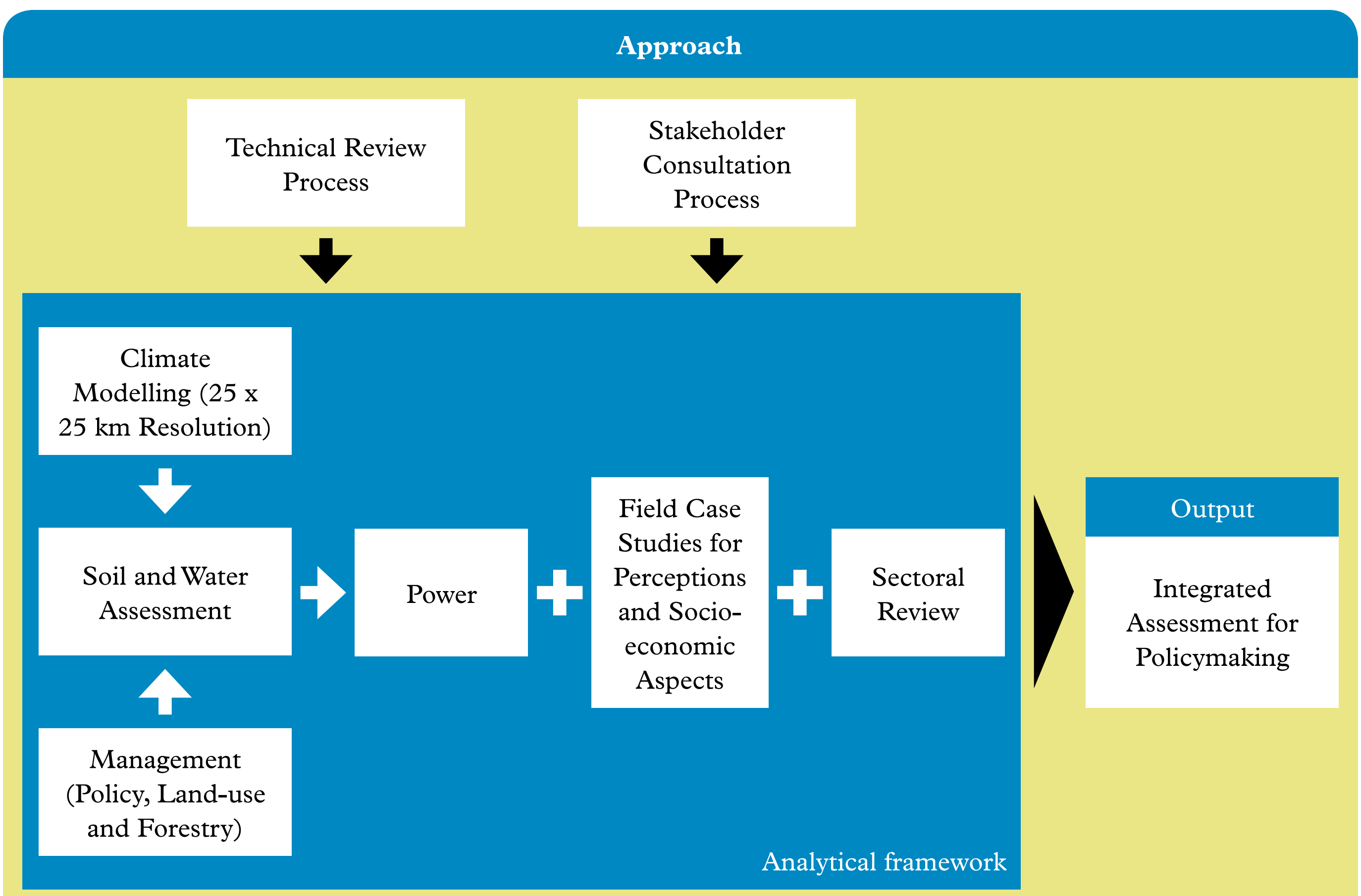

Figure 1.1: Approach for the Initiative

This report will, in four sections, feature the analysis that has been carried under this project. The first section is the climate modelling component, the second section features the soil and water assessment, the third section features power sector dynamics, and finally the fourth section features insights from local communities.

This document presents an assessment that aims to inform the State Government the considerations for a climate-resilient green growth development.

2

Climate Modelling for Himachal Pradesh

2.1 Introduction

The climate modelling component involves establishing climatological information of Himachal Pradesh and assessing near future climate variability over the State.

To establish the climatological information for Himachal Pradesh, historical trend analysis of the meteorological data and literature review has been carried out. Review on the latest available literature for the climatological trends for basic meteorological parameters over Indian domain and on sub-divisional scale has been done as the first step towards understanding the climate of the region.

Post literature analysis and historical data analysis, model identification was carried out and a high-resolution dynamical model was run under A1B SRES[1] scenario that simulates baseline run from 1970 to 2000 and near future time scale run from 2020 to 2040 (2030s) to arrive at future climate variability over the State. Analyses of extreme climate conditions were also performed.

2.2 Observed climatological trend over Himachal Pradesh

2.2.1 Temperature

The State shows a significant increasing trend of 0.06°C/year on annual mean maximum temperatures and 0.02°C/year on annual mean temperatures for the 1951–2010 time period. The annual mean minimum temperatures have shown a decreasing (–0.01°C/year) trend over the State for the same time period (Rathore et al. 2013) (Figure 2.1, left). The seasonal mean temperature trends for the 1951–2010 period shows a significant increasing trend for most seasons viz. winters (0.02°C/year), monsoons (0.03°C/year) and post-monsoon (0.02°C/year) but not significantly increasing for summers (0.01°C/year) (Rathore et al. 2013) (Figure 2.1, right).

A short-term analysis has shown that the rate of increase in maximum temperature is observed to be greater over higher latitudes as compared to lower latitudes, and the rate of warming in north-western Himalayan region have been significantly higher than the global average. The winter air temperature in the last two decades has also shown a clear increasing trend over the observation stations of Shimla and Solang and over the entire State region as well (Bhutiyani et al. 2007; HP-SAPCC 2012).

2.2.2 Rainfall

The annual average rainfall over Himachal Pradesh for the period 1951–2010 indicates a decreasing trend (–3.26 mm/year). The seasonal rainfall for summer (0.31 mm/year) shows an increasing trend for the same time period whereas the winter,

[1] SRES: Special report on emission scenarios, IPCC, 2000: http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=0

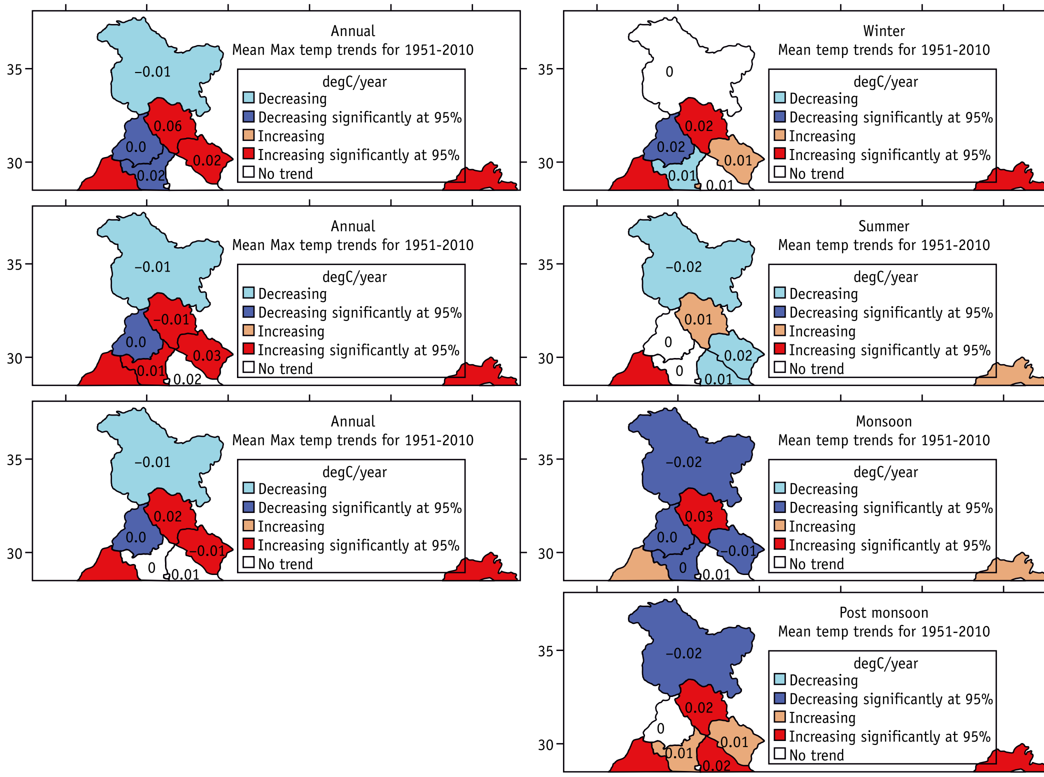

Figure 2.1: Trends in annual maximum, minimum, and mean temperatures (on left) and trends in seasonal mean temperatures (on right) for 1951–2010 period
Source: IMD monograph: ESSO/IMD/EMRC/02/2013

monsoon, and post-monsoon seasons show a decreasing trend of –0.18 mm/year, –2.85 mm/year, and –0.21 mm/year (Figure 2.2, left). For the individual monsoon months, the trend for the time period of 1951–2010 shows a decreasing trend for July at –1.72 mm/year (significant at 95 per cent level), August (–1.04 mm/year), and September (–0.24 mm/year), whereas June rainfall has shown an increasing trend of 0.48 mm/year for the 1951–2010 period (Figure 2.2, right).

The annual precipitation, winter and monsoon precipitation for the long time period (1866–2006), over the stations of Shimla have also shown a decreasing trend at 95 per cent confidence level (Bhutiyani et al. 2007). The trend over the district rainfall in the last 25 years have shown increasing trend of 33.5 per cent, 54.3 per cent, and 51.5 per cent for Kinnaur, Chamba, and Lahul & Spiti, respectively, whereas a decreasing trend of 8.7 per cent, 13.3 per cent, and 26.6 per cent for Solang, Shimla, and Sirmour, respectively (HP-SAPCC 2012).

2.2.3 Drought

Himachal Pradesh is enlisted under the 'frequent drought (10–20 per cent probability) prone area' as per Indian Meteorological Department's (IMD) classification of drought incidences from 1875 to 2004 period (Figure 2.3). A total of 23 droughts[2] have occurred in the State over the 1879–2009 time period of which 20 were moderate and 3 were severe with the drought probability of 17 per cent and four instances of consecutive droughts over 2 years (Shewale and Kumar 2005; Attri and Tyagi 2010; IMD met monograph 21/2005 and 01/2010).

[2] Drought: Meteorological drought over an area is defined as a situation when the monsoon seasonal (June-September) rainfall over the area is less than 75% of its long-term average value. Moderate drought: if the rainfall deficit is 26-50% and Severe drought: when the deficit exceeds 50% of the normal. A year is considered as a 'drought year' when the area affected by moderate and severe drought either individually or together is 20-40% of the total area of the country and seasonal rainfall deficiency during southwest monsoon season for the country as a whole is at least 10% or more

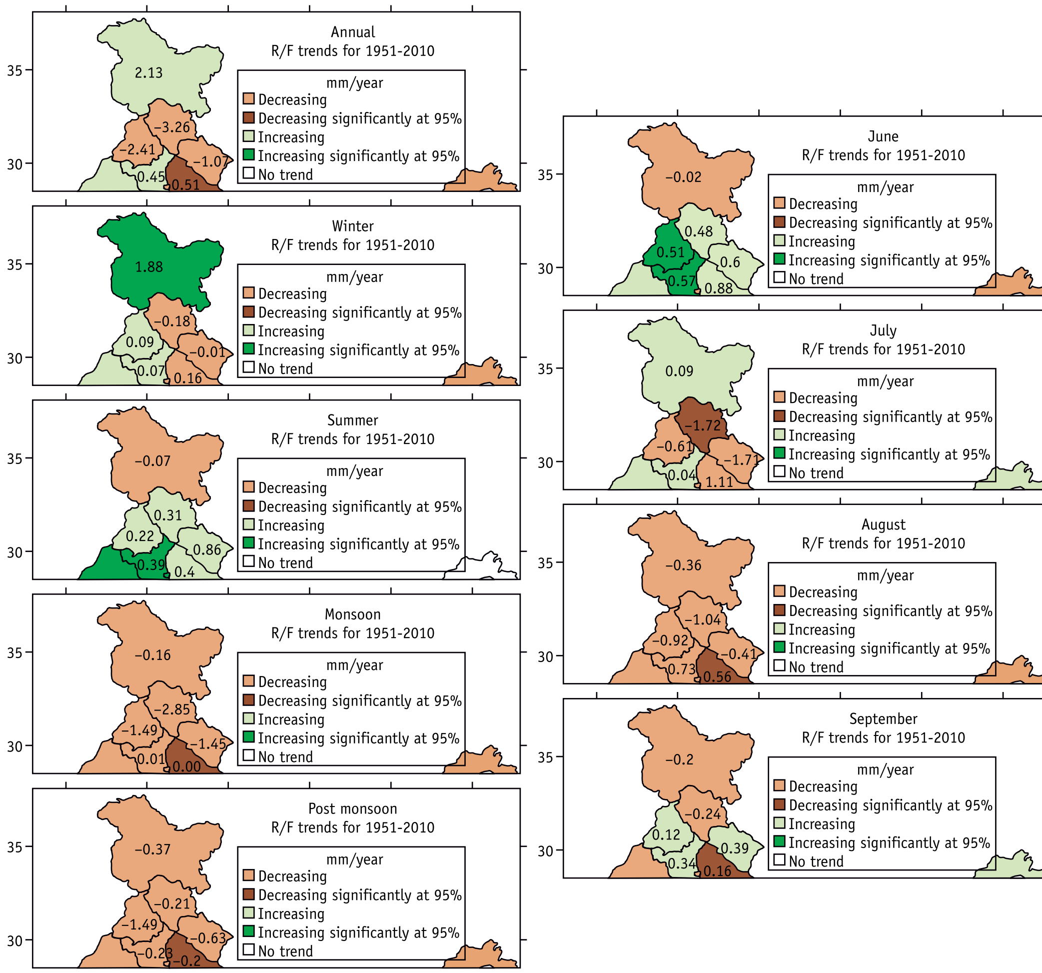

Figure 2.2: Trends in annual and seasonal rainfall (on left) and trends in monthly rainfall (on right) for 1951–2010 period
Source: IMD monograph: ESSO/IMD/EMRC/02/2013

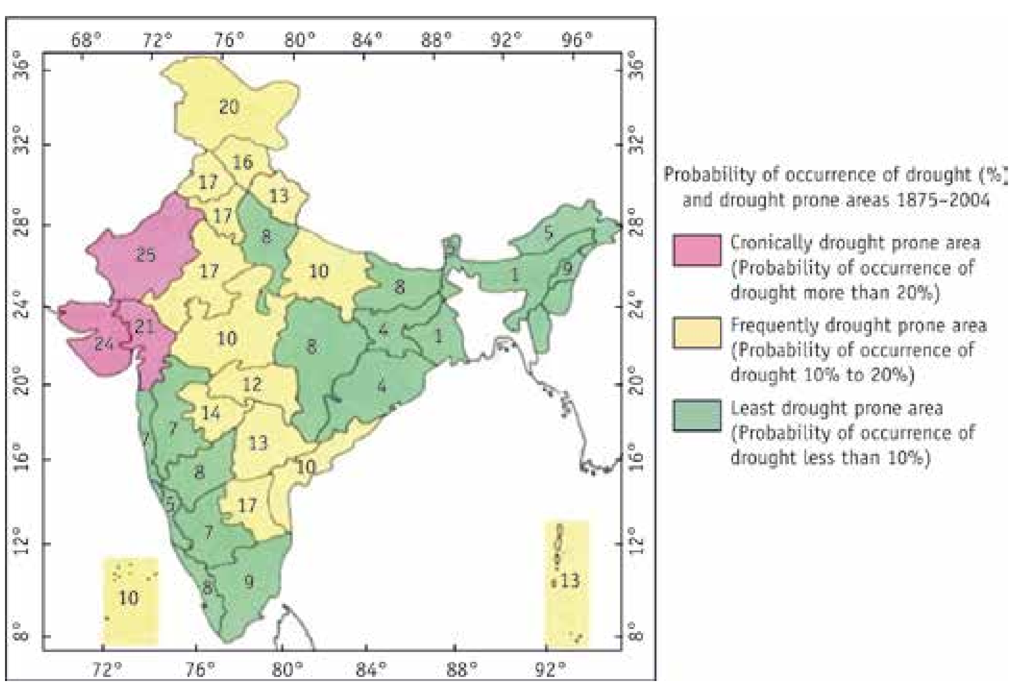

Figure 2.3: Probability of occurrence of drought (percentage) and drought prone areas 1875–2004
Source: IMD meteorology monograph - 2010

Cold Waves and snow fall: De et al. (2005) documented the cold waves[3] for different Indian states and it was found that for Himachal Pradesh the epochs of 1901–99 have seen occurrences of 22 cold waves of which the 1978–99 epochs have seen 18 incidences. The analysis on different altitudes in Himachal have shown a decreasing trend of snow fall at Bhang, Solang, Dhundi, and Patseo station for recent 20 years of observations.

2.3 Approach

2.3.1 Climate model

Objective: Analyse of future climate over the State using the regional model simulations at 25 km × 25 km resolution are being carried out. The model used in the study is Providing Regional Climates for Impacts Studies (PRECIS) Model.

Model setup: The model used in the study is PRECIS Model. It was developed at UK Met Office Hadley Centre. PRECIS is an atmospheric and land surface model of limited area and high resolution. Dynamical flow, the atmospheric sulphur cycle, clouds and precipitation, radiative processes, the land surface, and the deep soil are all formulated, while the boundary conditions at the limits of the model's domain are required to be specified. It gives a comprehensive representation of physical processes in atmosphere and on land in terms of

- Dynamics—atmospheric circulations, cyclones, fronts
- Radiation—effects of greenhouse gases and aerosols
- Clouds—radiative effects, sulphate aerosol effects
- Precipitation—convection, large-scale condensation
- Land-surface—soil hydrology (four levels), vegetation

The typical horizontal grid size is 50 km, which can be lowered as per the user. It has 19 levels in hybrid vertical coordinate (Simmons and Burridge 1981; Simon et al. 2004) with variable thickness. The sea surface boundary conditions would be taken directly from ocean component of the ECHAM05 model. The model has been tuned to simulate the baseline runs from 1970 to 2000 and future runs of 2030s (2020–40) under the A1B SRES[4] scenario. A1B scenario assumed a balance emphasis on all energy sources under the A1 emission scenario characterized by rapid economic growth with quick spread of new and efficient technology. In other words, this scenario assumed a business as usual state in near future and hence has been taken as the optimum climate scenario for simulation. PRECIS is highly relevant for scientists involved in vulnerability and adaptation studies particularly for national communication documents and have been extensively used throughout the world in numerous regional modelling experiments.

2.3.2 Sources of uncertainty/data gaps

For building a climate profile over a region, studying historical trends and undertaking model validation, long-term observational data from the station or from an observational gridded dataset is essential. Also, the type of dataset used and the granularity of the datasets (number of data points or number of observation stations) are important attributes towards minimizing uncertainty in the analysis. The IMD stations used in the 1951–2010 analysis, as shown earlier, are 5 for temperature and 36 for rainfall (Figure 2.4). Also, for the gridded dataset, the methodology is restricted over an area with less number of stations and hence, more approximations and interpolations are done to arrive at datasets. All these factors should be noted as the key factors for uncertainty in observational data and resulting model analysis. Figure 2.5 shows the data gaps in the analysis for meteorological droughts.

[3] Cold waves: Occurrences of extreme low temperature in association with incursion of dry cold winds from north into the sub-continent are known as cold waves. The northern parts of India specially the hilly regions and the adjoining plains are influenced by transient disturbances in the mid latitude westerlies which often have weak frontal characteristics and are called as western disturbances.

[4] SRES: Special report on emission scenarios, IPCC, 2000: http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=0

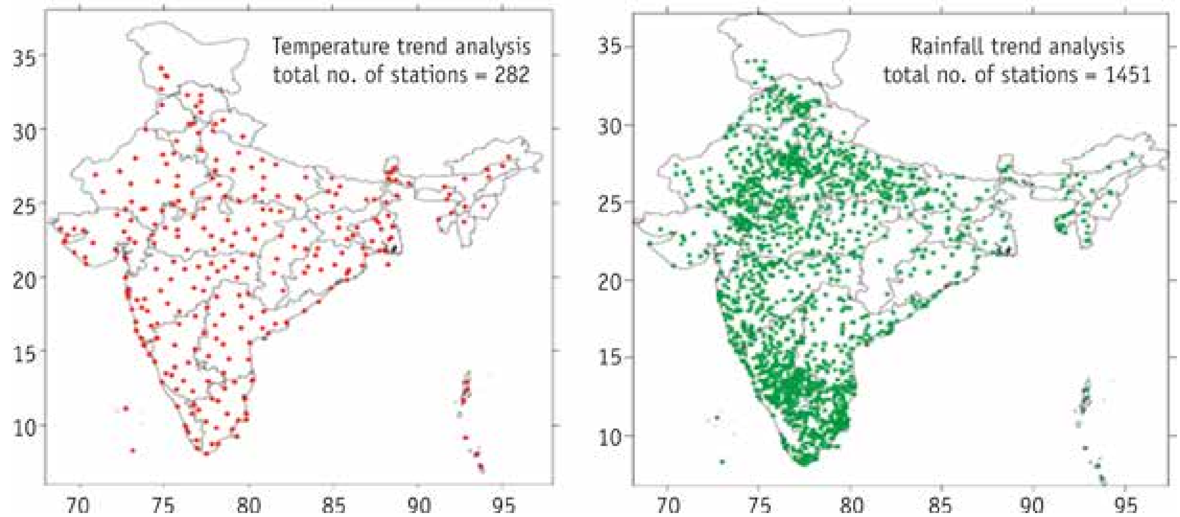

Figure 2.4: Distribution of met stations used for temperature trend analysis (on left) and rainfall analysis (right)
Source: IMD Meteorological Monograph No. ESSO/IMD/EMRC/02/2013

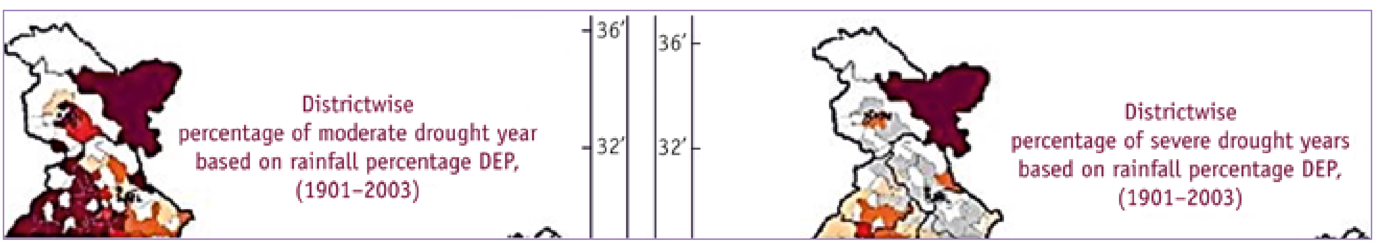

Figure 2.5: The white gaps show that the datasets were not available for long-term drought intensity and frequency analysis
Source: IMD Meteorological Monograph 2010

It may be noted that all the studies involving modelling assessments are probabilistic, which provide us the best indicator on how the climate has been evolving in the past and in coming future. The degree of certainty depends on many factors like input data and boundary forcings used, parameter being modelled, type of models used, resolution, and domain utilized.

2.4 Trend analyses

2.4.1 Rainfall

To analyse long period and seasonal rainfall trends over the State, latest IMD high-resolution gridded rainfall dataset (Pai et al. 2014) have been utilized. The spatial resolution of these datasets is 0.25° × 0.25° in the horizontal. The data has been extracted over the State and post-processed for the analysis. Since the dataset has square grids, which do not necessarily match with the irregular State boundaries, this may result in some minor mismatch with station data analysis as reported earlier.

The long period 1901–2013 annual accumulated rainfall over Himachal has been trendless although a slight decreasing trend has been observed for long-term monsoon accumulated rainfall. However, the rainfall variability has been very significant (Figure 2.6) in the past as well as in recent years.

As can be seen from Figure 2.7, the seasonal climatologies for winter (December, January, and February), pre-monsoon (March, April, and May), and post-monsoon (October and November) season show a decreasing trend for the 1970–2013 period using the IMD-gridded dataset. A slight increasing trend is seen for the monsoon (June, July, August, and September [JJAS]) season (Figure 2.8.a) in relation to other seasons. As seen from anomalies in Figure 2.8.b, the recent years have experienced more negative rainfall signifying poor monsoon than the long-term normal. Spatially, the model-simulated baseline shows that high rainfall bands over the State are mainly concentrated over the northern part of the State. Overall, the model is able to capture the observed rainfall spatially but overestimating a bit at some regions (Figure 2.9).

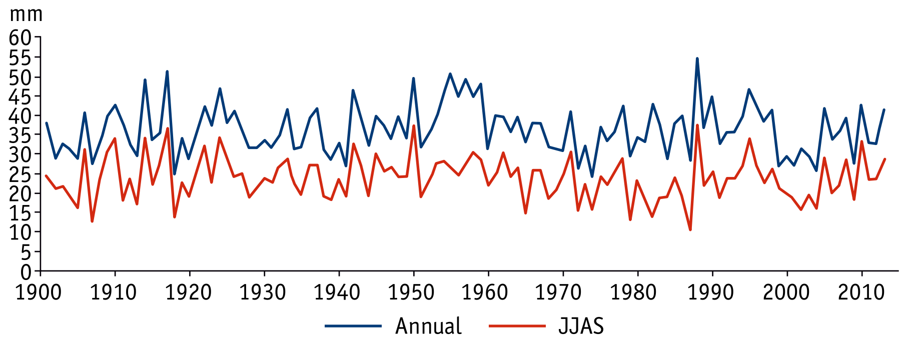

Figure 2.6: Annual and JJAS accumulated rainfall over Himachal Pradesh for the 1901–2013 period showing year-to-year variability
Source: TERI Analysis

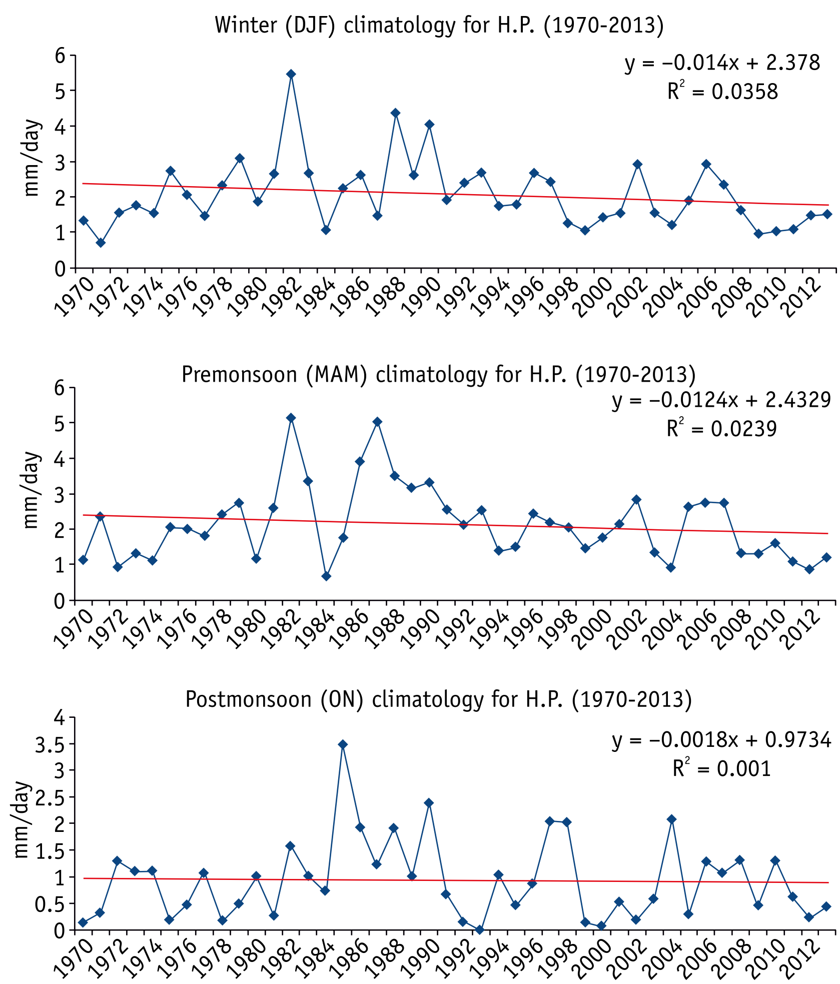

Figure 2.7: Rainfall climatologies for Himachal for (a) winters, (b) pre-monsoon, and (c) post-monsoon for the 1970–2013 period
Source: TERI Analysis

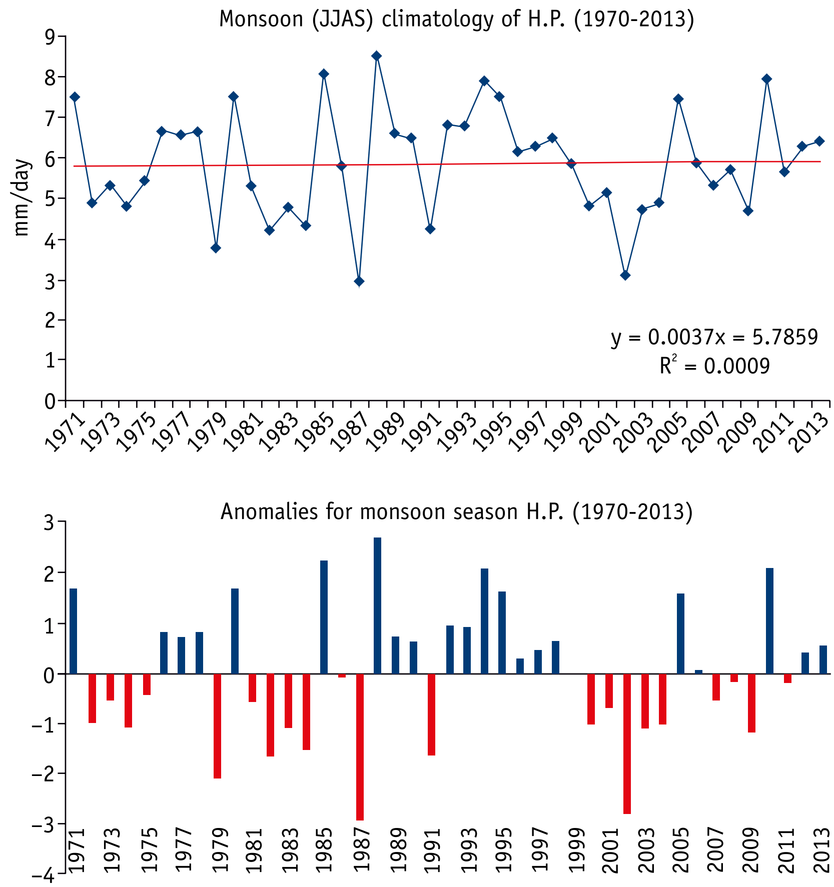

Figure 2.8: JJAS rainfall (a) climatology and (b) anomaly over Himachal Pradesh for the 1970–2013 period
Source: TERI Analysis

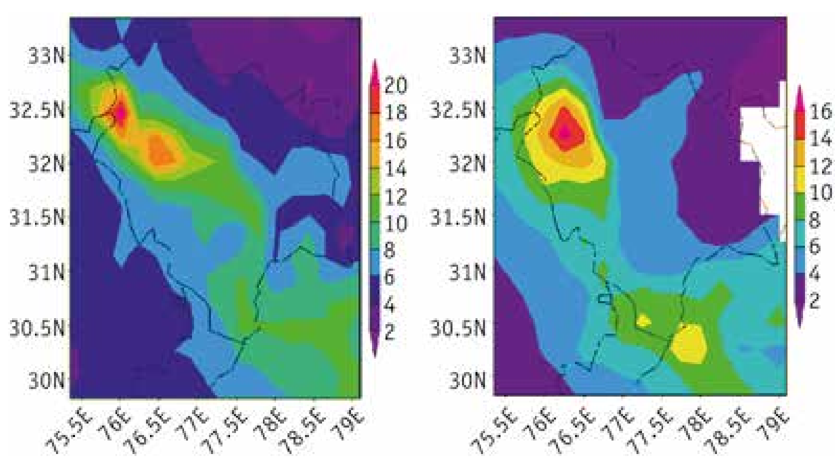

Figure 2.9: Monsoon (JJAS) rainfall climatology from IMD (left) and PRECIS (right) for the baseline period 1970–2000, both showing a high rainfall zone in the north
Source: TERI Analysis

2.4.2 Temperature

The annual mean temperatures from the gridded IMD temperature datasets (Srivastava et al. 2008) have been plotted (Figure 2.10 left) along with the model baseline (Figure 2.10 right). It is observed that the model is able to capture the east–west oriented temperature gradient but has a comparatively colder bias over the State. Currently various methods are being researched to minimize the model bias over the area which is topographically complex.

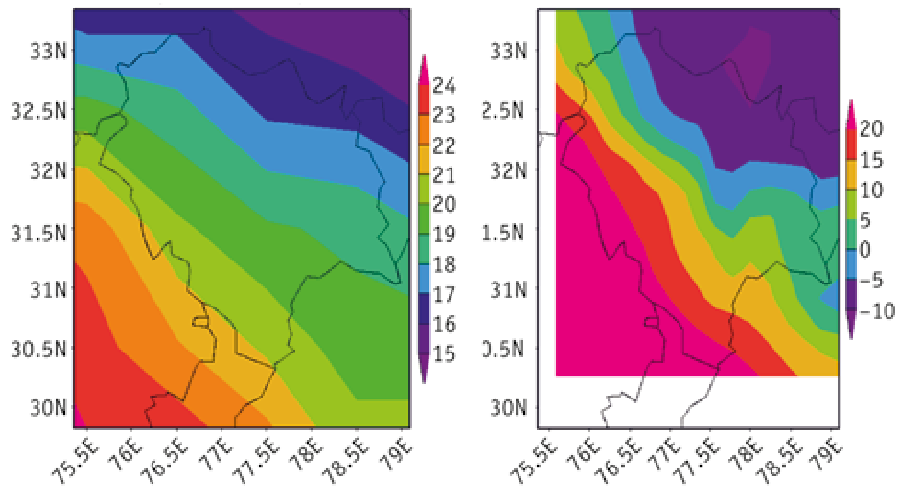

Figure 2.10: Annual mean temperatures from IMD (left) and model (right) for 1970–2000 baseline period over Himachal Pradesh

Source: TERI Analysis

2.5 Climate projections

2.5.1 Rainfall

Owing to variable terrain and inconsistency in long-term observations over the entire State, spatial variation is seen for precipitation projections for near future. Model projects the percentage precipitation change for monsoon months between the range –8 per cent and 12 per cent (Figure 2.11). This change for winter months of December, January, and February show a much larger variation, that is, from less than –10 per cent to over 30 per cent in some areas (Figure 2.12). The whole State shows a positive change for summer rainfall with a range of 5 per cent and 30 per cent (Figure 2.13). Post monsoon season also shows a variation in the changes of precipitation percentage in the range of less than –15 per cent in some areas to more than 30 per cent in others (Figure 2.14).

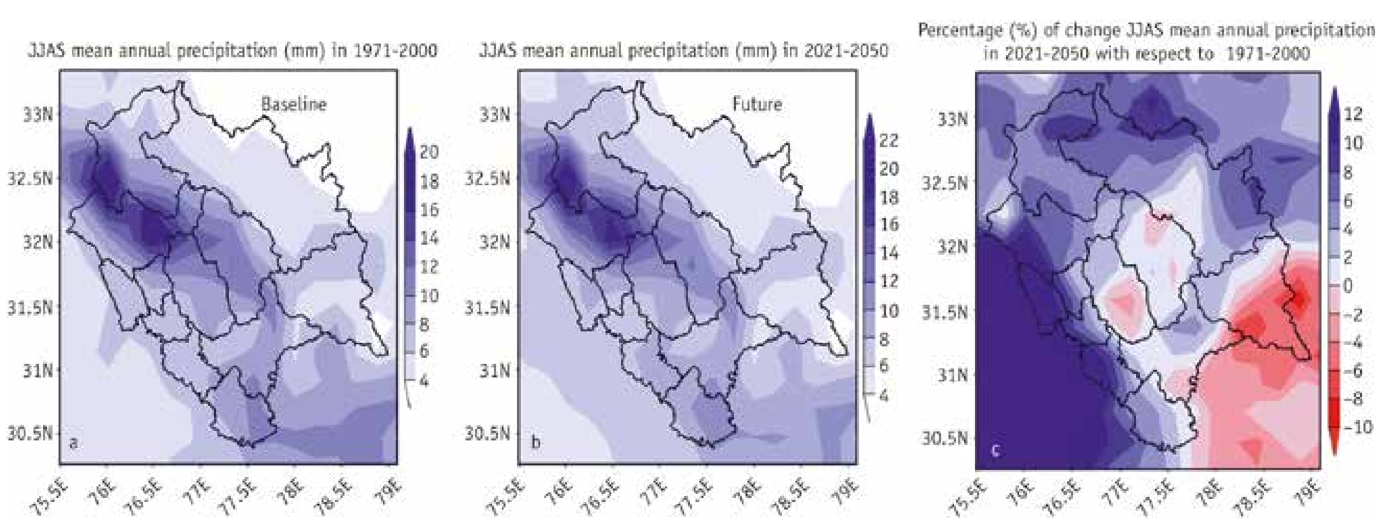

Figure 2.11: Mean annual summer monsoon precipitation for baseline period (a), near future (b), and change in near future (c) relative to baseline period

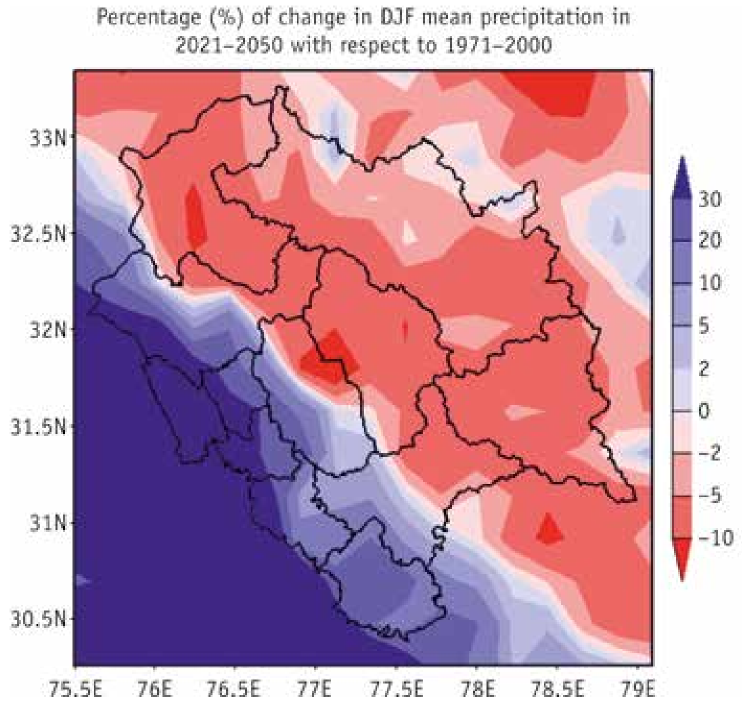

Figure 2.12: Mean winter precipitation change for near future (2020–2050) relative to 1970–2000

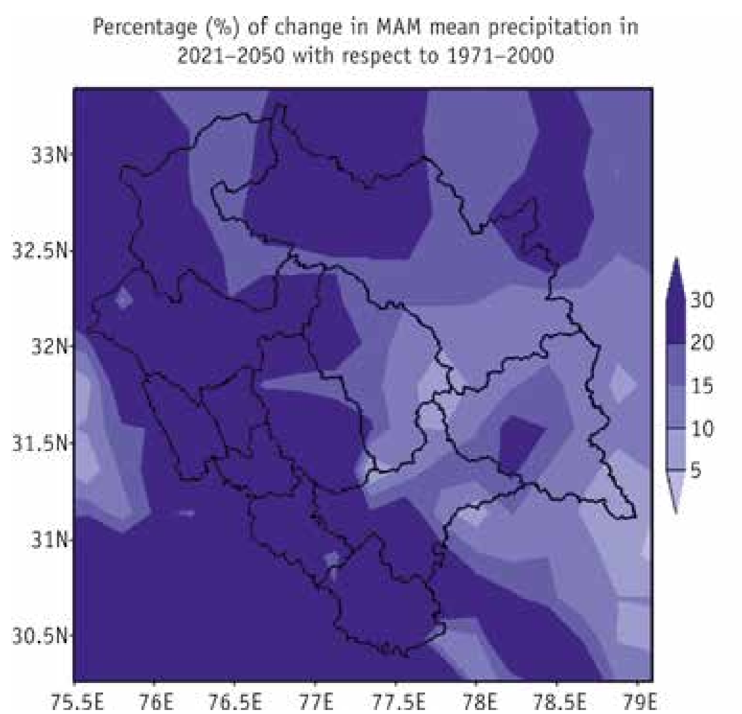

Figure 2.13: Mean summer precipitation change for near future (2020–2050) relative to 1970–2000

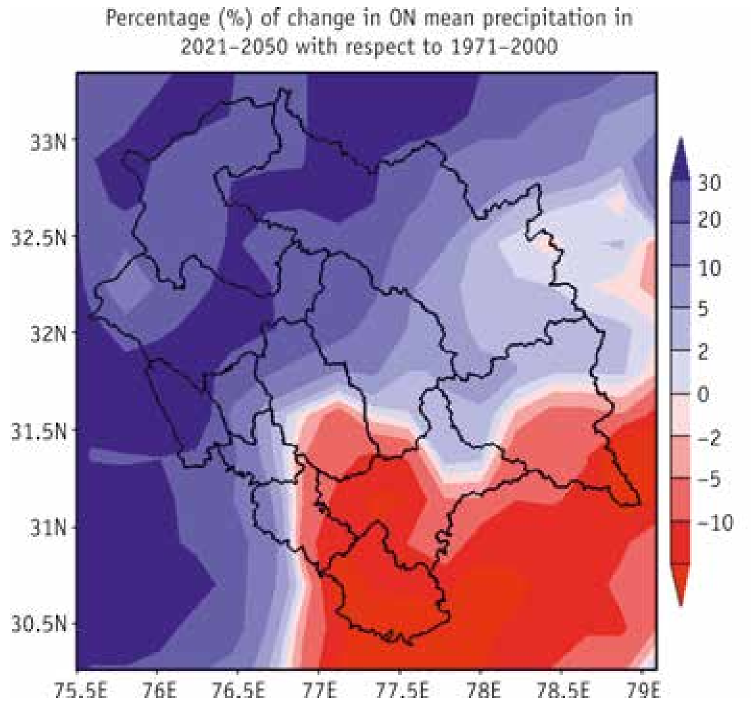

Figure 2.14: Mean post monsoon precipitation change for near future (2020–2050) relative to 1970–2000

2.5.2 Annual mean temperature

Overall warming projected over the State in the near future with respect to the baseline period is projected (Figure 2.15). Annual mean temperature projected to increase by 1.3-1.9°C for 2021-2050 relative to 1971-2000.

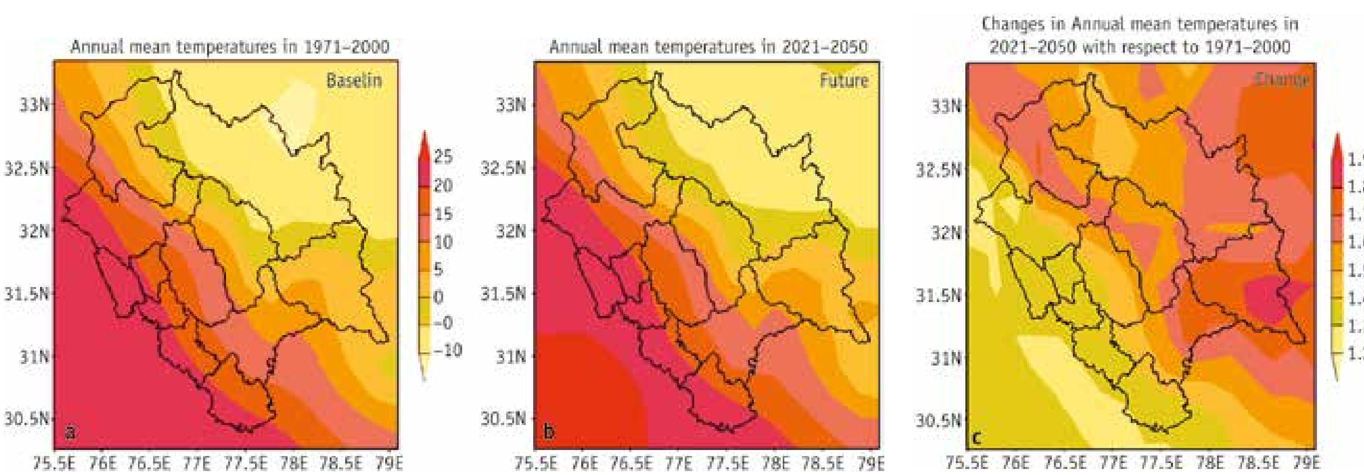

Figure 2.15: Mean annual temperature for baseline period (a), near future (b), and change in near future (c) relative to baseline period

2.5.3 Temperature extremes

Mean annual maximum temperature (Tmax) over the State is projected to increase by 1.1-1.9°C (Figure 2.16). The mean annual minimum temperature (Tmin) is also projected to increase over the study domain area in the range 1.5-1.9°C (Figure 2.17)). Relatively larger changes projected for minimum temperatures for the future. These findings corroborate with the historical trends over India, which have seen increase in minimum temperature to contribute more than maximum temperature for the increase in mean temperature over the baseline period (1970-2000) (also see INCCA report, MoEF 2010) Increase in minimum temperature has many impacts not only over plants, crops but over human comfort as well. This also indicates that night time temperatures also will increase in the near future relative to the baseline period.

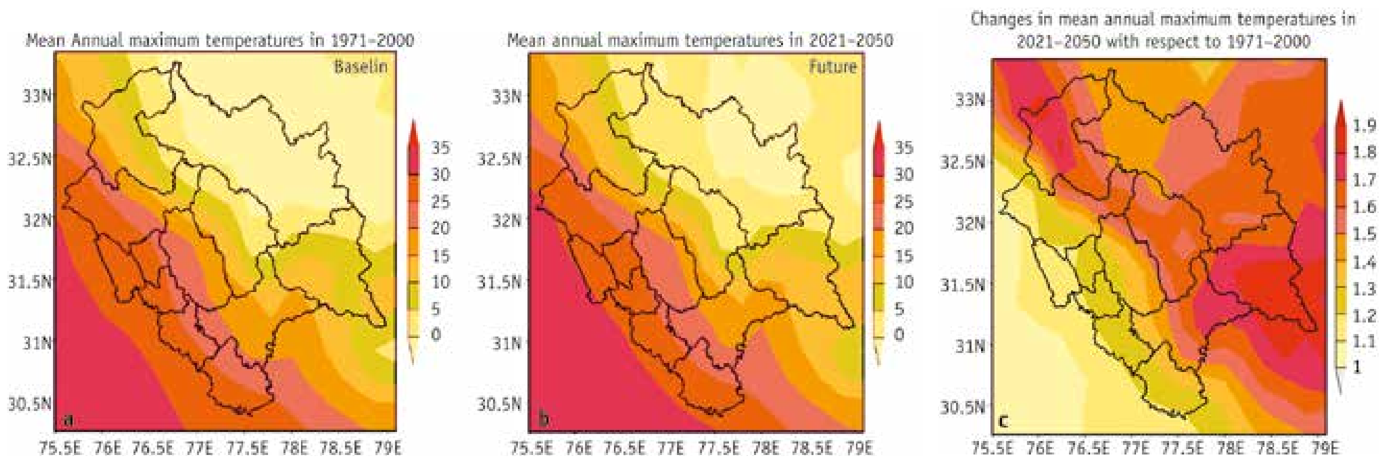

Figure 2.16: Mean annual maximum temperature (Tmax)

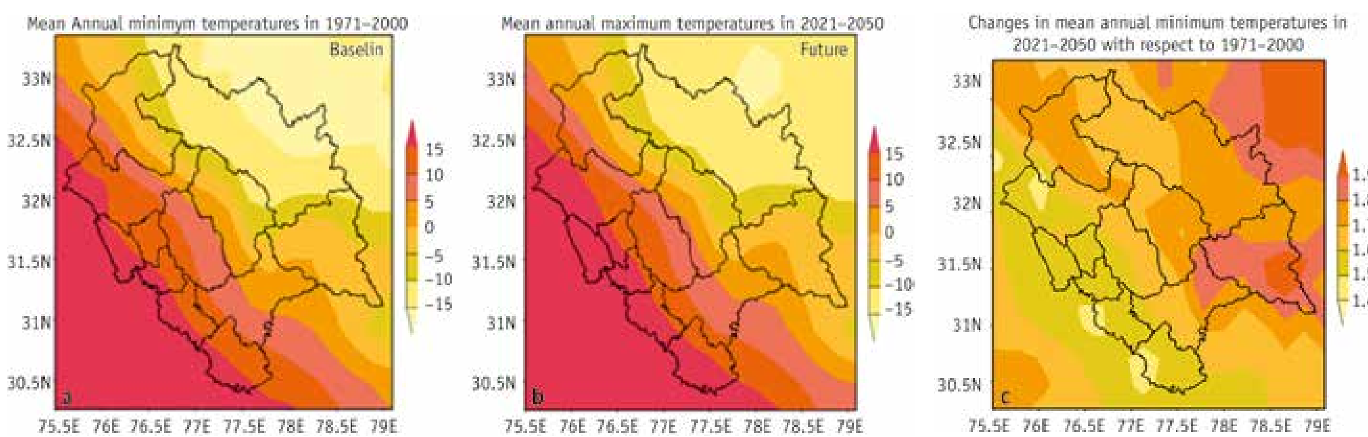

Figure 2.17: Mean Annual Minimum Temperature (Tmin)

2.5.4 Rainfall extremes

Extremely wet days were calculated as those days when the rainfall amounts exceed 99th percentile of the rainfall amounts in baseline period. This analysis provides us information on the contribution of extreme rainy days to the total rainfall in the near future. Figure 2.18 shows the precipitation amount (in percentage) of the total precipitation in future that is due to extremely wet days.

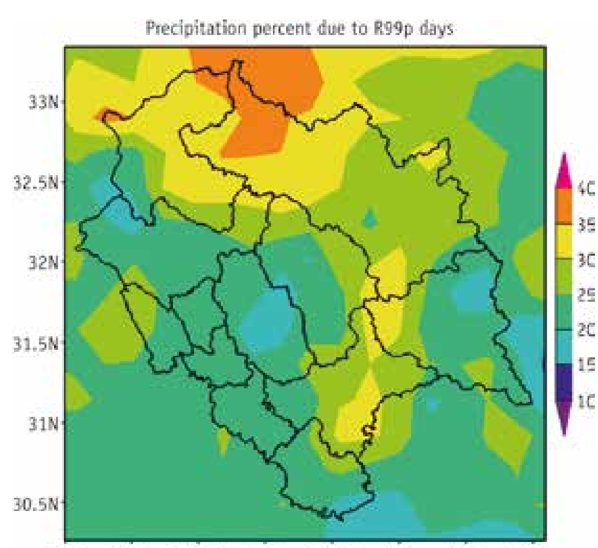

Figure 2.18: Extreme wet days contribution to the total rainfall—near future

Figure 2.19: Extreme Wet days in future relative to extreme rainfall in baselineFigure 2.19 shows the percentage of wet days in future where the daily precipitation amount is greater than extremely wet days of the baseline period. As seen from the figure, an increase over the entire state is seen for the future extreme rainfall for the period 2020–50 relative to the baseline period of 1970–2000. The wet days for the future years shows a relative increase from the baseline period (1970–2000), although no trend for the State is seen (Figure 2.19). A three-point moving average indicates higher number of extreme wet days frequency around 2035–45 time period within the entire 2020–50 time period analysed.

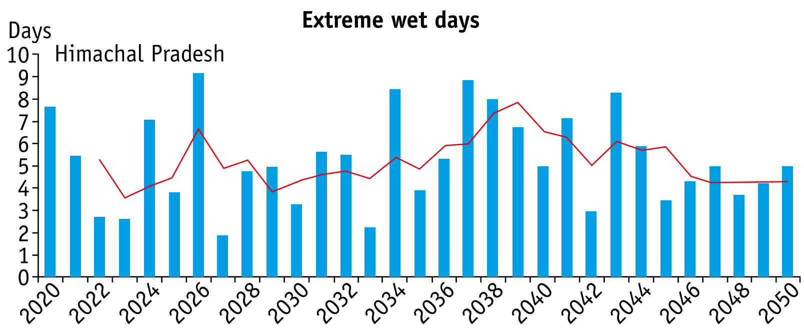

Figure 2.19: Extreme Wet days in future relative to extreme rainfall in baseline

Analysis of other major climate variables, such as solar flux, relative humidity, and wind speed, were also performed (Figure 2.20), which also showed inconsistency owing to effects of irregular terrain. These variables will be used for climate impact modelling. In the present study, the variables will be used as inputs to the Soil and Water Assessment Tool.

Fundamental physics, approximated equations and empirical estimates of unresolvable sub-grid scale processes are fused together in climate models. So, the models do have computational constraints. Hence, being probabilistic, the ranges in climate projections should be taken as indicative.

2.6 Discussion

The following key discussion points emerge:

- Spatial variation is seen for precipitation projections for near future for different seasons. The climate model projects the percentage precipitation change for monsoon months between the range of –8 per cent and 12 per cent. This change for winter months of December, January, and February show a much larger variation from less than –10 per cent to over 30 per cent in some areas. The whole State shows a positive change for summer rainfall in the range of 5 per cent and 30 per cent. Post monsoon season also shows a variation in the changes of precipitation percentage in the range of less than –15 per cent in some areas to more than 30 per cent in others.
- Overall warming projected over the State in the near future with respect to the baseline period is projected. Annual mean temperature projected to increase by 1.3–1.9°C for 2021–50 relative to 1971–2000.
- Mean annual maximum temperature (Tmax) over the State is projected to increase by 1.1–1.9°C. The mean annual minimum temperature (Tmin) also is projected to increase over the study domain area in the range 1.5–1.9°C. Increase in minimum temperature has many impacts not only over plants, crops but over human comfort as well.
- The percentage of wet days in future where the daily precipitation amount is greater than extremely wet days of the baseline period.
- The high-resolution variables generated by this model can be applied for various types of impact modelling, which in turn can inform policy making. For the present study, the dataset from the climate model have been utilized and integrated with a hydrological model to assess various hydro-implications for the state. The model dataset can also be integrated with other biophysical models used for agriculture crop modelling, forestry, air quality, disaster management, and health impact modelling studies.

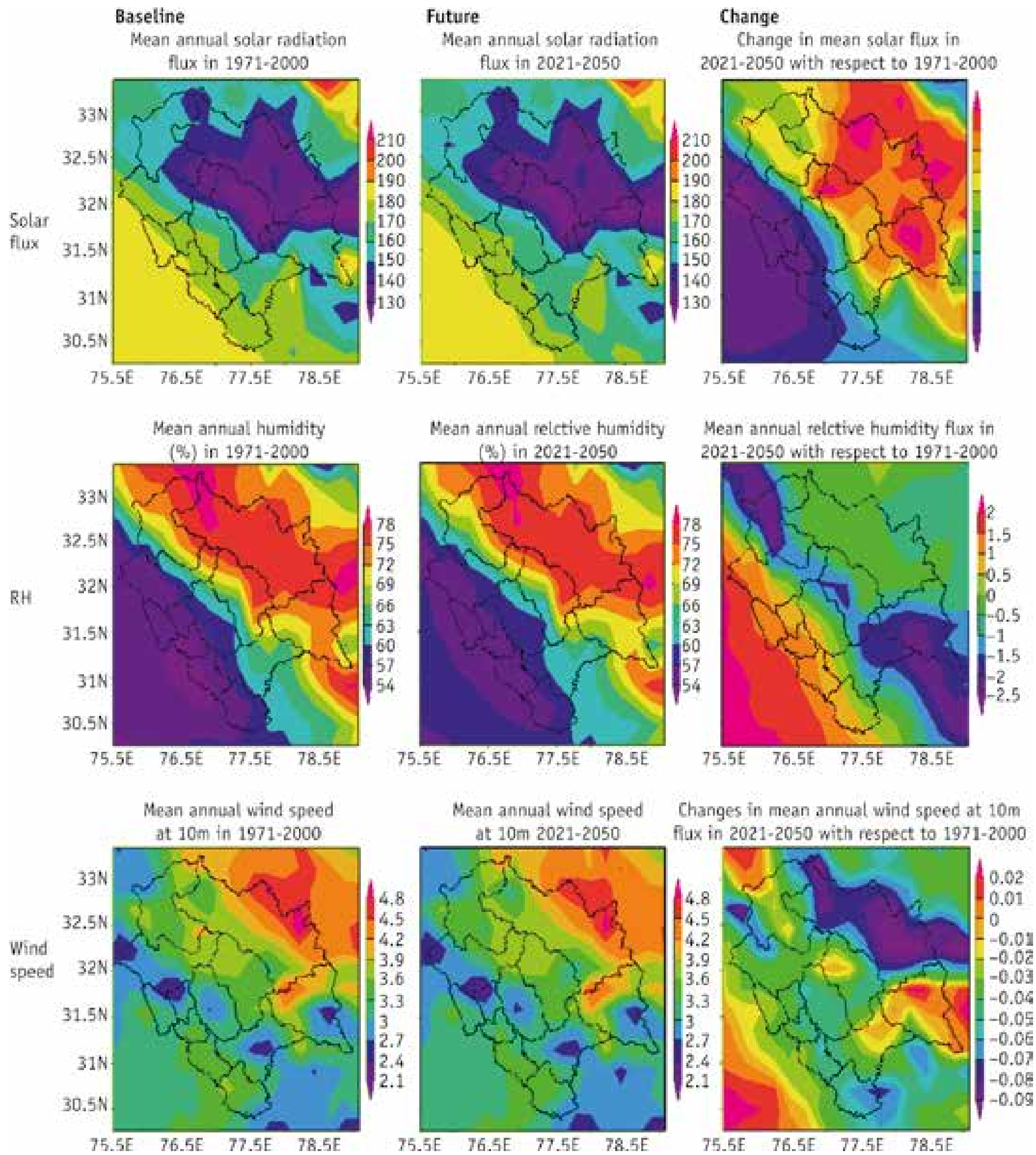

Figure 2.20: Spatial pattern of solar flux (top panel), relative humidity (middle panel), and wind speed (bottom panel) and the change in near future relative to the baseline period.

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3

Soil and Water Assessment for Himachal Pradesh

3.1 Introduction

The state of Himachal Pradesh covering an area of 55,673 sq. km, is located in northern India between 30°22′40″ to 33°12′20″ north latitudes and 75°45′55″ to 79°04′20″ east longitudes. The State is bordered by Jammu and Kashmir in the north; Punjab in the southwest; Haryana in the south; Uttarakhand in the southeast, and Tibet in the east. Himachal is divided into 12 districts—Kangra, Hamirpur, Mandi, Bilaspur, Una, Chamba, Sirmaur, Kinnaur, Kullu, Lahaul and Spiti, Shimla, and Solan.

Owing to the variation in the elevation, the State experiences various climatic conditions. The average temperatures during the summer months range between 28°C and 32°C. Many of the areas receive heavy rainfall during the rainy season. The State is drained majorly by the Indus river basin system comprising of Sutlej, Beas, Ravi, Chenab, and Chandra rivers. Some regions of the State get drained by the Ganga basin system comprising of Yamuna River in the State.

The share of agriculture including horticulture and animal husbandry in Gross State Domestic Product declined from 26.5 per cent in 1990–91 to 14.42 per cent in 2012–13. With a net area sown of approximately 5.38 lakh hectares, the cropping intensity stands at 176.6 per cent. About 81 per cent of the total cultivated area in the State is rain fed with a gross irrigated area of 1.87 lakh hectares and net irrigated area of 1.06 lakh hectares. During the year 2012–13, food grains production achieved was at 15.68 lakh MT. Although the mechanization of the hill farms is on the rise, small land holding size and inadequate irrigation facilities is still limiting the usage of modern farm implements. High usage of tractors is observed in the districts of Hamirpur, Bilaspur, and Chamba. These districts having their livestock production system dominated by buffaloes has higher usage of chaff cutters. The level of fertilizer consumption has increased from around 30 kg/ha in1993–94 to around 51.3kg/ha in 2009–10.

The area under apple cultivation has increased from 23,100 hectares in 1970–71 to 101,484 hectares in 2010–11. The production has increased from 94,922 MT in 1970 to 892,112 MT in 2010 (The share of agriculture including horticulture and

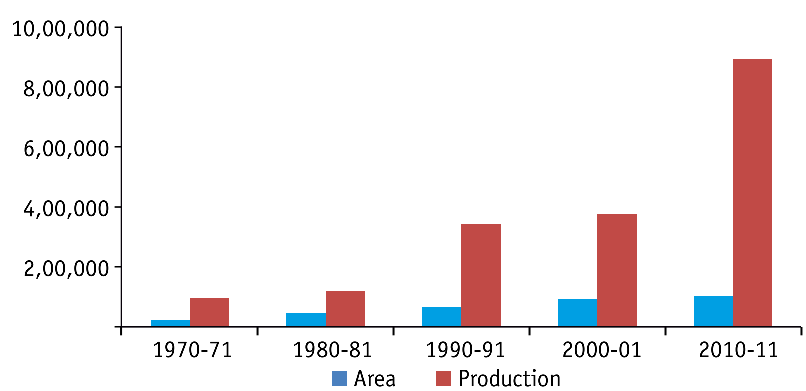

Figure 3.1: Apple area (hectares) and production (MT) in Himachal Pradesh (1970–2010)

animal husbandry in Gross State Domestic Product declined from 26.5 per cent in 1990–91 to 14.42 per cent in 2012–13. With a net area sown of approximately 5.38 lakh hectares, the cropping intensity stands at 176.6 per cent. About 81 per cent of the total cultivated area in the State is rain fed with a gross irrigated area of 1.87 lakh hectares and net irrigated

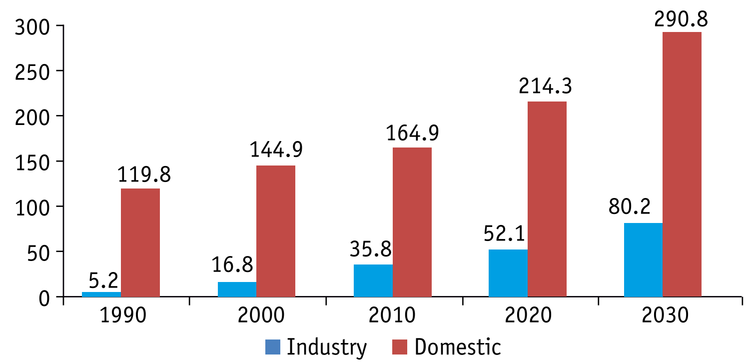

Figure 3.2: **Industrial and domestic water requirement (1990–2030) in million meter cube**

area of 1.06 lakh hectares. During the year 2012–13, food grains production achieved was at 15.68 lakh MT. Although the mechanization of the hill farms is on the rise, small land holding size and inadequate irrigation facilities is still limiting the usage of modern farm implements. High usage of tractors is observed in the districts of Hamirpur, Bilaspur, and Chamba.

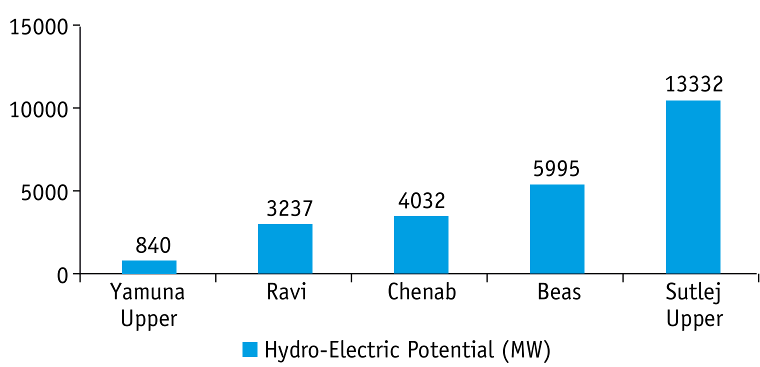

Figure 3.3: **Sub-basin–wise hydro-electric potential in Himachal Pradesh in 2012**

These districts having their livestock production system dominated by buffaloes has higher usage of chaff cutters. The level of fertilizer consumption has increased from around 30 kg/ha in1993–94 to around 51.3kg/ha in 2009–10.).

The rise in domestic water demand is more than the industrial water requirement. The industrial and domestic water requirement was around 5.2 and 119.8 mm^3 in 1990, which would increase to 80.2 and 290.8 mm^3 in 2030, respectively (Figure 3.2).

Sutlej Upper river basin covering 18,506.22 sq. km area has the highest hydro-electric potential (13,332 MW) amongst all the sub-basins present in the state of Himachal Pradesh. Yamuna Upper sub-basin covering a small portion of the state has its hydro-electric potential at 840 MW (The rise in domestic water demand is more than the industrial water requirement. The industrial and domestic water requirement was around 5.2 and 119.8 mm3 in 1990, which would increase to 80.2 and 290.8 mm3 in 2030, respectively (Figure 3.2).).

In the backdrop of the above and future climate variability, it becomes important to understand as to what will be the impact of climate variability on the soil and water parameters, especially keeping in mind that the state's economy is dependent on hydropower and natural resource management.

3.2 Literature Review

The Soil and Water Assessment Tool (SWAT) model is a basin-scale distributed hydrologic model. The SWAT model has its limitations when it comes to explicitly allowing for the inclusion of spatial data as model inputs. To overcome this limitation, ArcSWAT, a public domain graphical user interface program, has been developed that aims at an effective use of spatial data to enhance hydrological modelling. It has been designed such that it links the hydrologic model SWAT and the geographical information system package ARC/INFO.

The SWAT model allows basin to be divided into sub-basins, which can further be divided into hydrological response units (HRUs), which are a unique combination of soil and land cover.

SWAT model has been used in various studies with a wide range of applications in India. A study conducted at the Mula and Mutha Rivers, Pune, India used the SWAT model to assess the impact of land use change on water resources (Wagner et al. 2013). There have been numerous studies in which a comparison has been done between SWAT and other hydrologic models. In another study, the SWAT model was applied for assessing the water yield in Dudhi micro watershed in Madhya Pradesh (Gosain et al. 2013). Using SWAT, a 2014 study attempts to estimate the runoff of the Sutlej basin by deriving the parameters necessary for runoff modelling with the help of a geospatial database for a period of 30 years from 1980 to 2010 (Panhalkar 2014). A 2003 study assessing the potential of Spatial Decision Support System (SDSS) in calculating water and sediment yields based on a SWAT model concluded that SDSS could be used to recognize priority areas that have high soil and water losses within the selected catchment area. The study further established that due to existing large areas under the long duration, crops including paddy and maize in conjunction with low forest cover seemed to be the a main cause for the high soil and water losses (Kaur et al. 2003). A Ganga river basin study tries to understand the risks and opportunities in the selected study basin (World Bank 2014). Other studies in hydrology using the SWAT model include Jain and Kaushika (2009) and INRM Consultants (n.d.).

3.3 Methodology

In this integrated assessment, the SWAT model will take inputs from spatial analysis as well as the climate model. The model takes into consideration parameters such as drainage network, land use and cover pattern, soils, elevation, and climatic

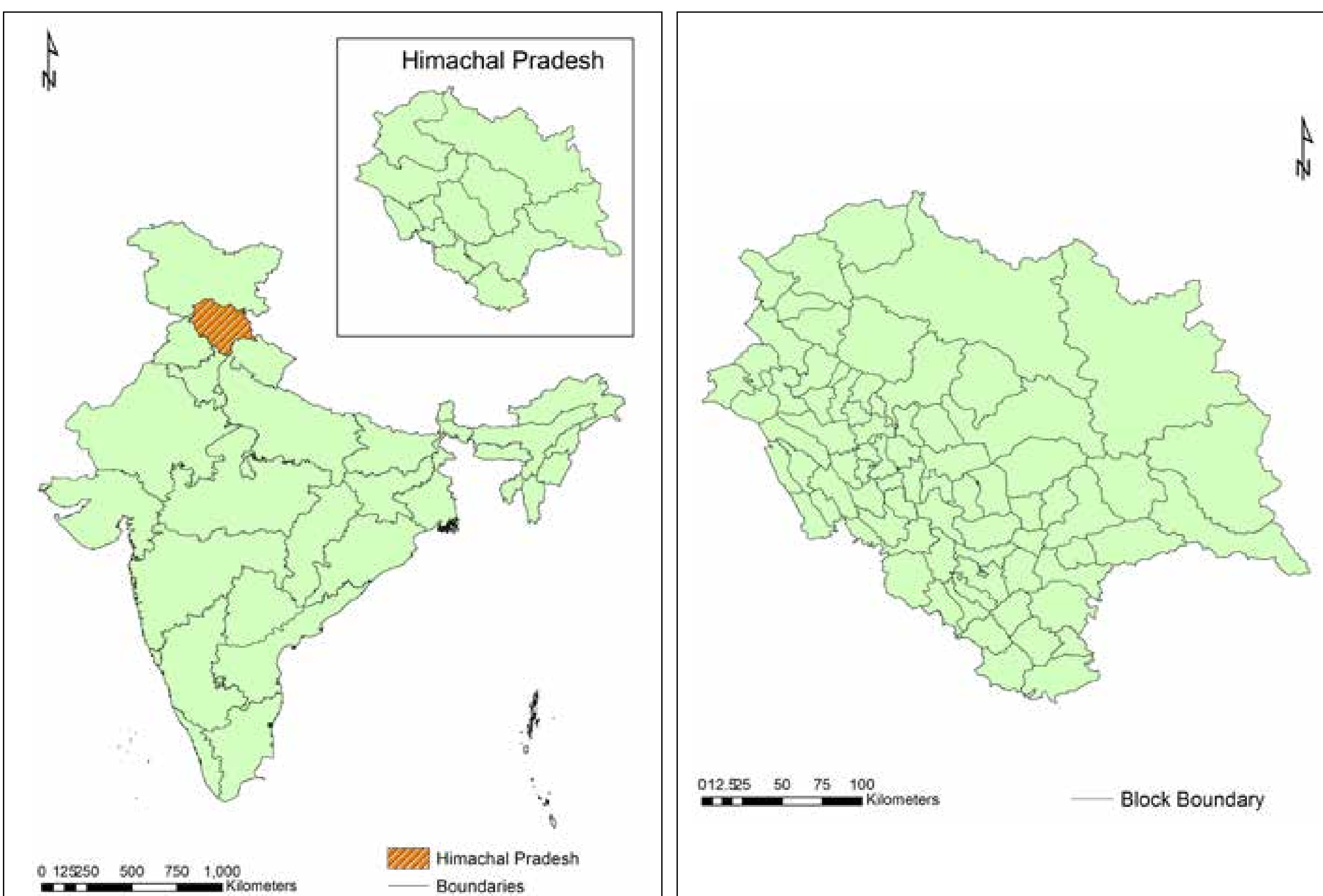

Figure 3.4: Study area Himachal Pradesh, India

parameters for simulating water balance (rainfall, surface and ground water quantity, evapotranspiration (ET), base flow, and amount of water retained in soil), yield (crop and tree), and indicative soil and water quality of the region. The climate data

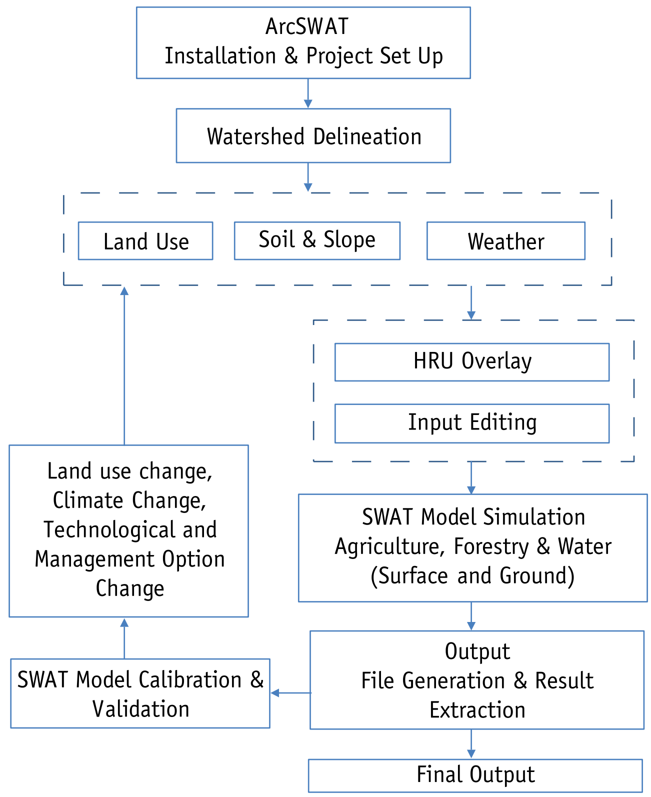

Figure 3.5: Modelling approach

used in ArcSWAT is output of PRECIS (Providing Regional Climates for Impacts Studies) model.
A brief summary of the model is given below:

- **Model to be used:** ArcSWAT for SWAT 2012
- **Modelling Unit:** River Basin (Watershed)–Sub-basin–HRU–Administrative Boundary
- **Modelling Process:** Simulation Modelling
- **Climatic Data:** 1980 to 2000 and 2020 to 2030 (Projection)
- **Spatial Data:** 1980, 1990, 1998, 2014 (Landsat Imageries)

This model will be applied to the study area of Himachal Pradesh (This model will be applied to the study area of Himachal Pradesh (Figure 3.4).).

Figure 3.5 shows the modelling approach for the ArcSWAT model. For a detailed understanding of SWAT, please refer to Annexure 3.1. shows the modelling approach for the ArcSWAT model. For a detailed understanding of SWAT, please refer to Annexure 3.1.

Policies link different land use to technology and management options for enhancing socio-economic conditions, livelihood, and ultimately the standard of life. Hence to evaluate, reflect and recommend on such policies; multifaceted, multidisciplinary, and compatible group of models gives added edge by facilitating decision making. ArcSWAT is one of the most useful tools as it has different modules like land use, surface and ground water, tree and crop growth module, and particle movement analysis.

Each of these options can be applied to ArcSWAT model individually or in combination of other options to study quantifiable results of natural resources like different land use area, water quantities, pollution incidence, agriculture and forestry production, economic benefits, and environmental benefits in terms of quantities conserved.

3.3.1 Inputs for Model

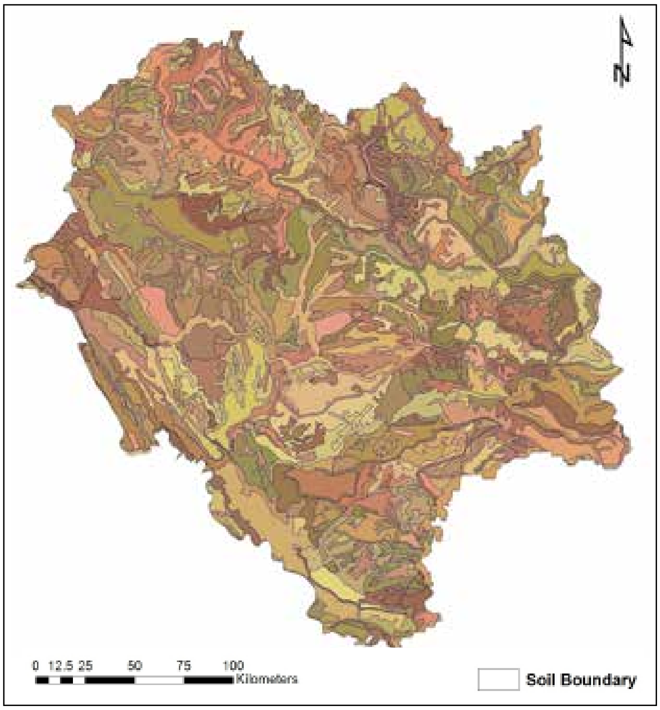

Figure 3.6: Soil types of Himachal Pradesh
Source: Digitized using National Bureau of Soil Survey & Land Use Planning

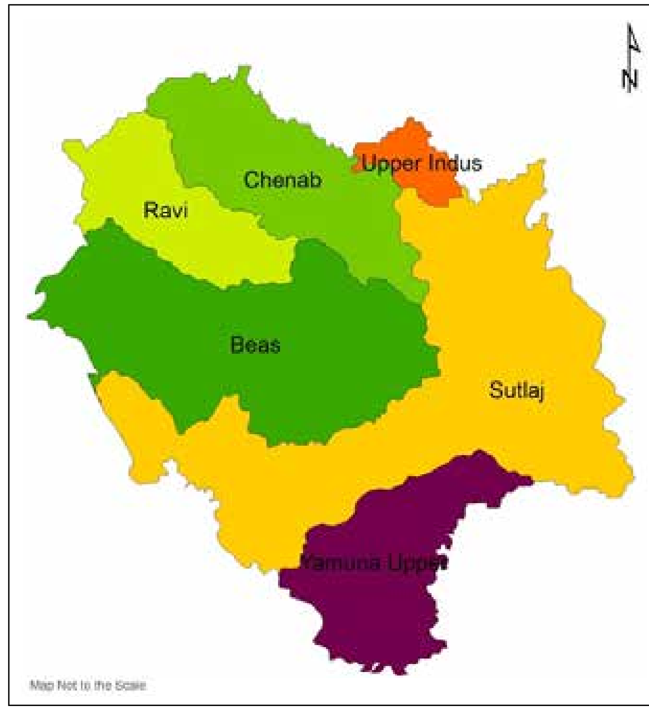

Figure 3.7: Sub-basins of Himachal Pradesh

Table 3.1: ArcSWAT Input Files

File Extension	File Name	File Extension	File Name
	Watershed Level Files		**Sub-basin Level Files**
.cio	Master watershed file	.sub	Subbasin input file
.fig	Watershed configuration file	.wgn	Weather generator input file
.bsn	Basin input file	.pnd	Pond/wetland input file
.pcp	Precipitation input file	.wus	Water use input file
.tmp	Temperature input file	.rte	Main channel input file
.slr	Solar radiation input files		**HRU Level Files**
.wnd	Wind speed input file	.hru	HRU input file
.hmd	Relative humidity input file	.mgt	Management input file
.pet	Potential ET input file	.sol	Soil input file
.cst	Weather forecast input file	.chm	Soil chemical input file
.cal	Auto-calibration input file	.gw	Groundwater input file
crop.dat	Land cover/plant growth database file		**Output Files**
till.dat	Tillage database file	input.std	Summary input file
pest.dat	Pesticide database file	output.std	Summary output file
fert.dat	Fertilizer database file	output.hru	HRU output file
urban.dat	Urban database file	output.sub	Subbasin output file

The model takes in spatial as well as non-spatial datasets. To work with different tools available in ArcSWAT various input files are required. ArcSWAT takes a number of input files to facilitate the modelling process. Figure 3.6 shows the soil map of Himachal Pradesh. Figure 3.7: Sub-basins of Himachal Pradesh shows the sub-basins in the state of Himachal Pradesh. Table 3.1: ArcSWAT Input Files depicts a few of the major inputs.

3.3.2 Data used

The daily climatic parameters that include precipitation, temperature (min, max), relative humidity (min, max), wind speed, and sun shine hours were acquired from the Indian Meteorological Department (IMD). Details of all major existing water resource infrastructures were obtained from Water Resource Information System (WRIS), India and state government toposheets. Existing standard irrigation and the management practices were taken from packages of practices in Kharif and Rabi season published by the state departments. Actual area and production and yield of major crops, vegetables, and fruits were obtained from Ministry of Agriculture and Co-operation website and 'Statistics at a Glance—Various Issues'. Stream-flow data of 11 locations *(KarchamWangtoo, NathpaJhakri, Rampur, Beas, and Parbati in Himachal Pradesh)* was used for validation.

For weather parameters, data from National Data Centre, IMD was used. For validation, station data from Shimla, Sundernagar, Bhuntar, Manali, and Nahan in Himachal Pradesh was applied. RECESS program was used for calculating baseflow recession constant (α_{BF}) and this constant then used for SWAT model. The SWAT model input–output was used for calibration and validation using stream-flow data. This validated model that predicted baseflow was then used for cross-checking with RECESS predicted baseflow. Then at final stage, all existing management practices were simulated to match actual observed yield. Data used in the model is listed in Annexure 3.2.

3.3.3 Integration

Weather inputs for base period (1970–2000) and projected period (2030s) were taken from the PRECIS model. The range of water flow for base period and projected period were helpful in understanding the framework for water, soil, and energy inter-dependencies.

3.3.4 Relevance of SWAT model for state development policies

Based on the secondary data analysis, review of literature, expert consultation, and field visits various major problems and challenges have been found out for Himachal Pradesh. The state has major challenges like climate change impact adaptation, development of various sectors in sustainable manner, increased income from forest and non-timber forest products, sustainable harvesting of natural resources.

SWAT model has been used for surface runoff and groundwater recharge predictions for observed climatic data period 1970–2000 and for future predicted climatic data (2030s). The model results will help in understanding the impact of climatic variability on the different aspects of land and water.

The model also sets a robust base for policy interventions related on disaster risk reduction and disaster management.

3.4 Results and Discussion

This study, with the help of the ArcSWAT model, measures the impact of climate change on the water availability in various sub-basins within the main Indus basin and parts of Ganga basin.

The simulations done using the ArcSWAT model have been performed for future climate scenario pertaining to the time period 2020–50. The model validation was done at various locations (Karcham Wangtoo, Nathpa Jhakri, Rampur HEP, Beas, etc.) for which the stream flow data were available. For the entire validation process the details of all major existing water resource infrastructures were obtained from WRIS India and state government toposheets. The climatic parameters including precipitation, temperature (min, max, mean), relative humidity, wind speed, and solar flux were acquired from the IMD. Incorporation of the existing irrigation levels and the current management practices has been done for modelling.

3.4.1 Impact of climate change on apple productivity in Himachal Pradesh

Apple is favourite fruit crop of Himachal Pradesh and in recent years it has emerged as the leading cash crop amongst fruit crops. The area under apple cultivation has increased from 23,100 hectares in 1970–71 to 101,484 hectares in 2010–11. The production has shown a nine times increase and gone up from 94,922 in 1970 to 892,112 in 2010. However, productivity

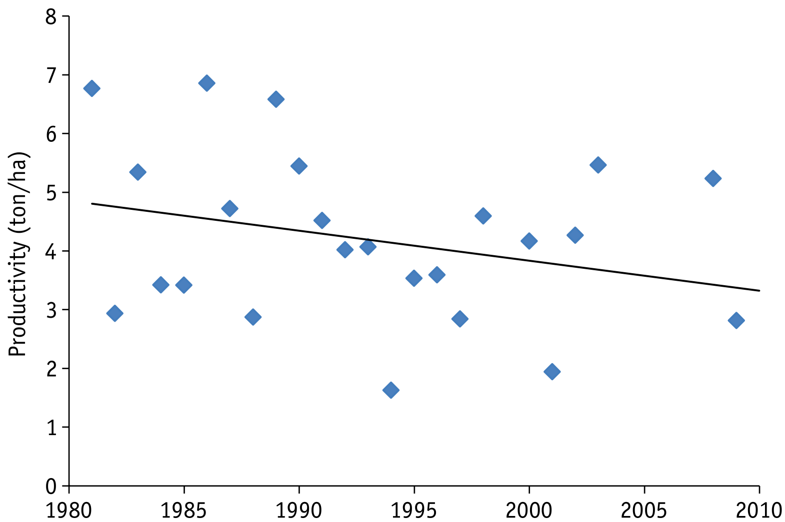

Figure 3.8: Apple productivity in Himachal Pradesh over years

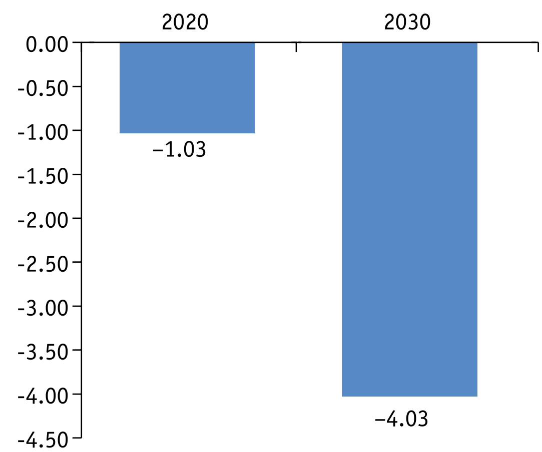

Figure 3.9: Impact of climate change on apple productivity (percent change) in Himachal Pradesh

of crop has decreased over time. Changes in the climate in the form of erratic precipitation increase in upper and lower bound of temperature and reduction in days providing effective chilling units are some of the reasons responsible for this.

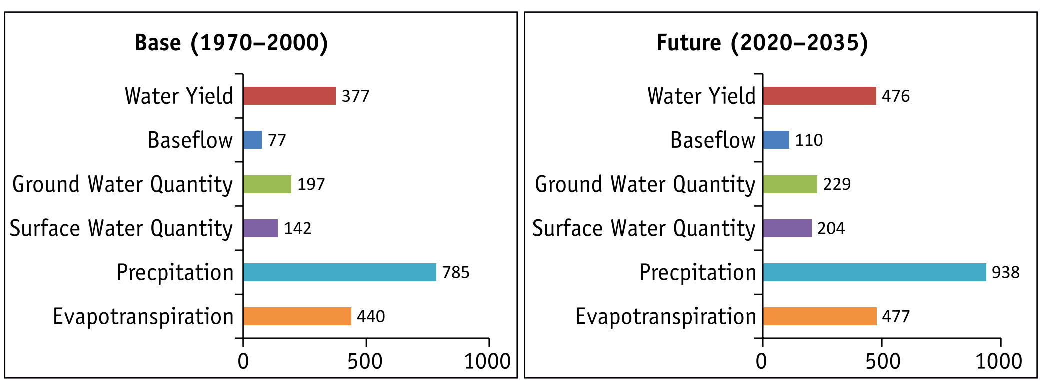

Figure 3.10: Water balance components (WBC) of Beas sub-basin

Figure 3.8: Apple productivity in Himachal Pradesh over years shows the declining trend of apple productivity in Himachal Pradesh over years. Based on SWAT model results, it is predicted that as a result of climate variability especially increase in maximum and minimum temperature and decreased snowfall, Apple productivity in Himachal Pradesh will decrease by 1 per cent by 2020 and 4 per cent by 2030 (Figure 3.9: Impact of climate change on apple productivity (percent change) in Himachal Pradesh)

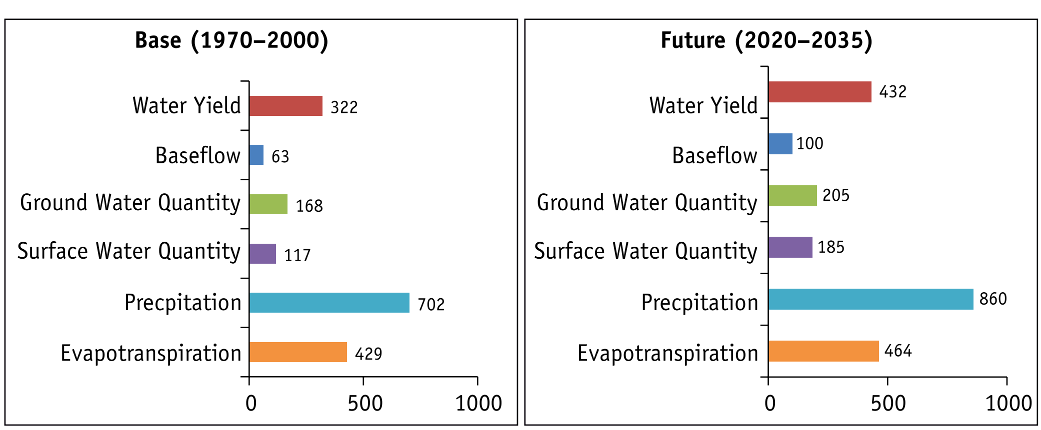

Figure 3.11: WBC of Ravi sub-basin

3.4.2 Water Balance in Different Sub-basins in HP

The Beas sub-basin partially covering the state of Himachal Pradesh is projected to show an increase in the water yield from 377 mm to 476 mm by the year 2035. This increase in the water yield can be attributed to the increased precipitation projections of about 19 per cent. The surface water quantity and ground water quantity show an increasing trend with percentage changes of 44 per cent and 16 per cent, respectively. The ET increases by merely 8 per cent (Figure 3.10: Water balance components (WBC) of Beas sub-basin). The sub-basin in the time period from 1970–2000 had severe erosion and will continue to fall in this category with erosion reaching 78 tons/ hectare in the 2020–35 time period.

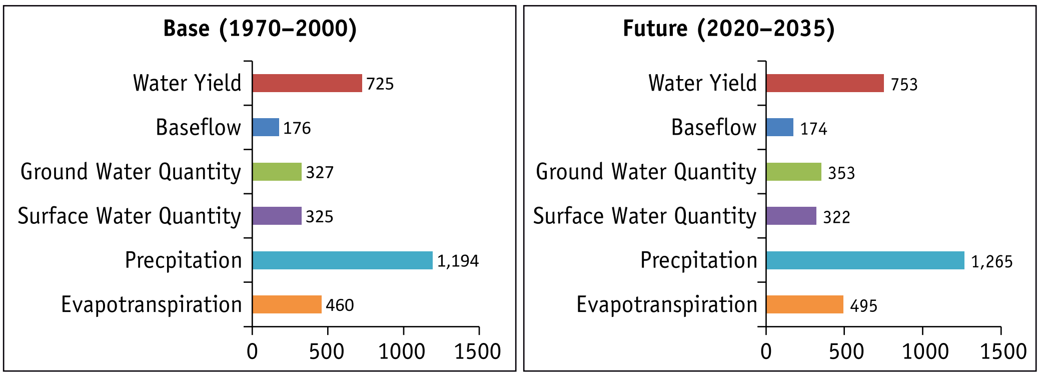

Figure 3.12: WBC of Chenab sub-basin

The Ravi sub-basin covering part of Himachal Pradesh is projected to experience increase in the water yield from 322 mm to 432 mm. A 23 per cent increase in the precipitation could be credited to the increased water yield in the time horizon of 2020–35. There is also an increase of 58 per cent and 22 per cent in the surface water quantity and ground water quantity, respectively. The evaporative losses show an 8 per cent increase (Figure 3.11: WBC of Ravi sub-basin). The sub-basin currently has very severe erosion and will continue to fall in this category with erosion reaching 120 tons/ hectare in the 2020–35 time period.

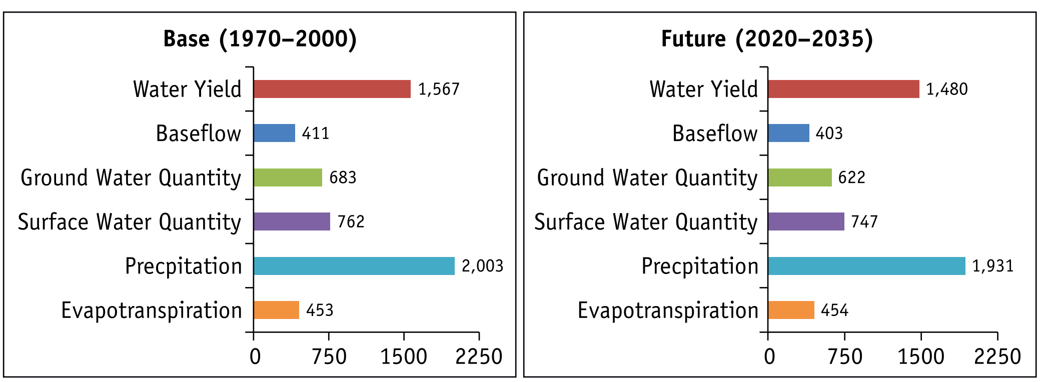

Figure 3.13: WBC of Upper Indus sub-basin

The Chenab sub-basin is projected to show a small increase from 725 mm to 753 mm in the water yield while the precipitation is expected to increase by only 6 per cent. There will be a slight decrease in the surface water quantity, whereas an increase of 8 per cent in the ground water quantity which could be attributed to the change in the landuse/landcover pattern over the years. The evaporative loss will increase by 8 per cent as well (Figure 3.12: WBC of Chenab sub-basin). The sub-basin currently has very severe erosion and will continue to fall in this category with erosion reaching 203 tons/ hectare in the 2020–35 time period.

The Upper Indus sub-basin is expected to show a slight decrease in the precipitation during the time period 2020–35 due to which the water yield in that time period would also experience a slight decrease, although the ET would remain unchanged. There would also be a decrease in the surface water quantity and ground water quantity (Figure 3.13: WBC of Upper Indus sub-basin). The sub-basin in the time period from 1970–2000 had severe erosion (36 tons/ hectare), which would slightly decrease to 35 tons/ hectare but still fall in the category of severe erosion in the 2020–35 time period.

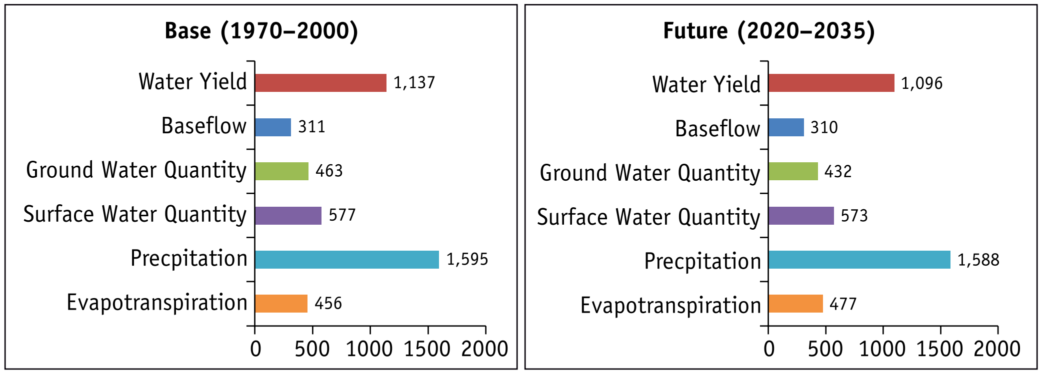

Figure 3.14: WBC of Sutlej Upper sub-basin

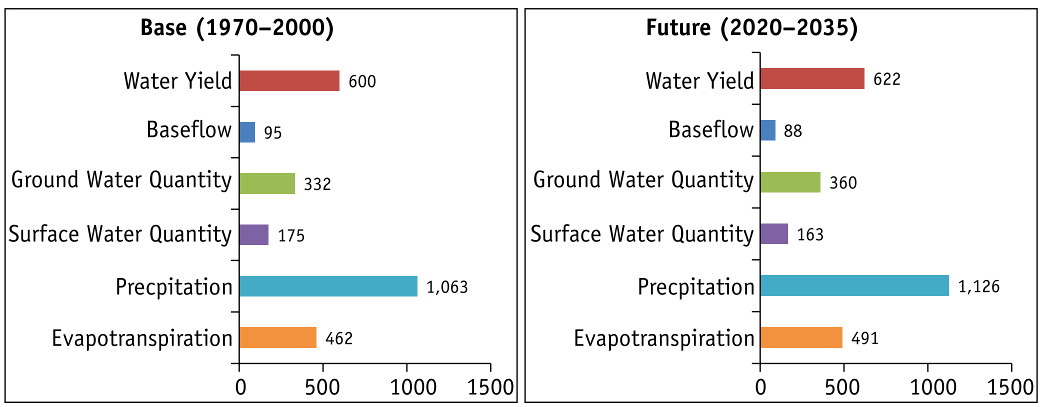

Figure 3.15: WBC of Yamuna Upper sub-basin

The Sutlej Upper sub-basin is projected to experience slight decrease in the water yield while there will be no change the precipitation. The surface water quantity and ground water quantity are also predicted to show a decrease whereas the ET would increase by 5 per cent (Figure 3.14: WBC of Sutlej Upper sub-basin). The sub-basin in the time period from 1970 to 2000 had very severe erosion at 305 tonnes/hectare, which is projected to increase to 334 tonnes/hectare, placing the sub-basin in the catastrophic erosion category in the 2020–35 time period.

In the Yamuna Upper sub-basin, the water yield would increase to 1,096 mm by 2035. This increased water yield could be attributed to the 6 per cent increase in precipitation. There will be a slight decrease in the surface water quantity, whereas an increase of 8 per cent in the ground water quantity could be attributed to the change in the landuse/landcover pattern over the years. The ET will increase by 6 per cent as well (Figure 3.15: WBC of Yamuna Upper sub-basin). The sub-basin in the time period from 1970 to 2000 had severe erosion and would continue to fall in this category with erosion reaching 73 tonnes/hectare in the 2020–35 time period.

3.4.3 Impact of Surface Runoff on Hydroelectric Projects (HEPs)

Himachal Pradesh has huge hydroelectric potential**.** Through preliminary hydrological, geographical, and topographical investigations, it is found out that state is having about 23,000 MW hydroelectric potential (GoHP 2013). Natural resources of Himachal Pradesh have direct relationship with its physiographic conditions including slope, drainage, climate, and geology. Most of the surface water resources in the state are available from the perennial rivers comprising glacier melt water and catchment runoff water. It is predicted that rainfall in some areas of the state will decrease while in some areas it will increase in future. Figure 3.16: Hydroelectric power projects affected due to change in annual surface runoff (2030s) shows the hydroelectric power projects affected due to change in annual surface runoff. It can be said referring Figure 3.16: Hydroelectric power projects affected due to change in annual surface runoff (2030s) that blocks from Lahaul and Spiti, Kinnaur, Shimla, and Sirmour will affect due to medium to high decrease in total annual surface runoff. As compared

Figure 3.16: Hydroelectric power projects affected due to change in annual surface runoff (2030s)

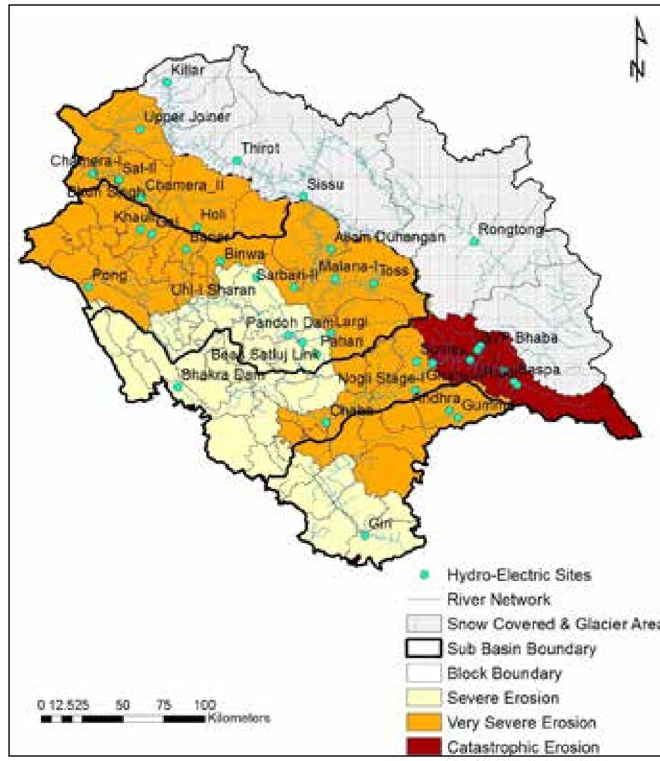

Figure 3.17: HEP regions affected due to soil erosion by water (2030s)

to this, blocks in Chamba and Kangra districts will have medium to high increased surface runoff. Hence HEPs located in these regions need special arrangements to handle increased surface runoff. Besides already commissioned projects, many projects are under construction and many are proposed by the state in these regions.

3.4.4 Impact of Soil Erosion on HEPs

National Mission on Sustainable Agriculture has major component of scheme for the soil health management. Under this program, the state aims to promote integrated nutrient management and improve soil health and productivity. As soil is important part of agricultural production system, loss of fertile soil is major loss. Soil formation is very slow process. It takes 1,000 years for nature to make one cm layer of soil. Hence, even slight-to-moderate soil erosion is not desired.

By applying modified universal soil loss equation through ArcSWAT, we found out soil erosion by water in 2020–35 (Figure 3.17: HEP regions affected due to soil erosion by water (2030s)). Referring to Figure 3.17: HEP regions affected due to soil erosion by water (2030s), it can be seen that 11.61 per cent area of the state will have catastrophic soil erosion (more than 320 tonnes/hectare/year), 65.96 per cent area will have very severe soil erosion (80–320 tonnes/hectare/year), and 22.44 per cent area will have severe soil erosion (24–80 tonnes/hectare/year). Figure 3.17: HEP regions affected due to soil erosion by water (2030s) shows already commissioned hydroelectric power projects in these regions. Besides already commissioned projects, many projects are under construction and many are proposed by the state in these regions. Hence, these projects will need specific attention to de-silting mechanisms in the reservoirs, head walls, and project constructions. Thus, soil and water conservation activities assumes greater role in the state.

3.5 Ways Forward

- Water is one of the most important natural resources of Himachal Pradesh. The state has very rich, unique, and diversified combination of natural resources, flora and fauna, and physiography. Major sub-basins of the rivers Sutlej, Beas, Ravi, Chenab, and Indus generate huge volume of water from the catchment areas and augmented mainly by glacier melt water. Besides water supply of perennial rivers, limited amount of groundwater resources are also available for few districts. In future (2020–35), Beas, Ravi, Chenab, and Upper Yamuna sub-basins will have increased precipitation while Upper Indus and Sutlej Upper will have decreased precipitation.

- As compared to 1970–2000, in 2020–35 water yield is projected to increase in sub-basins of Beas, Ravi, Chenab, and Yamuna. The water yield will decrease for Upper Indus and Sutlej. Development activities involving industry, power generation, and domestic sector will need planning accordingly.
- Water availability for irrigation purpose will vary sub-basin wise. Upper Indus, Sutlej Upper, and Chenab sub-basins might have decreased surface water availability. ET is expected to increase by 6 per cent to 8 per cent across all sub-basins. Considering the delivery, conveyance, and application losses, actual irrigation will be considerably more, depending upon the type of irrigation method. Hence, agriculture and horticulture activities in these sub-basins need attention.
- Soil formation is a very slow process. It takes a thousand years for nature to make one centimetre layer of soil. Hence, even slight-to-moderate soil erosion is not desired. It was found that 11.61 per cent area of the state will have catastrophic soil erosion (more than 320 tonnes/hectare/year), 65.96 per cent area will have very severe soil erosion (80–320 tonnes/hectare/year), and 22.44 per cent area will have severe soil erosion (24–80 tonnes/hectare/year). Besides soil and water conservation schemes, catchment area development and catchment area development programmes continuous strengthening for long-term strategic planning.
- Himachal Pradesh has huge hydroelectric potential**.** Through preliminary hydrological, geographical, and topographical investigations, it is found out that state is having about 23,000 MW hydroelectric potential (GoHP 2013). Hydro power is emerging as a powerful mechanism for speedier economic growth and overall development of the State. As a result, the State has many commissioned projects; many projects under construction and many are proposed by the state in these regions.
- It is found out that blocks from Lahaul and Spiti, Kinnaur, Shimla, and Sirmour will affect due to medium to high decrease in total annual surface runoff. As compared to this, blocks in Chamba and Kangra districts will have medium to high increased surface runoff. Hence, HEPs located in these regions need special arrangements to handle increased water runoff. Projects will also need specific attention to de-silting mechanisms in the reservoirs, head walls, and project constructions.
- Himachal Pradesh has abundant natural resources including water and soil resources; different land use and physiographic conditions including slope, drainage, climate, and geology. The State also has huge hydroelectric potential. Hence, impact of climate change on hydroelectric power projects can be studied in detail linking energy–ecology–economy. Apple has emerged as the leading cash crop amongst fruit crops. Role of different weather parameters, soil dynamics, soil depth, and soil nutrients as well as different climate change adaptation techniques for apple and crop cultivation can be explored in detailed at block or districts level using locally carried out experimental information. The State has massive Catchment Area Treatment plans. It will be very useful to evaluate the effectiveness of these treatment structures to estimate soil and water conservation potential as well as for improving and implementing such measures at larger scales.

3.6 References

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Exhibit 1: ArcSWAT Interface

3.7 Bibliography

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Exhibit 2: Project Setup

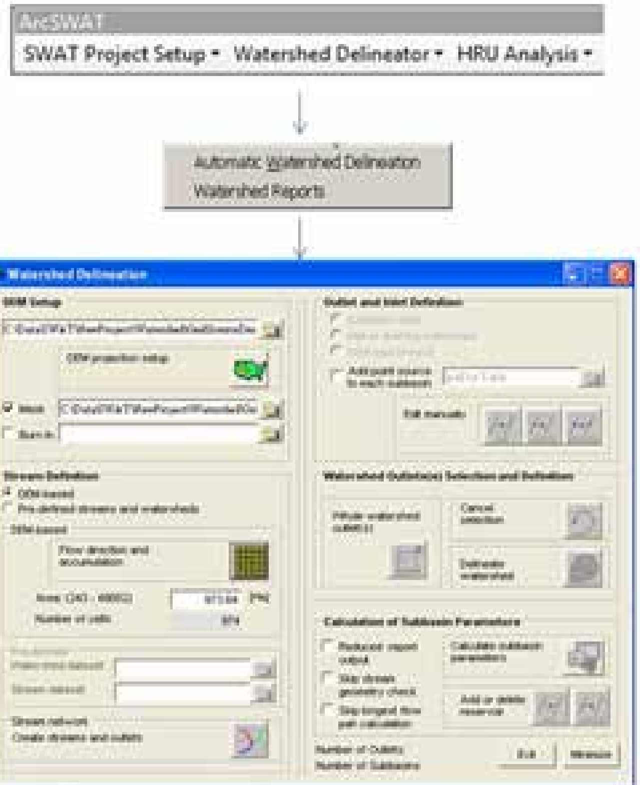


Exhibit 3: Watershed Delineation

the Environment 28:205–41.

Exhibit 4: HRU Analysis

3.8 Annexures

Annexure 3.1: Note on ArcSWAT model

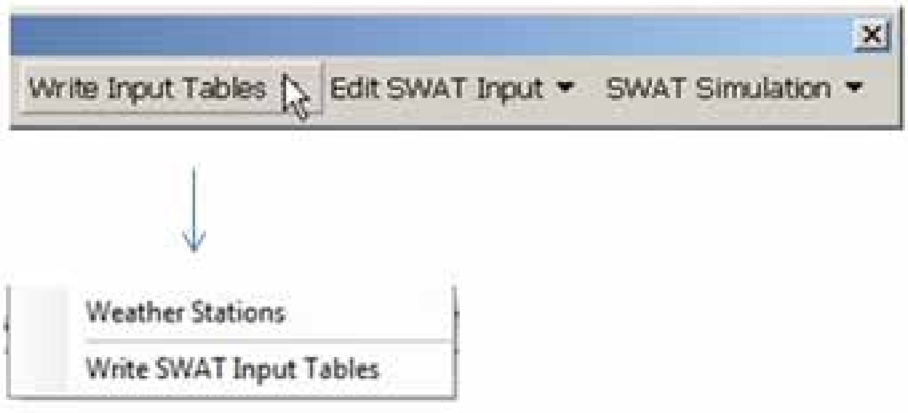


Exhibit 5: Write Input Tables

The SWAT model simulates the quality and quantity of surface as well as ground water and predicts the environmental impact of land management practices, climate change, land use, etc. An average ArcSWAT toolbar consists of six basic functions viz. SWAT Project Setup, Watershed Delineator, HRU Analysis, Write Input Tables, Edit SWAT Input, and Swat Simulation.

The tool works in a series of steps starting with project set-up, performing a series of analysis, and finally coming up with an output (Exhibit 1). To begin with, a new Project needs to be set up or an already existing project can be loaded (Exhibit

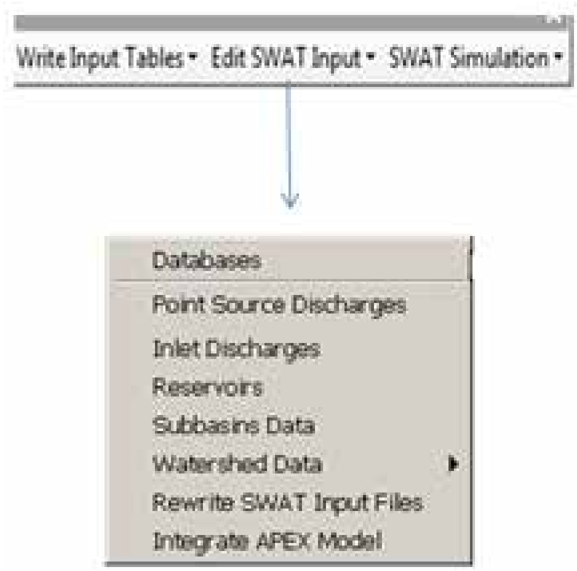


Exhibit 6: Edit SWAT Input

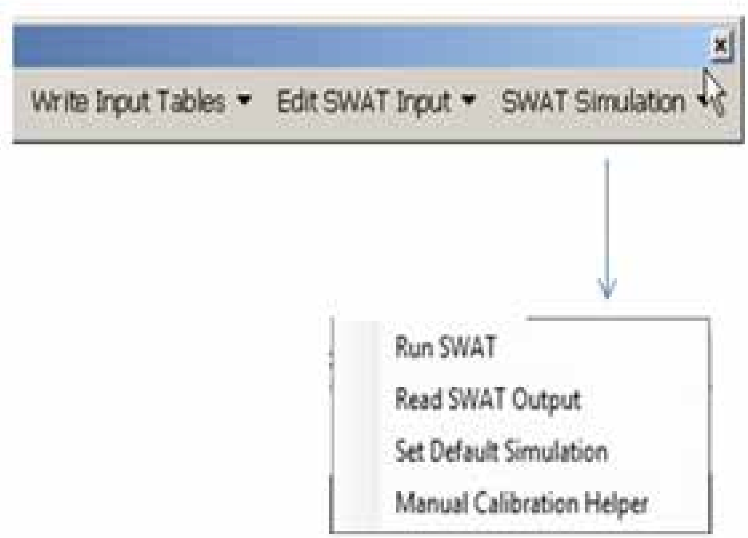


Exhibit 7: SWAT Simulation

2). The project set-up will automatically create a project geodatabase, raster storage, and a parameter geodatabase in the chosen directory. Once the project set-up is done, the Automatic Watershed Delineation command opens up a dialogue box with the help of which one can perform sub-basin delineation and evaluate the results (Exhibit 3). The interface generates topographic reports that can be accessed through the watershed reports command.

With the help of the HRU Analysis tool, the land use, soils, and slope analysis can be performed, which are used to generate SWAT HRUs (Exhibit 4). The Land Use/Soils/Slope Definition command used to import land use and soil maps and perform overlay.

Next to the HRU Analysis tab in the ArcSWAT toolbar is the Write Input Tables tab; the basic function of this tool is to generate the ArcSWAT geodatabase files that are used by the interface to store input values for the SWAT model (Exhibit 5). The Weather Stations command is used to load weather station locations and data for use.

The Edit SWAT Input tool allows to edit the SWAT model databases and the watershed database files containing the current inputs for the SWAT model (Exhibit 6). It contains various commands including Database, Point Source Discharges, Inlet Discharges, Reservoirs, Watershed Data, Re-Write SWAT Input Files, Integrate APEX Model, which facilitate the tool for the proper functioning. The last tab in the ArcSWAT toolbar is the SWAT Simulation tool that allows the user to run the SWAT model and perform sensitivity analysis and calibration (Exhibit 7). The Simulation tool supports four commands viz. Run SWAT, Read SWAT Output, Set Default Simulation, and Manual Calibration Helper.

SWAT is a process-based distributed-parameter simulation model, operating on a daily time step. The model was originally developed to quantify the impact of land management practices in large, complex watersheds with varying soils, land use, and management conditions over a long period of time. SWAT uses readily available inputs and has the capability of routing runoff and chemicals through streams and reservoirs, and allows for the addition of flows and the inclusion of measured data from point sources. Moreover, SWAT has the capability to evaluate the relative effects of different management scenarios on water quality, sediment, and agricultural chemical yield in large, ungauged basins. Major components of the model include weather, surface runoff, return flow, percolation, ET, transmission losses, pond and reservoir storage, crop growth and irrigation, groundwater flow, reach routing, nutrient and pesticide loads, and water transfer.

For simulation purposes, SWAT partitions the watershed into subunits including sub-basins, reach/main channel segments, impoundments on the main channel network, and point sources to set up a watershed. Sub-basins are divided into hydrological response units that are portions of sub-basins with unique land use/management/soil attributes. The geographical information system interface of the model (AvSWAT; Di Luzio et al. 2002) enables users to specify a critical source area (CSA) that controls the number of sub-basins and the density of the channel network in the study area. This CSA is the minimum area that is required for initiation of channel flow. The number of sub-basins and the density of the channel network increase with decreased CSA (Di Luizo et al. 2002; Arabi et al. 2006).

Hydrologic Component

SWAT uses a modification of the soil conservation service (SCS) curve number method to compute surface runoff volume for each HRU. Peak runoff rate is estimated using a modification of the Rational Method. Daily or sub-daily rainfall data is used for calculations. Flow is routed through the channel using a variable storage coefficient method developed by Williams in 1969 or the Muskingum routing method. In this study, SCS curve number and Muskingum routing methods along with daily climate data were used for surface runoff and stream flow computations.

Sediment Component

Sheet erosion is estimated for each HRU using the Modified Universal Soil Loss Equation (MUSLE) (Williams 1975):

$$S = 11.8 \times (Q \times q \times A)^{0.56} \times K \times C \times P \times LS \times F$$

Where, S is the sheet erosion on a given day (metric tons), Q is the surface runoff volume (mm water), q is the peak runoff rate ($m^3\ s^{-1}$), A is the area of the HRU (ha), K is the USLE soil erodibility factor, C is the USLE cover and management factor, P is the USLE support practice factor, LS is the USLE topographic factor, and F is the coarse fragment factor.

Nutrient and Pesticide Components

Movement and transformation of several forms of nitrogen and phosphorus and pesticides over the watershed are accounted for within the SWAT model. Nutrients are introduced into the main channel through surface runoff and lateral subsurface flow, and transported downstream with channel flow. Pesticides loadings from land areas to streams and water bodies are simulated in soluble or sorbed forms. Transport and transformation of pesticides in the channel network is modelled with a simple mass balance analysis.

Model Evaluation

SWAT already has an established method for modelling hydrology along with several agricultural practices. The model also has the capacity to represent many other commonly used practices in agricultural fields through alteration of its input parameters. Crop yield one of the major outputs of the crop growth component of the model, accounts for both ET and soil moisture required for vegetative growth. Therefore, crop yield can be used as an evaluation parameter. Groundwater is an integral part of hydrologic budget and is always under attention. The description of recession of water in the ground can be used for the evaluation of aquifer properties and the sustainability of groundwater. In this regard, recession curves make a significant contribution to integrated river basin management by analysing ground water and by separating baseflow from streamflow. The United States Geological Survey developed RECESS model that creates the master recession curve (MRC) method can enhance the accuracy of prediction. Considering this, the major parameters evaluated in this study are actual ET, streamflow, baseflow, baseflow recession constant (α_{BF}), and crop yield.

Annexure 3.2: Data Used for the Study

	Data Source	Time Period
Spatial Data		
Digital Elevation Model (DEM)	The National Aeronautics and Space Administration: ASTER	2009
Sub-basin boundaries	Water Resource Information System, GoI	2012
LULC map	Generated from LANDSAT remote sensing Image using ERDAS and ArcGIS	1980, 1990, 1998, 2014
Soil map	National Bureau of Soil Survey and Land Use Planning	1994, 1997
River Network and Drainage map	Ministry of Water Resources, GoI	2012
Non-Spatial Data		
Agricultural Area, production and yield of major crops, and fruit trees	Ministry of Agriculture & Co-operation, GoI	1950, 1960, 1970, 1980, 1990–2014
Climatic parameters (rainfall, temperature, wind speed, relative humidity, and sunshine hours)	National Data Centre, Indian Meteorological Department, GoI	1995–2000, 2009–2010
Fertilizer (NPK)	Fertiliser Association of India	1950, 1960, 1970, 1980, 1990–2013
Forestry	Forest Survey of India	1970, 1980, 1990, 2010, 2012
Ground water depth and observation well information	Central Ground Water Board, GoI	1990–2001, 2009–2010
Demographics (population, workers, medical, roads, power, etc.)	Census of India	1951, 1961, 1971, 1981, 1991, 2001, 2011
Number of Industries, Annual Production, etc.	Survey of Industries, Ministry of Statistics and Programme Implementation, GoI; Planning Commission Himachal Pradesh	1980–2013
Farm machinery and implements	Ministry of Agriculture & Co-operation, GoI and State Agricultural Departments	1970, 1980, 1990–2012

4

Green Growth and Hydro-Power in Himachal Pradesh

4.1 Introduction

Himachal Pradesh has rapidly evolved in terms of economic growth. The net state domestic product (NSDP) and per capita NSDP show increasing trends over the years (Figure 4.1).

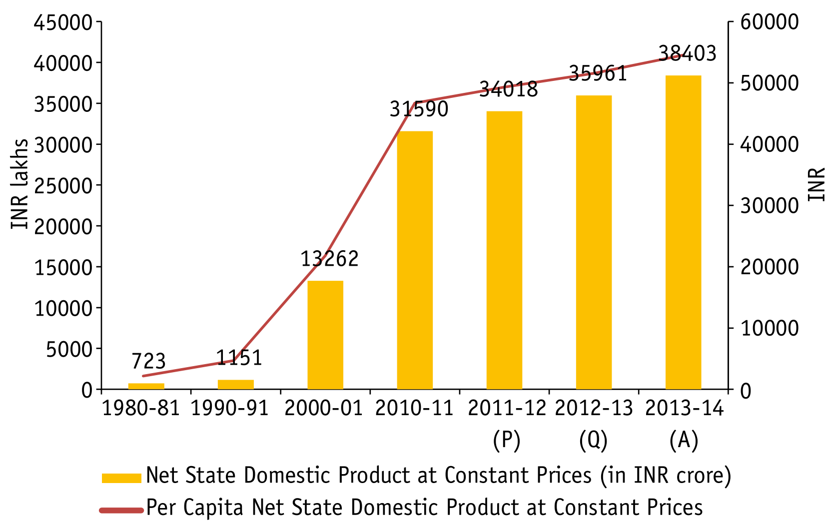


Figure 4.1: NSDP at constant prices of Himachal Pradesh
Source: Department of Economics and Statistics, Himachal Pradesh, 2014

Figure 4.1 shows the steady growth in per capita income and NSDP for the State. The economy of Himachal Pradesh has shown a shift from agriculture sector to industrial and services (including tourism and hospitality). While the contribution of the primary sector to the GSDP declined, 57.93 per cent of the working population was dependent on this sector. This indicates that while there has been a diversification of the State economy from agrarian to an economy with greater contribution from the tertiary and secondary sector, a significant proportion of the population is still dependent on the primary sector as an occupational choice.

Percentage contribution of agriculture in gross state domestic product (GSDP) has declined from 25 per cent in 2000–01 to 19 per cent in 2013–14 (Figure 4.2). The secondary sector showed healthy signs of industrialization and modernization as its contribution increased from 25 per cent in 1990–91 to 38 per cent in 2013–14 (Department of Economics and Statistics 2015). Tourism has been recognized as an important sector of the economy. Himachal Pradesh has the natural capital and resources for being a tourist destination. All these structural economy dynamics have an implication for the State's energy demand.

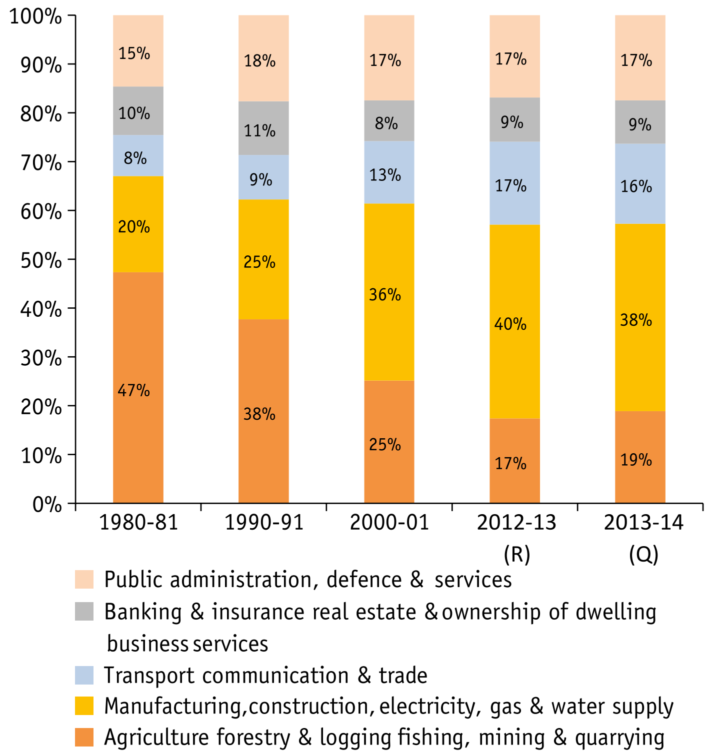


Figure 4.2: GSDP at Factor Cost at Constant Prices
Source: Department of Economics and Statistics, Government of Himachal Pradesh, 2015

4.2 Hydro-power and relevance to green growth

Himachal Pradesh is significant in terms of ecosystem services that constitute a major natural watershed for the North Indian region. The State is critical to the livelihoods of more than 200 million people in Haryana, Punjab, Uttar Pradesh, and Rajasthan. Himachal Pradesh also has one of the main sources of clean energy—hydropower—for the country that can help address both the energy and peak shortages of the Northern Region.

Hydropower and green growth needs to be seen within a national green growth context rather than only looking at hydro-power as being important to socio-economic development in Himachal Pradesh. Figure 4.3 shows hydropower generation capacity for India under different scenarios—reference and alternative. In order to meet the objective of India's energy security and clean energy, hydropower will continue to play an important role.

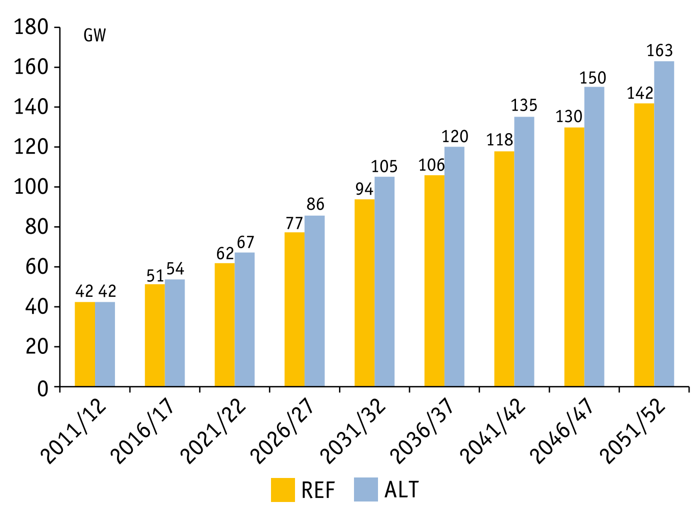


Figure 4.3: Hydropower generation capacity (in GW) for India under different scenarios
Source: TERI Energy Security Outlook

4.3 Power sector in Himachal Pradesh

Himachal Pradesh has emerged as a model of economic development and prosperity among hill states in India. Secured power supply at an affordable price is one of the key enablers of the State's economic growth. Not only has power availability been adequate to meet the overall yearly State power demand,[1] surplus power is also exported to other states. It is worthwhile to mention that Himachal Pradesh has significant economically exploitable hydro power potential, reportedly around 23 GW[2] (Economics & Statistics Department 2014), thanks to five river basins, namely Yamuna, Satlej, Beas, Ravi, and Chenab.

As hydro power is insulated from fuel market volatility, its cost of generation (also expressed as levelized cost of energy) is believed to be predictable and stable and also cheaper in the long run compared to most of the other energy options. In order to realise the economic benefits of the hydro power potential in the State, the government of Himachal Pradesh has put in place certain policy frameworks, in the form of State Hydro Power Policy of 2006 (Govt. of HP 2006). The policy is expected to attract investments in hydro power projects, especially from private sector, generate revenue channel for the State, and create fund for the people affected by the hydro projects.

Apart from hydro power, the State government is also giving emphasis on solar energy. The State Solar Power Policy of 2014 (Govt. of HP 2014) has targeted capacity addition of solar power up to 50 MW in the period from 2013 to 2017 and additional 250 MW from 2017 to 2022.

4.3.1 Power supply

The power supply in Himachal Pradesh is dependent on hydroelectricity projects; the latter is broadly classified as small (up to 5 MW installed capacity) and large hydro (more than 5 MW) according to a project's installed power generation capacity. This capacity-wise classification holds significance as there are dedicated State policies and regulations for small and large hydro projects. The latest available data shows that 10,234 MW of hydro power is currently harnessed (Directorate of Energy interaction), out of which large hydro accounts 97 per cent. However, small hydro projects outnumber large projects; the former comprises nearly 70 per cent of projects commissioned. This apart, the State is witnessing considerable hydro power capacity addition in the coming years. As per latest available data, a total of 73 projects with aggregate capacity of 2,650 MW are under construction. More projects are at different stages of assessment. Figure 4.4 gives a snapshot of hydro power development in the State.

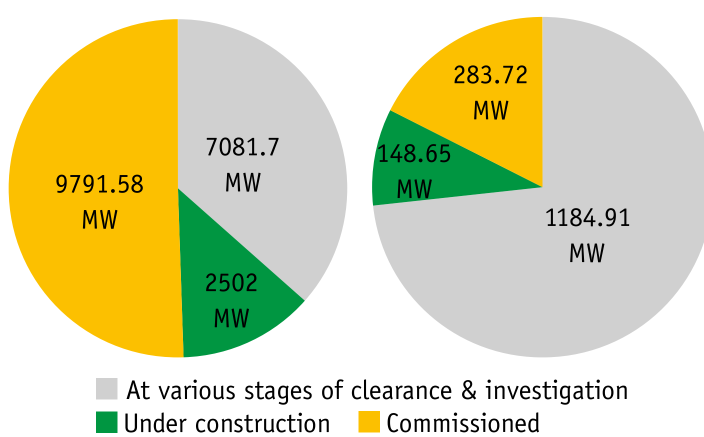


Figure 4.4: Current status of hydro power projects in Himachal Pradesh
Source: TERI analysis. Data sourced from Himachal Pradesh government

[1] The State is found to draw power from other states and central generation stations during certain periods of a year. Himachal Pradesh generates surplus power and exports it to other states during the peak season of the year and draws from power from other states during the lean season.

[2] The State Economic Survey 2014–15 has put the value at 27 GW following a recent re-assessment of hydro potential. However, the figure is yet to be adequately validated.

One can see that more than 11 GW of capacity is at different stages of development. A salient feature of hydro power development in the State is participation of private sector, which accounts 65 per cent of projects commissioned. Involvement of private developers is more pronounced in case of small hydro. Of the current 90 small hydro projects commissioned, 69 projects are developed by private entities. The share is expected to increase considerably as all 41 small hydro projects under construction are developed by private sector. This can be attributed to the existing institutional framework dedicated to developing small hydro segment of the State's power sector.

Small hydropower project construction and operation in Himachal Pradesh is entirely privatized. Small hydropower projects apply run-of-the-river power generation technologies to convert hydropower into electricity. Till 2015, nine years after the implementation of the hydro power policy of the state, there have been a total of 90 small hydropower projects generating electricity in the state (including approximately eight projects commissioned before 2006). Forty-one more small hydro power projects have been under construction and 548 more under various stages of planning approval. Himurja offers the private developers hydro power project sites.

Once the allotted project site is received, the private corporation has to prepare a detailed project report (DPR) of the site, which will include two years of stream flow data and analysis of engineering, economic, hydrological, geological, and environmental characteristics of the project.

Once the DPR is approved by Himurja, Himurja and the project developer signs a Memorandum of Understanding, a Techno-Economic Clearance document, and eventually an Implementation Agreement.

The private developer has to take "No Objection Certificates" from the relevant state and local government entities, which includes Forest Department, Irrigation and Public Health Department, Fisheries Department, Wildlife Department, Public Works Department, Pollution Control Board, Revenue Department, and the panchayats that can be affected through the hydro power project. This process can take time, and if delay happens, then cost escalation can happen in the construction cost of the project, which is generally ₹6–8 crores/MW.

However, Himachal Pradesh State Electricity Board (HPSEB) guarantees to buy power from the independent power producers (IPPs) at a purchase price of ₹2.50 per Kwh, which translates to ₹2.2 crores per megawatt per year. So the IPPs have a buy back agreement by the HPSEB. Any small hydro project reverts to the State Government free of cost after 40 years of operation.

The power producers will not pay any power sector royalty to the state for first 12 years. In the next 18 years, the developer needs to provide 12 per cent of the power free of charge to the state; for the remaining 10 years, it must provide 18 per cent free electricity to the state.

For small hydropower projects, environmental and social impact assessments are not required. The developer also does not need to hold public hearings on the pros and cons of the project. In the absence of these processes, often the voices of members of project-affected communities, civil society groups regarding the projects' future anticipated effects are not internalized. This leads to local opposition from rural communities and disrupts rural livelihoods, employment generation, and often other forms of direct compensation.

Small hydro power projects can also disrupt Kuhl irrigation systems and can physically damage the irrigation system or can divert water on which the irrigation system relies. If this happens, then farmers need to shift to rain-fed cultivation, which can result in variability in outputs owing to unpredictable rainfall, increased vulnerability to drought, and damage from hailstorms at harvest time.

In Himachal Pradesh, small hydropower projects have often disabled at least 14 Kuhl irrigation systems without compensating farmers for their losses. A disruption in a single irrigation system can disrupt the supply of irrigation water to at least 2,000 households.

To promote small hydro projects in the State and encourage private investment in the sector, the government of Himachal Pradesh has designated Himurja as the nodal State agency (Box 4.1).

With regard to large hydro, the State-owned power utility, HPSEB currently operates 12 projects. This apart, there are 12 Central and joint projects (cumulative capacity ~7,457 MW) and 16 projects are operated by private entities (~1,867 MW). In recent times, some initiatives can be noticed on solar front. According to a 2010 Renewable Power Purchase Obligation

Box 4.1: State nodal agency for small hydro and solar

Initially established as Himachal Pradesh Energy Development Agency, Himurja has the mandate to handhold the interested entities, both State and private, in implementation of hydro projects in the State up to 5 MW of installed capacity. In most cases, Himurja identifies potential projects and allots them to interested parties. It is neither involved in implementation and operation of a hydro project nor has any financial stake.

Himurja is also recently designated as the competent authority to register solar power projects and monitor progress of the sector in the State.

directive of the Himachal Pradesh Electricity Regulatory Commission (HPERC), the distribution licensee in the State, that is, HPSEB has a target to procure a minimum of 0.25 per cent of its total power purchase from solar energy (HPERC 2014). The target is envisaged to increase to 0.50 per cent in the year 2018–19 and further to 0.75 per cent in the following year. Till financial year 2013, the actual solar power purchase by the licensee has been nil (HPERC 2014). However, the State nodal agency, Himurja has taken certain initiatives to promote rooftop solar photovoltaic (PV) for captive use.

4.3.2 Power demand and sales

With rise in economic activity, Himachal Pradesh has witnessed a threefold jump in per capita electricity consumption in last 15 years, much higher than the corresponding national growth rate. A look at the power consumption trend in the State (Figure 4.5) shows that industrial power demand, which has registered an annualized growth rate of around 12 per cent since the year 2000, has probably contributed most to the rapid increase in power consumption in the State.

Against the annual power demand of 7,554 million units (MU) in 2013–14 (Department of Economics and Statistics 2015), the State utility HPSEB recorded a net in-house power generation of 1,947 MU (Department of Economics and Statistics 2015). This is further supplemented by power supplied from non-HPSEB hydro power stations in the State. In addition, HPSEB has power sharing arrangements with central generating stations and other states. This includes power banking; Himachal Pradesh has power sharing agreements with other states wherein the former can export surplus electricity to the latter in summer and is entitled to draw back electricity during winter (lean period) when hydro power generation drops and power demand in Himachal Pradesh rises. In 2013–14, Himachal Pradesh reportedly registered electricity sales to outside the State to the tune of 1,999 MU (approximately) (Department of Economics and Statistics 2015).

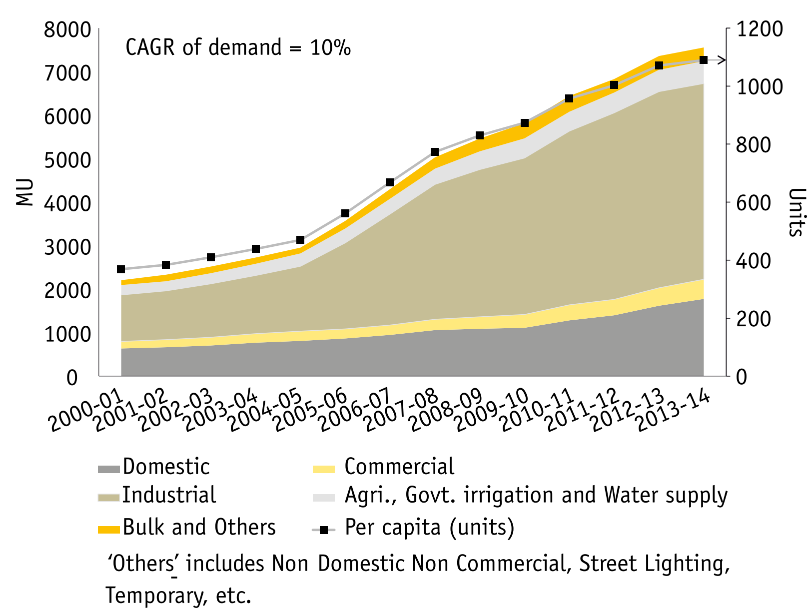


Figure 4.5: Power consumption trend in Himachal Pradesh
Source: TERI analysis. Data sourced from State Statistical Abstract, Himachal Pradesh

4.3.3 Existing power sector policies and plans

Notwithstanding the resources available in a state, a forward-looking, unequivocal policy signal is essential to translate the potential to real opportunities. Himachal Pradesh government merits special mention here. With regard to hydro power development in the State, they have framed the Hydro Power Policy (2006) (Govt. of HP 2006). The Policy sets separate guidelines for large (>5 MW) and small hydro (up to 5 MW) projects, and deals with different aspects of hydro power development quite comprehensively. Among the broad features, the Policy mentions creation of a Local Area Development Fund (LADF), which will finance infrastructure improvement activities in the vicinity of hydro projects and provide a corpus for cash incentives to the local population in project affected area. In addition, the Policy gives directive to companies to employ bonafide Himachalis (minimum 70 per cent in case of small hydro project) in the execution, operation, and maintenance of the projects. Figure 4.6 highlights some key takeaways of the Himachal Pradesh Hydro Power Policy, classified under four broad metrics: Royalty, Local Area Development, Incentives to Project Developers, and Environmental Impact Mitigation.

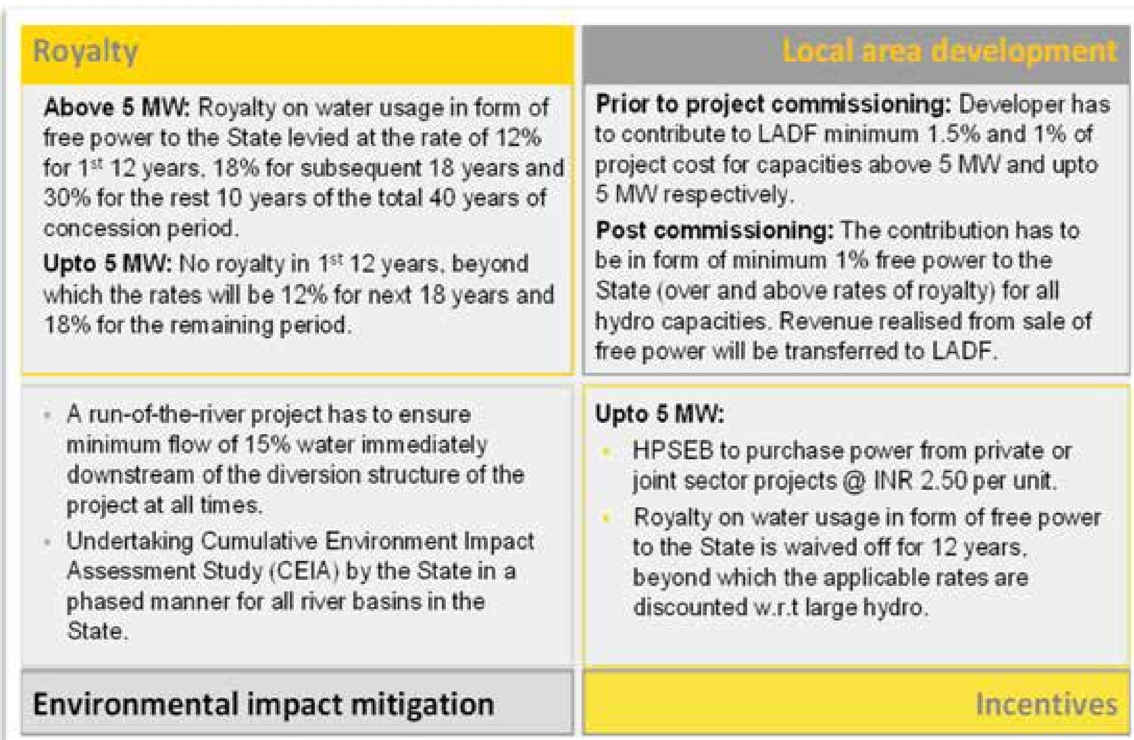


Figure 4.6: A snapshot of salient features of Hydro Power Policy in Himachal Pradesh.

The State's policies in power sector are not limited to hydro power development only. The government has adopted the State Solar Power Policy in 2014 (Govt. of HP 2014). The provisions contained in the Policy are applicable to all the solar PV plants installed in the State and will remain effective till March 31, 2022, in line with the operative period of the Jawaharlal Nehru National Solar Mission (JNNSM). One of the main objectives of the Policy is to promote JNNSM and Ministry of New and Renewable Energy schemes in the State (Box 4.2).

Box 4.2: Solar Power Policy 2014

Key features:
- The maximum allowed capacity installation during 2013–17 (Second Phase) and 2017–22 (Third Phase) set at 50 MW and 250 MW, respectively.
- Applicable tariff determined by HPERC based on net metering and remain firm for the entire project lifetime, that is, 25 years.
- Himurja designated as the nodal agency.
- Plan to set up solar power plant of 10-MW capacity through viability gap funding.

Having significant potential to generate hydro and solar power in the State, enabled by dedicated power sector policies to attract required investments, the Himachal Pradesh government has set ambitious plans to harness the potential. On hydro power front, the government is targeting to tap over 70 per cent of the hydro power potential (~23 GW) by 2020 (Department of Environment, Science & Technology 2012) and presumably the full potential of 23 GW by the end of 16th Five Year Plan period (starting 2032). On the other hand, the State Solar Power Policy envisages solar PV capacity addition of 50 MW by the end of the 12th Five Year Plan period and another 250 MW by the 13th Plan period.

However, time-bound execution necessitates preparedness of the State actors to plan their future implementation activities and make strategies to face any envisaged challenge. Comprehensive assessment of the future scenario(s) in line with the State plans and policies and connected with the current sector status can be crucial in making more informed decisions.

4.4 Approach

4.4.1 Objective of the current study

The current exercise intends to project possible scenario(s) associated with Himachal Pradesh's power sector. This will not only offer the State actors the information of key sector parameters but will also provide them useful insights into the likely implication of the existing sector plans and policies on energy security and finance of the State. The analyses attempt to capture a broad range of aspects of the State's power sector, from technical to economic, which will aid in the planning and decision-making process of the State government for the coming Plan periods. In a nutshell, the aforesaid exercise conducted for the hydro sector aims to

- Explore and understand planning and preparedness of the State in implementing power sector plans and policies, namely Himachal Pradesh Hydro Power Policy (2006) and Himachal Pradesh Solar Power Policy (2014).
- Analyse the State's future power demand–supply balance and interstate sales potential.
- Understand impact on power tariff and fiscal implications of the State's power sector plans and policies.
- Track potential revenue and fund generation for the State and aggregate monetary flows.

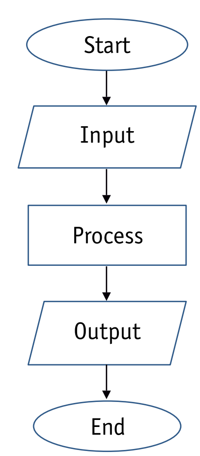
4.4.2 Methodology

The study considers a time horizon up to 2032, split into four plan periods: Thirteenth Plan period (2017–22), Fourteenth Plan period (2022–27), Fifteenth Plan period (2027–32), and Sixteenth Plan period (starting from 2032). It is believed that the aforesaid time span is sufficient to take into account Himachal Pradesh government's power sector plans and policies, namely, Himachal Pradesh Hydro Power Policy (2006) and Himachal Pradesh Solar Power Policy (2014), and examine their short to medium-term impact.

The projection exercise takes into account the past trend of the State's power supply and demand, current status of hydro and solar projects in the State (based on latest available information), the government's incumbent sector plans and policies, the State's existing and expected future power sourcing dynamics, tariff guidelines of the State and Central Electricity Regulatory Commissions, and relevant market data. Moreover, the State's economic and demographic trends over past decades are also analysed.

The projection exercise adopts a methodology having three separate but inter-connected parts (Figure 4.7). An analysis deals with projection of power capacity addition and corresponding investment requirements, resulting power supply pool and per unit power purchase cost. To project power demand in the State, the study employs logistical function that takes into account projected population in the State and per capita income (GDP per capita). A balance of power supply and in-house demand gives the value of inter-state sales.

However, the study is not limited to giving insights into power supply and demand dynamics of the State. It also aims to understand the possible fiscal implications of the government's power sector plans and policies. This is because if hydro power promotion is one of the central plank of the green growth and development strategy, then the fiscal implications of such a strategy needs to be realized.



General approach

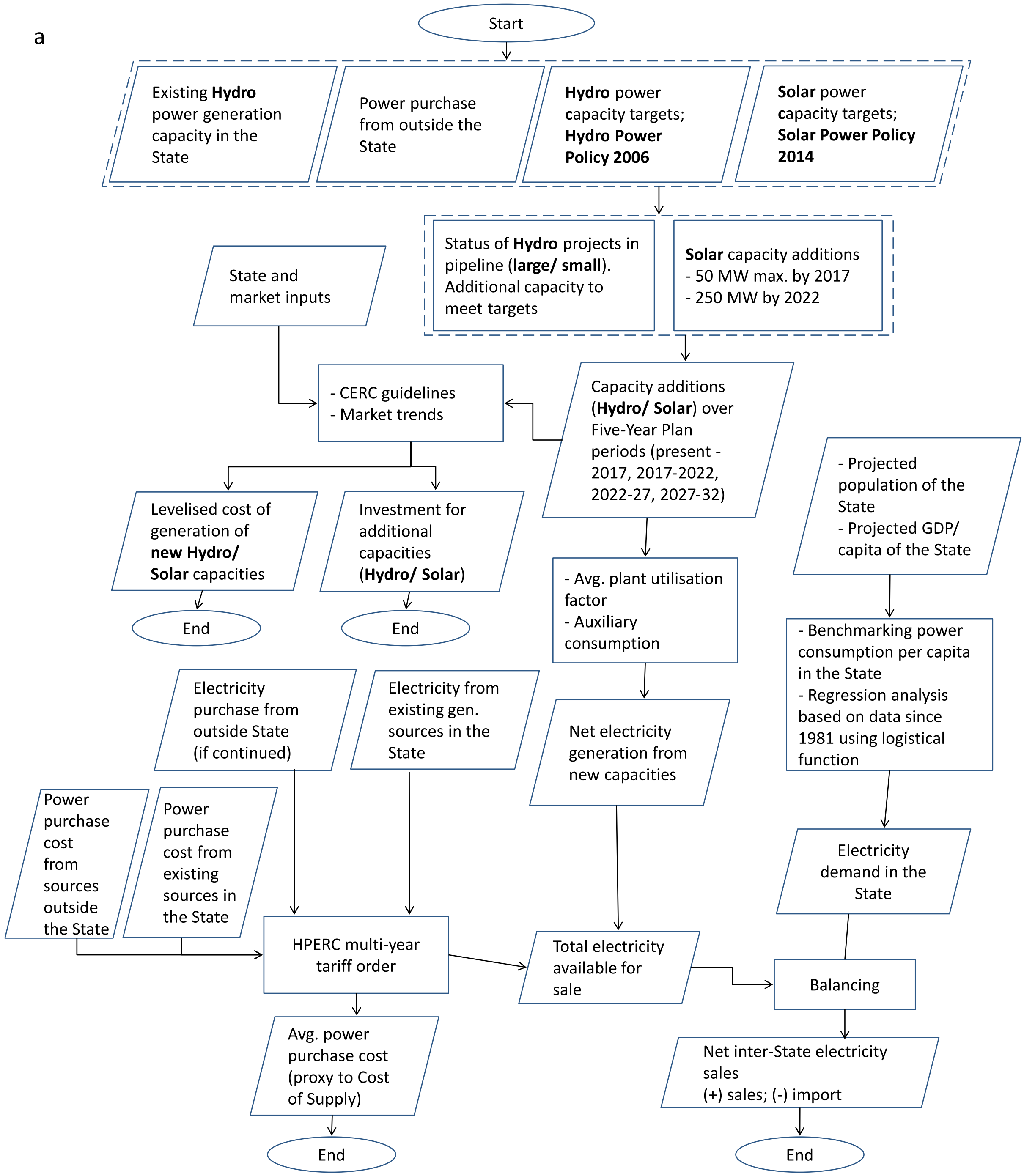


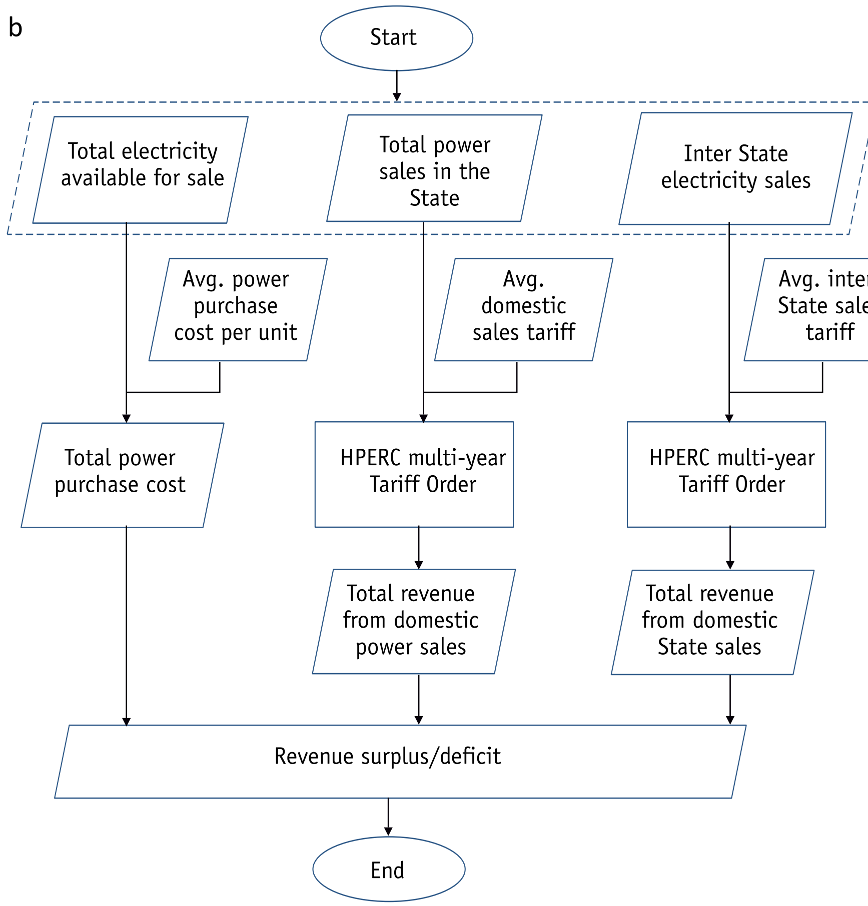
Figure 4.7: Schematic representation of the modelling projection methodology

4.5 Results and analysis

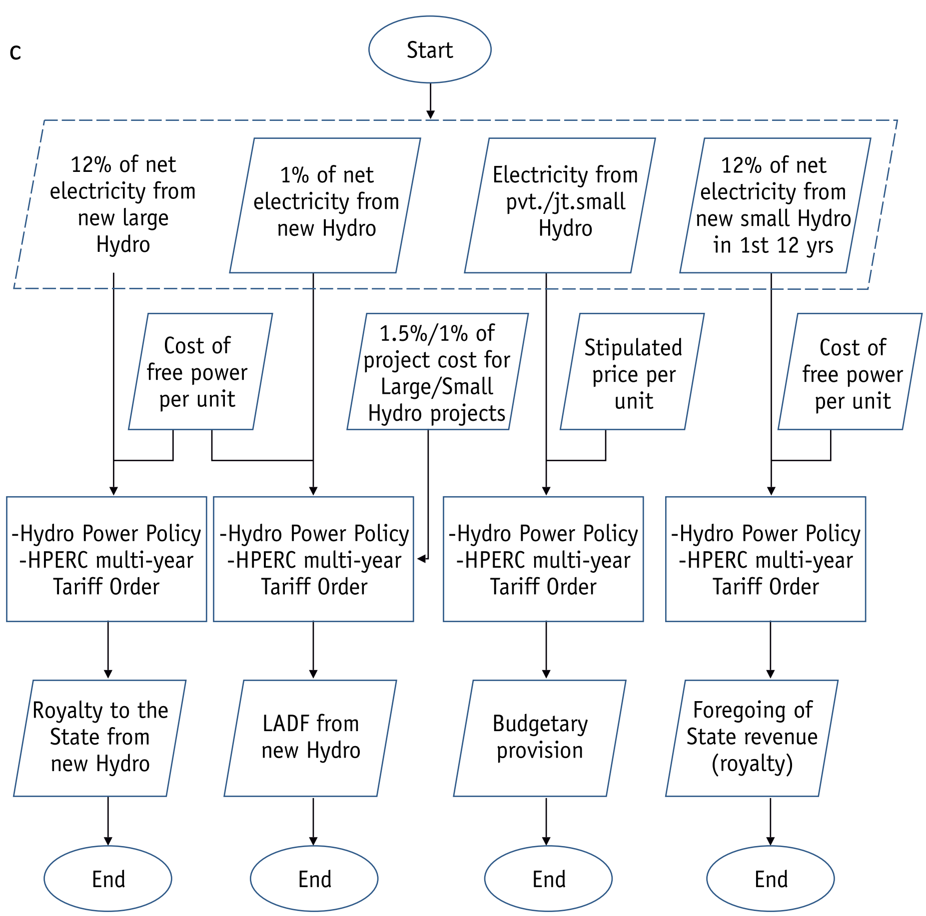
4.5.1 Power supply and sales (2017–22)

An analysis of HPERC's latest multi-year tariff-order envisages annual net electricity generation from existing hydro projects in the State to the tune of around 7,498 MU from 2017–18. This volume of electricity will be complemented by power purchase from sources outside the State. This includes power sharing arrangements of the State utility, HPSEB with central generating stations, and other states.

According to the multi-year tariff order, HPSEB is likely to draw around 1,900 MU from outside Himachal Pradesh. This includes long-term power purchase agreements and power banking. This apart, the domestic power output may be bolstered b


Start
Total electricity available for sale
Total power sales in the State
Inter State electricity sales
Avg. power purchase cost per unit
Avg. domestic sales tariff
Avg. inter-State sales tariff
Total power purchase cost
HPERC multi-year Tariff Order
HPERC multi-year Tariff Order
Total revenue from domestic power sales
Total revenue from domestic State sales
Revenue surplus/deficit
End

c


Start
12% of net electricity from new large Hydro
1% of net electricity from new Hydro
Electricity from pvt./jt.small Hydro
12% of net electricity from new small Hydro in 1st 12 yrs
Cost of free power per unit
1.5%/1% of project cost for Large/Small Hydro projects
Stipulated price per unit
Cost of free power per unit
-Hydro Power Policy -HPERC multi-year Tariff Order
-Hydro Power Policy -HPERC multi-year Tariff Order
-Hydro Power Policy -HPERC multi-year Tariff Order
-Hydro Power Policy -HPERC multi-year Tariff Order
Royalty to the State from new Hydro
LADF from new Hydro
Budgetary provision
Foregoing of State revenue (royalty)
End
End
End
End

by new hydro projects in the State. The study expects that small hydro projects under construction, with combined installed capacity of 153 MW may be commissioned by 2017–18.

Upon examining the commissioning schedules (expected) of new large hydro stations in the State, the study finds that another 3,128 MW is likely to come on line by the Twelfth Plan period. Thus, the hydro power sector can generate additional 12,803 MU annually during the Thirteenth Plan period (assuming a conservative 45 per cent plant utilization factor for new hydro power stations).

If Himachal Pradesh's Solar Power Policy is considered, then the State may witness addition of 50 MW solar PV capacity by 2017, which can generate 83 MU annually in an optimistic scenario (if 19 per cent capacity utilization factor (CUF) is achieved). This will increase the State's in-house yearly electricity generation to more than 17 thousand MU during the Thirteenth Plan period.

Taking into account the power drawn from outside the State, per annum electricity availability in Himachal Pradesh is estimated to be over 19 thousand MU during 2017–22 (transmission and distribution losses accounted). This is in surplus against a projected demand of 8,776 MU over the same period. Thus, the State may potentially achieve outside-State sales of more than 10,000 MU a year during 2017–22.

4.5.2 Power supply–demand dynamics (2017–2032)

Considering the plan of the Himachal Pradesh government to realize 23 GW of installed hydro power generation capacity (small and large hydro projects combined), one may see addition of more than 10,000 MW over the coming three Plan periods, that is, from 2017 to 2032. However, as on date, about 7,800 MW of hydro capacity is planned. The competent authority has to plan for capacity addition of another 2,400 MW in hydro power sector over the aforesaid period. Of this, about 1,200 MW has to be brought on line by 2022, in addition to the planned capacities comprising about 443 MW and 1,680 MW of small and large hydro projects, respectively. This is required to reach the government's target of harnessing 70 per cent of hydro power potential by 2020 (Department of Environment, Science & Technology 2012).

In the projection of power supply, generation from remaining 1,100 MW out of 2,400 MW of yet-to-be planned hydro capacity is considered evenly over the Fifteenth and Sixteenth Plan periods.

Private IPPs are going to play a major role in adding new hydro power capacities in Himachal Pradesh. Currently, private players account about 65 per cent of hydro power projects in the State; the share may go up to 88 per cent if the planned projects see the light of day. Figure 4.8 gives an overview of the projected hydro power development in Himachal Pradesh in a 23 GW hydro power scenario by 2032.

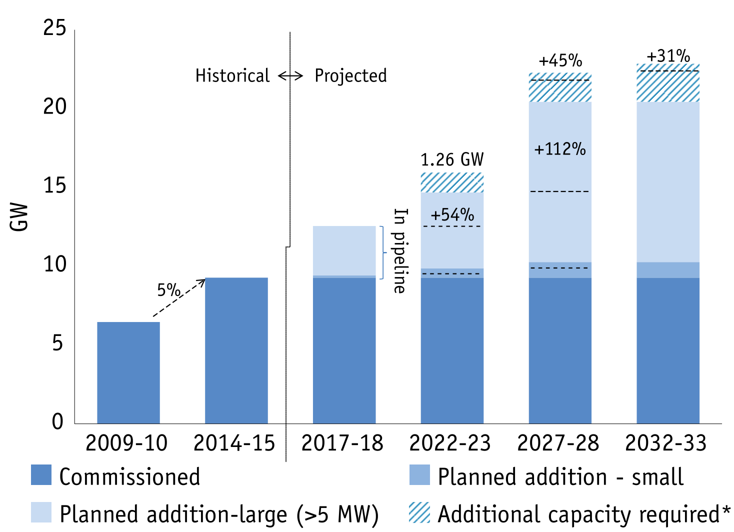


Figure 4.8: Projected hydro power capacity development in Himachal Pradesh (2017–32)
*This represents the yet-to-be planned hydro power capacity, necessary to achieve 23 GW of cumulative installed hydro power generation in Himachal Pradesh by 2032.
Source: TERI Analysis

On solar power front, the State Policy aims to add 250 MW during the Thirteenth Plan period, which will drive up the cumulative solar PV generation to 300 MW.

If the State realizes the capacity targets in the set timeline, the aggregate electricity generation in the State may reach 53,000 MU by 2032 at a CAGR of more than 11 per cent from the 2012 level. In terms of electricity demand, the State is expected to witness twofold rise by 2032 from the 2012 level (Figure 4.9); the total electricity demand is projected to be about 14,400 MU with average per capita electricity consumption around 1,800 units.

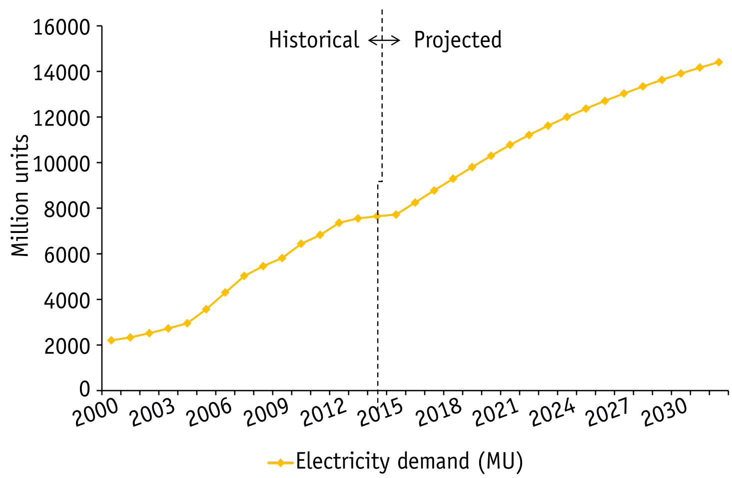


Figure 4.9: Electricity demand projection—Himachal Pradesh (2015–32)
Source: TERI Analysis

Thus, Himachal Pradesh is expected to improve its power surplus position in the coming years if it remains on track in adding power generation capacity. However, as hydro power generation shows considerable seasonal variation, peak generation during summer and trough in winter months, Himachal Pradesh may continue with its power sharing arrangement with outside State parties to maintain enough power availability in the State throughout the year. HPERC's multi-year tariff order for the period FY15 to FY19 is found to take into account about 1,900 MU of electricity annually from outside the State. Hence, this study considers two cases in projection: one case considers continuation of drawing about 1,900 MU yearly from outside[3] and in the other case, Himachal Pradesh is assumed to depend only on own generation (no power purchase from outside) post Thirteenth Plan period.[4] In a no outside State power purchase (from 2022) scenario, Himachal Pradesh may have potential to realize per annum inter-state sales to the tune of 18,000 MU in the Fourteenth Plan period (2022–27), which may reach 38,000 MU by 2032. Figure 4.10 gives an impression of the possible electricity supply and demand dynamics in the State till 2032 in a no outside State power purchase (from 2022) scenario.

4.5.3 Investment

Notwithstanding the estimated hydro and solar power potential in Himachal Pradesh and corresponding government plans, the State has to draw sufficient investment within the target period. Looking at the current hydro projects at different stages of development, a total of around 11 GW of hydro projects are in pipeline; however, investments for further 2,400 MW of hydro power are required. Similarly, the State has to realize considerable investments in solar power. This projection study envisages requirement of nearly ₹29,000 crores over Thirteenth to Fifteenth Plan periods (escalation in cost is accounted) in hydro power, 45 per cent of which has to be tapped in the Thirteenth Plan period. On the other hand, the required investments to implement State solar power plans are estimated to be more than ₹2,000 crores over Twelfth and Thirteenth

[3] In the multi-year tariff order, HPERC has suggested to continue with the bilateral power arrangements with the intention to reduce power purchase cost.

[4] This is in line with the policy decisions taken by HPERC with the intention to achieve 100 per cent green power in terms of consumption.

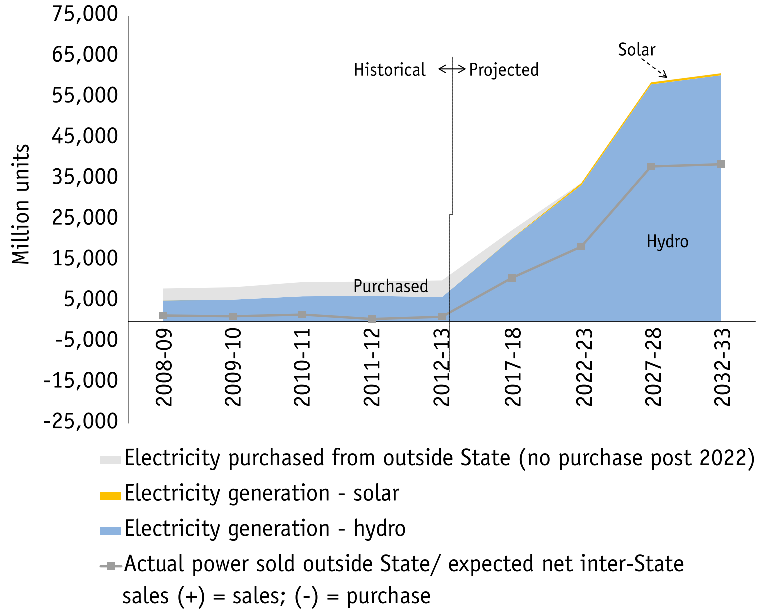


Figure 4.10: Projected electricity supply dynamics in Himachal Pradesh (2017–32)
Source: TERI Analysis

Plan periods. It is worthwhile to mention here that there will be additional investment requirements to expand/augment the grid infrastructure in the State to allow evacuation of the increased amount of electricity.

4.5.4 Cost of power

Another crucial aspect of the current investigation that needs to be flagged is the possible implication on power tariff in Himachal Pradesh. This especially holds significance as energy pricing in India involves political economy. This study attempts to find out the probable future changes in average per unit power purchase cost in the State, this considered being an acceptable proxy to cost of power supply which in turn guides consumer power tariff-setting. This is done by calculating the expected costs of power generation (per unit)/power purchase costs (per unit) of the possible power sources of HPSEB over the time period and subsequently estimating the weighted average cost based on the amount of electricity drawn from different power sources. Possible changes in power cost and power supply pool in the State are factored in hereby.

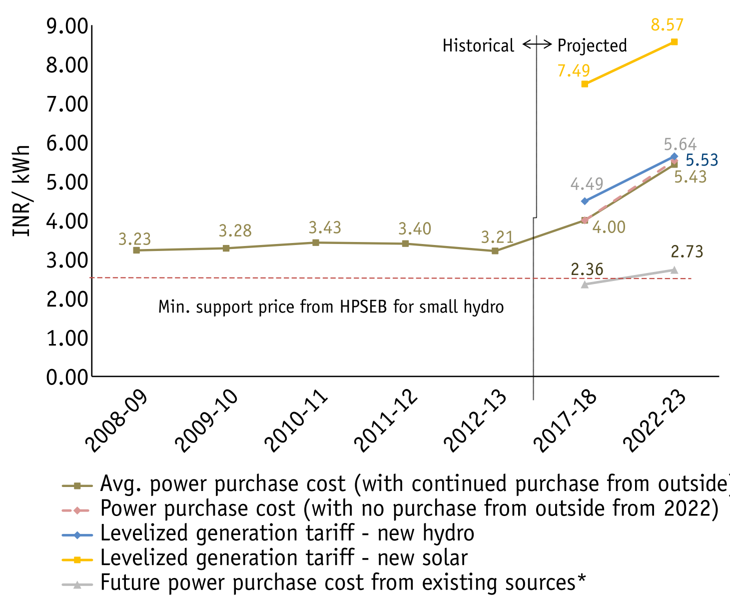


Figure 4.11: Projected power purchase cost in Himachal Pradesh (2017–22)
Source: TERI Analysis

The average power purchase cost is expected to increase by around 4 per cent annually till the Thirteenth Plan period compared to 2012 level (cost escalation accounted), largely because of greater share of new power plants, both hydro and solar, which will possibly have higher production tariffs (Figure 4.11). However, production tariff may come down if incentives such as accelerated depreciation benefit, renewable energy certificates, carbon credits, etc. become realizable. It is interesting to see that the average power purchase cost can be less if Himachal Pradesh continues purchasing power from outside beyond the Thirteenth Plan period at an average rate of ₹3.21 per unit. The assumption is that the current tariff guidelines continue.

4.5.5 Fiscal implications

Apart from investments, the success of Himachal Pradesh's power sector plans and policies hinges on their bearing on State fiscal health. As part of this assessment, the modelling exercise provides a time-series analysis of monetary flows on account of purchase of entire volume of electricity generated in the State and its sale in and outside the State (Figure 4.12). In order to estimate the revenue realizable from sale of power, the analysis takes into account average per unit revenue of ₹5.17 from sale of power in the State in 2015. This is as per HPERC's multi-year tariff order for the period FY15 to FY19. Likewise, the analytical exercise considers ₹4.45 per unit as the rate of power sale outside the State in 2017. A total of 3 per cent year-on-year escalation is considered on both the rates.

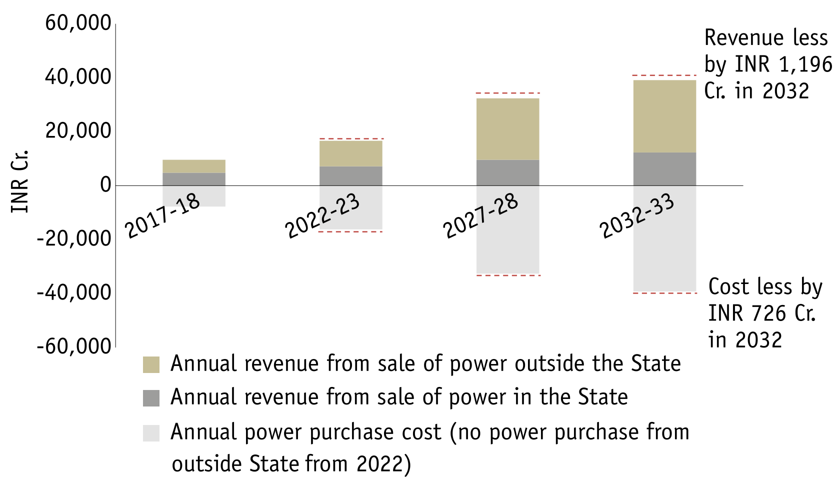


Figure 4.12: Projection of monetary flows from purchase and sale of power by Himachal Pradesh (2017–32)
Note: The dotted lines indicate the total power purchase cost or revenue from sale of power outside the State in a scenario wherein Himachal Pradesh continues purchasing power from outside beyond the Thirteenth Plan period (2022 onwards).
Source: TERI Analysis

The analysis finds that the total revenue from sale of power exceeds total power purchase cost throughout the period (2017–32) if Himachal Pradesh continues purchasing power (~1982 MU yearly) from outside at a rate of ₹3.21 per unit (this is as per the tariff guidelines). However, in a no power purchase from outside the State (from 2022) scenario, though Himachal Pradesh may save a part of the power purchase cost, a corresponding decrease in revenue is envisaged to outweigh the saving. Moreover, the study predicts a negative net monetary flow during Fifteenth and Sixteenth Plan periods in this scenario. This is considering the tariff structure in the State.

The State can realize additional revenue in the form of royalty (free power from large hydro to the tune of 12 per cent of electricity in first 12 years; cost of free power in 2014–18 is ₹2.87/ unit). Figure 4.13 shows the potential revenue from royalty. Concurrently, the State policy offers certain incentives to small hydro power projects, like waiving off royalty for a period of 12 years[5] and assuring minimum purchase price of electricity (₹2.50/ unit) generated by private or joint sector.

[5] Reckoned after 30 months from date of signing of Implementation Agreement

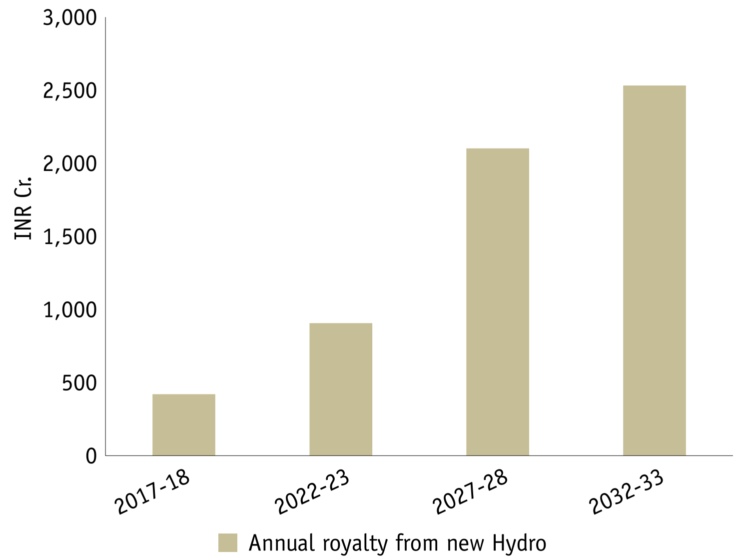


Figure 4.13: Projected fiscal impact as a result of new hydro power projects in Himachal Pradesh (2017–32)
Source: TERI Analysis

The State has also included a provision to create a corpus for compensation for the displaced population and for development of the local area, known as the LADF where 1.5 per cent and 1 per cent of project costs of large and small hydro projects, respectively, in addition to free power of 1 per cent electricity from all hydro projects is to be provided by the developer.

4.6 Environment, climate change, and hydropower

4.6.1 Ecological minimum flow

The results produced by this projection exercise indicate that hydro power development in Himachal Pradesh can generate revenue to the State. However, the sector is not insulated from uncertainties, especially bio-physical factors, like water-flow of river basins. A reduction in water-flow rate of a river basin may potentially decrease turbine water discharge, which can result in slump in power generation from a hydro project (Box 4.3).

Box 4.3: Relation between power output and discharge in a hydro project

P = output (kw)
Q = water-flow through turbine (discharge) (m^3/s)
H = net head of water (difference in water levels between upstream and downstream of turbine) (m)
η = station efficiency
μ = specific weight of water (N/m^3)

$$P = \frac{(\eta \times \mu \times Q \times H)}{1000}$$

A change in water-flow will have implications on existing as well as new hydro projects. In case of new hydro power project, the impact can be gauged while designing the power generation capacity of the station, whereas the effect can be understood from the CUF of an existing hydro power facility.

Apart from natural causes, a regulatory compliance requirement may impact performance of a hydro power project. A notification (No. MPP-F (1)-2/2005-V) by the Department of MPP & Power stipulates that a hydro power project in the State has to maintain minimum flow of 15 per cent water downstream of the diversion structure of the project at all times. A change in the percentage value is expected to affect the power output of a hydro project as per the aforesaid relation. This is keeping in mind the fragile ecology and environment and also to address issues concerning riparian rights downstream.

This projection exercise undertakes an impact assessment of minimum discharge on power output from existing and new hydro power projects. It is found that the power output from a hydro power facility may decrease or increase by 6 per cent if mandatory minimum discharge level is raised to 20 per cent or reduced to 10 per cent, respectively. Consequently, this will have economic implications. With change in electricity generation, the volume of royalty and LADF realizable by the State will vary. It is envisaged that if mandatory minimum discharge level is raised to 20 per cent, electricity generation from existing hydro power capacities may drop by about 2200 MU annually. Thus, the State may lose ₹1,869 crores from royalty over the next four Plan periods.

In case of upcoming hydro power projects, the regulation will have similar bearing; the realised hydro power capacity may drop by 814 MW. It is envisaged that the State may see loss of opportunity to the tune of ₹1,789 crores and ₹167 crores in royalty and LADF, respectively, over the next four Plan periods if mandatory minimum discharge level becomes 20 per cent. The State can realize additional financial resource of similar amounts in case the required discharge level decreases to 10 per cent. Figure 4.14 depicts the losses in cumulative electricity generation from hydro projects (existing and new) and corresponding financial loss to the State over the coming four Plan periods due to increase in mandatory minimum discharge level to 20 per cent. This number however does not account for ecosystem services lost or generated upstream and downstream.

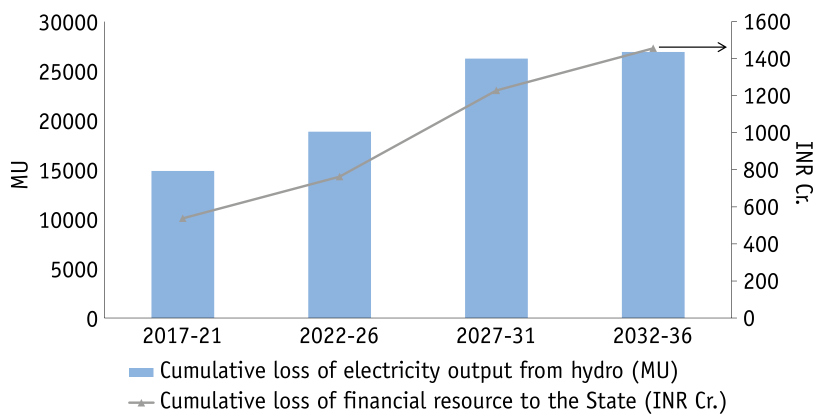


Figure 4.14: Probable loss in electricity generation from hydro projects and corresponding economic cost with increase in minimum discharge level to 20 per cent

Source: TERI Analysis

4.6.2 Climate change and hydropower

Though seasonal or occasional year-on-year changes in water flow rate of rivers are normal, a long-term change in water flow rate across the river basins in Himachal Pradesh may have deeper implications on this hydro-powered State. Climate change is an important factor that can cause long-term changes in water flow of the river basins in the State. An investigation into the possible consequences of climate change on the precipitation, it is observed that precipitation is likely to vary from –8 per cent to 12 per cent over different regions of Himachal Pradesh. It is also seen that 15–40 per cent of total rainfall will be concentrated within short durations. This is also discussed in the climate modelling report.

As a result of climate variability, the average flow rate observed in the base period (2.98–3.92 m^3/sec) will be increased to 3.06–4.71 m^3/sec in the near future (2030s). The range of discharge is widened and as a result the duration of high flow will be reduced. The flow of the river changes over different regimes of the river. Flow rate also varies for different rivers within a basin.

Currently, for Parbati River in Beas sub-basin, the water flow rate is 3.27 m^3/sec. For Larji River in Beas sub-basin, water flow rate is 5.0 m^3/sec. For Rongtong River in Sutlej sub-basin, water flow rate is 3.54 m^3/sec. It will be worthwhile to further explore these results in the light of river regime-wise topography, contribution of surface and surface and snow melt run-off, and local withdrawals for domestic and industrial water-use. This has further implications for forest lands, land-use, local livelihoods, and environmental parameters. Hydro-power infrastructure management needs to consider increased silt transport due to surface-runoff and soil erosion. This is further discussed in the SWAT modelling component of the project.

4.7 Precautionary note

LADF with its two components (one-time contribution as part of the project cost and recurrent fund generation out of sale of free power) may amount to ₹84.2–131.2 crores per GW (current price) of hydro power in the State. The range is due to variation between small and large hydropower.

An assumption of ₹10 lakhs per hectare of forest land is taken between for forest land (Chopra and Dasgupta 2008). This valuation measure is higher than the compensatory afforestation payment of ₹50,000 per hectare paid for conversion of land. Based on project DPR documents, on a conservative basis, for 0.02 GW of extra capacity addition, 4.5 hectares of forest land diversion is considered. This essentially translates to 225 hectares of forest land diversion for 1 GW of capacity addition. This translates to ₹23 crores for every 1 GW of capacity addition

Further, income of the State from forestry- and biodiversity-related tourism and related services has been estimated using simultaneous equation system. It included historical data of the earning from the tourism sector, which was weighted by ecosystem services provided from forest cover to arrive at historical income of the State from forestry- and biodiversity-related tourism and related services (Das and Chopra 2012).

Based on project DPR documents, on a conservative basis, a conversion factor of 0.83 units of forest ecology saved per unit of GW is arrived at. Income from the tourism sector arising due to forestry and biodiversity was predicted taking the historical data and a time series econometric model. Econometric model comprised of interrelationship between electricity generation, hydro power capacity addition, and value added from the sectors. Using this set of econometric relationship predictions of future income from tourism sector owing to forestry and biodiversity has been estimated. Loss to forest land as a result of per unit addition of hydro-power and its impact on the future income from the tourism and forestry sector has been predicted using this econometric relationship. This income estimate came to be as ₹100 crores for every 1 GW of hydro capacity addition.

Combining the two valuations the loss from forestry sector and tourism sector for every 1 GW hydro capacity addition is estimated to be ₹123 crores (₹100 crores from the tourism and tourism service–related sector, ₹23 crores from the forestry sector). This valuation does not include aspects relating to riparian rights such as drinking water, health, and downstream livelihoods. This valuation also does not consider monetary valuation of biodiversity as the principle of incommensurability, used in ecological economics, applies. The National Environment Policy of 2006 also talks of entities with "incomparable value" that may be applicable to aspects involving biodiversity and rare species.

Even so, it is worthwhile for the State to consider the various trade-offs (monetary and non-monetary) involving hydro-power, forests, tourism sector, livelihoods, and biodiversity.

4.8 References

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5

Socio-Economic Issues and Perceptions around Hydropower Development in Himachal Pradesh: A Case Study Approach

5.1 Context

Hydropower is considered as a preferred source of clean energy and since water is replenished by the earth's hydrological cycle, it is considered as a renewable source of energy. However, the influential 2000 report of the World Commission on Dams concluded that while dams can bring "substantial benefits", the record of dam building is one of "pervasive and systematic failure to assess the range of potential negative impacts" including the impact on "downstream livelihoods". This has resulted in the "impoverishment and suffering of millions, giving rise to growing opposition to dams by affected communities worldwide" (World Commission on Dams 2000).

The hydropower potential of India is around 145,000 MW and at 60 per cent load factor, it can meet the demand of around 85,000 MW. So far, 26 per cent of the available potential has been utilized (Ministry of Power, Government of India). The share of hydropower in the energy mix of the country has faced a steady decline in the past decade, with the share of hydropower declining from 25.01 per cent at the end of the Ninth Plan period (March 30, 2003) to 15.50 per cent by the Mid-Twelfth Plan period (as on April 30, 2015). In the corresponding period, the share of coal in the energy mix has increased from 59.15 per cent at the of the Ninth Plan period to 61.52 per cent by the Mid-Twelfth Plan period.

Himachal Pradesh has the potential of generating 27,436 MW (about 24,000 MW harness able) of power of the total hydro-power potential of 148,701 MW in the country. This corresponds to a potential contribution of 15.5 per cent to the overall potential contribution of 80.3 per cent of the hydropower sector to the overall energy contribution in the country (Kumar and Katoch 2014). The State has a hydropower policy; key features of the State hydropower policy are listed in Annexure 5.1.

Among the many features of the comprehensive 2006 Hydropower Policy of Himachal Pradesh is the provision for disbursement of 1.5 per cent of the total project cost of the project by the developer for projects beyond 5 MW towards local area development fund (LADF) for activities relating to agriculture, horticulture, animal husbandry, fisheries, forest, and others. The norms regarding management of LADF have been formulated by the Government of Himachal Pradesh. An overview can be seen in Annexure 5.2.

The purpose of this study is to examine the socio-economic issues involved in implementation of hydroelectric projects (HEPs) in the State. Such an understanding would help us in understanding the concerns of the local people with respect to such projects. This understanding should assist policy makers in improving their procedures with respect to project planning and implementation of HEP, which could potentially minimize the negative externalities of such projects and also possibly improve the perceptions of the local people of the government being 'sensitive' to their concerns.

5.2 Approach

To achieve the objective, a qualitative field research was undertaken by TERI researchers to four hydro-electric plants (HEPs) in the State in consultation with the Directorate of Energy, Government of Himachal Pradesh. The research included focused group discussions (FGDs) along with key person interviews (KPIs) using a semi-structured questionnaire to interview hydro developers, villagers, and relevant government officials at State, district, and village level. Stakeholders consulted are shown in Figure 5.1.

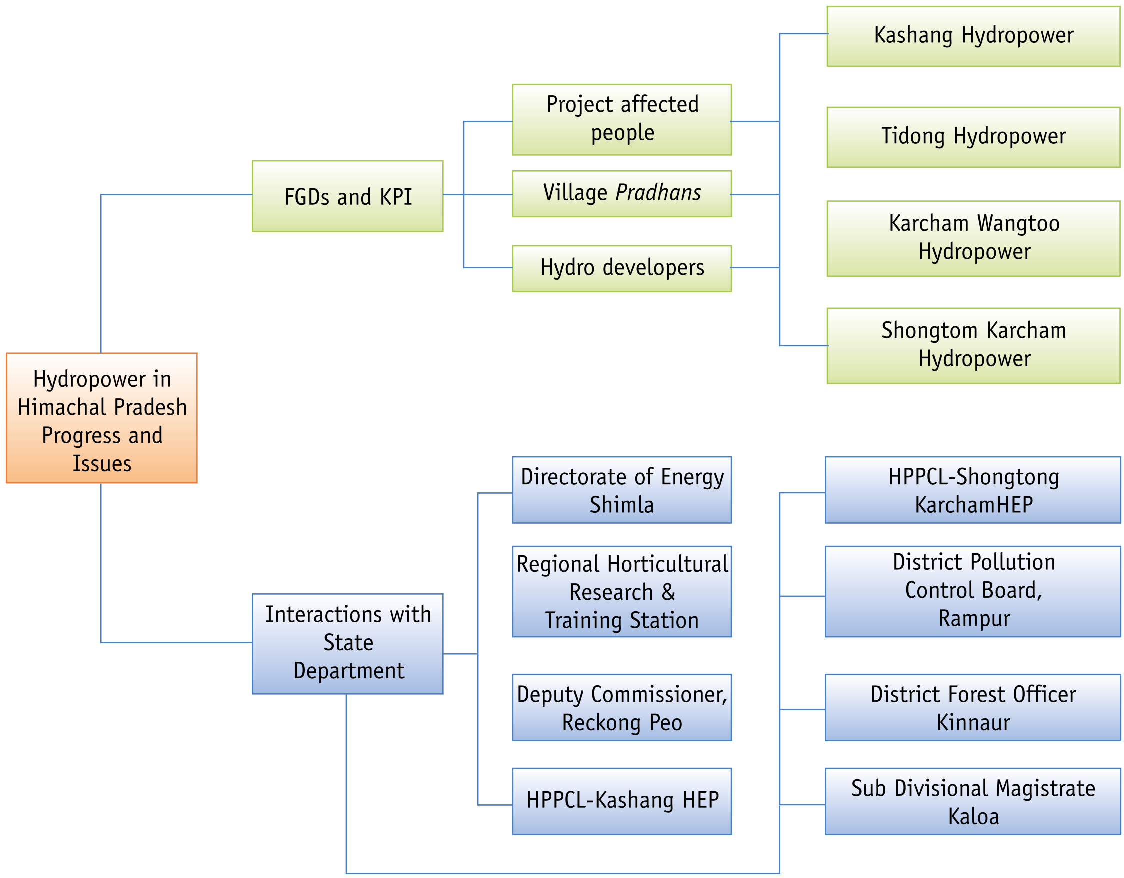

Figure 5.1: Stakeholders consulted during the study

The discussions allowed the team to gauge the outlook of the community as a whole towards hydro power in the State as also, helped temper some of the extreme sentiments towards some issues in the area. Moreover, it also helped corroborate and correct the facts, views and opinions expressed by the developer as well as the village heads. Documents and secondary information relevant to the selected hydropower projects for the study were collected from the respective government departments and hydropower developers and analysed as per the scope of the study.

In relation to the study, the first field visit to Kinnaur district commenced in October 2014 and included the assessment of the perception of the villagers located upstream and downstream of Kashang (Integrated) HEP and Tidong-I HEP. A brief visit was made in December 2014 to undertake discussions with State officials as well as to establish contact with the hydro developers. The second leg of the field visit was undertaken in June 2015 for Karcham–Wangtoo HEP and Shongtong–Karcham HEP. The villages and HEP sites are depicted in Figure 5.2.

Four case studies, one for each HEP, have been developed based on the interaction with the stakeholders. This is supported by two tables highlighting the major issues as perceived by the villagers and the project developers (Annexure 5.3 and Annexure 5.4).

Some of the perceived key issues relate to LADF, employment in HEP areas, compensation, impact of blasting and tunnelling, compensation, and environmental degradation. These case studies aim to analyse these issues, overlooking biases that may have cropped up during conversations. Moreover, one must also remember that the genesis of many of these issues cannot be solely blamed on just one party. The team hopes that by the end of the case study, the controversies surrounding these issues would be a little clearer than earlier.

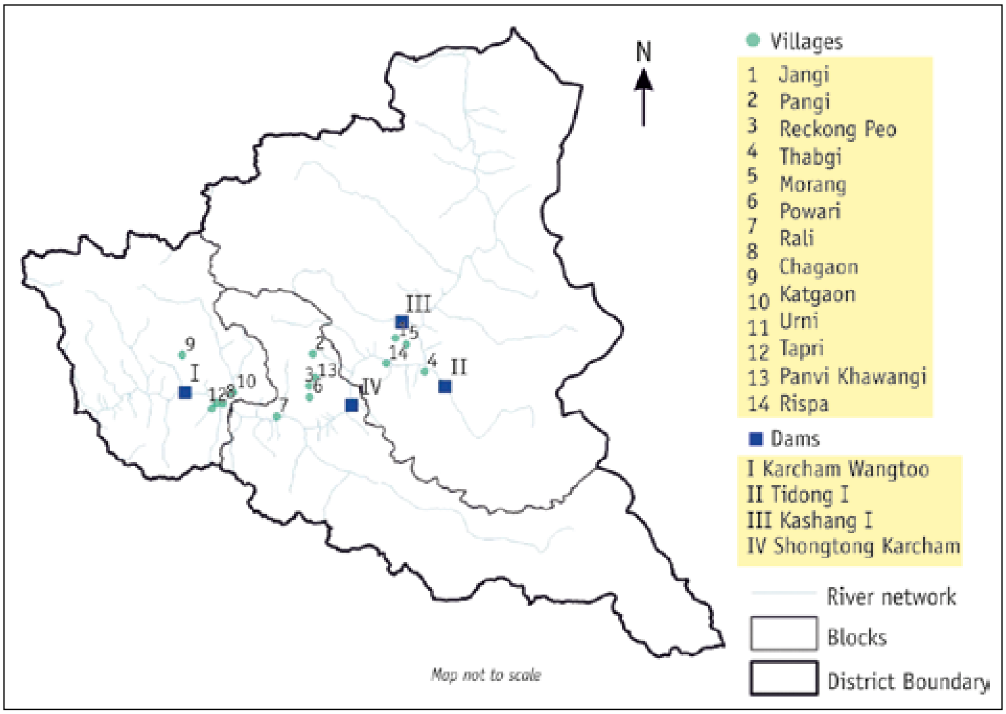

Figure 5.2: Villages and HEPs covered in the study

5.3 Case Studies

5.3.1 Case Study-1: Tidong-I hydroelectric project

Introduction

The proposed 100 MW Tidong-I hydroelectric run of the river project is situated along the tributary of the Satluj in Kinnaur on the Tidong Khad. Tidong is primarily a snow-fed stream that also receives inflow from rainfall and snowfall. The total catchment area at the proposed barrage is about 571 km^2 while the catchment area at diversion is 497.86 km^2. The power house for the project would be located at Rispa village with the project site located along the National Highway 22 at Moorang and thereafter 13 Km up to Thangi village. The total land requirement of the project is 42.2557 hectares out of which 3.2011 hectares of private land was diverted with the remaining being forest land. The hydro developer has paid the total requisite amount of ₹7.2 crores towards catchment area treatment (CAT) plan implementation and ₹2.7 crores towards net present value (NPV). An amount of ₹45 lakhs has been deposited by the developer towards the cost of reclamation plan for dumping sites while ₹1.68 crores has been realized as cost of trees from the developer. Discussions undertaken by the team brought out a couple of key issues that were highlighted by the relevant stakeholders. Some of the key issues are highlighted below.

DEVELOPER: M/S NSL RENEWABLE POWER PRIVATE LIMITED
TOTAL INSTALLED CAPACTY: 100 MW (AS PER DEVELOPER)
TOTAL DISPLACED: 28 PERSONS
AFFECTED PANCHAYATS: 4
LADA FUND APPROVED: 8.02 CR INR

Rehabilitation and resettlement

The 28 families whose private land was purchased for the project did not get physically displaced but had to give up their agricultural land, which comprised of both irrigated/orchard and non-irrigated/un-cultivable waste land. Further, four kutcha structures and 173 fruit bearing trees in addition to land belonging to a temple was also affected due to land acquisition.

The hydro developers deposited ₹2.582 crores with the Deputy Commissioner of Kinnaur, which was subsequently disbursed among the land owners. The compensation for the private land acquired and other structures have been made as per the Land Acquisition Act 1894, which includes payment of statutory interests but all the families are dissatisfied with the compensation received and have filed a petition in the courts.

According to the interim report of the Expert Committee constituted by Hon'ble National Green Tribunal vide their Orders dated July 07, 2015, it was indicated that no land owner diverted 70 per cent of their total land holding to the hydro power company who by definition are treated as fully affected family/person for compensation package. It was further informed by the project proponent that 29 families belonging to the villages Roowang (21 nos), Lizang (3 nos.), and Lambar (5 nos.) were affected with the land loss of these families ranging between 0.9–32.2 per cent.

In addition to the payments made towards the LADF, Rehabilitation and Resettlement (R&R) provisions, and Environment Management Plan (EMP), the developer has deposited amounts of ₹2 crores each to gram panchayats (GPs) of Rispa and Thangi and ₹1 crore to Rispa and Thangi of Moorang for which No objection certificates (NOCs) were obtained from the GP subject to certain commitments. Apart from employment, other commitments include provision of water in the event of any source drying up on account of project activities, street light installations, crop compensation for loss (if any), pollution and dust abatement, etc. The total amount received under the NOC was utilized for construction of toilets and sanitation facilities as indicated by the three GPs.

Local area development authority

Equal annual instalments will be expedited by the hydro developer to the respective deputy commissioner with effect from the date of financial closure for the entire duration of the project construction. Of the total amount of ₹8.02 crores to be contributed to Local Area Development Authority (LADA), 80 per cent of the amount has been contributed as on March 2014. The amount sanctioned for development works was ₹1.98 crores, of which ₹1.04 crores have been utilized/disbursed till the end of March 2014. The development works have been sanctioned according to the plan and have been undertaken in consonance with consultations with the gram pradhans. The hydropower company has also disbursed ₹17.78 crores during the pre-construction stage under the CAT) plan. The three GPs, where the interactions took place, indicated that the received LADA fund has been utilized for development works for project-affected families. As per the interim report of the Expert Committee constituted by Hon'ble National Green Tribunal vide their Orders dated July 7, 2015, the developer has spent ₹14.6 crores for community development through LADA and CSR initiative.

Employment

NOCs were obtained from the GP subject to certain commitments including relating to employment. This includes employment provisions to project-affected people (PAP) depending upon qualifications and vacancies for which 46 persons from the 3 project-affected panchayats have been recruited. Priority is accorded for contract works to the project-affected villages of which 42 numbers of contracts have already been awarded, which are worth ₹26 crores to date. The villages affected by the Tidong-I project and those who are going to be affected once the project gets commissioned have expressed an unfavourable perception as they do not foresee any concrete benefits in terms of enhanced infrastructure or employment opportunities in spite of promises made by the developer.

Tunnelling and blasting activity

Villagers felt the impact of tunnelling and blasting activities taking place through the mountains. There is also mass dumping of debris that has largely polluted the river and caused air and water pollution. Villagers in both upstream and downstream regions felt that tunnel digging and blasting have caused cracks in the houses, terraced farms, and apple orchards. Villagers felt that blasting activities and other underground civil works caused vibrations resulting in cracks in houses near these components.

It was perceived that air pollution is due to the dust, muck, and poisonous gases from the excavated material during the tunnelling and blasting processes. The company had also undertaken some modifications in the project layout in regard to alignment of headrace tunnel (HRT) and access road so as to accommodate the environmental and social concerns of the villagers of Rispa and Moorang.

An approximate estimation of 6.4 lakh cubic meters of muck is estimated to be generated from the project construction, of which 45 per cent of the muck shall be used for backfill and other construction work while the remaining muck shall be disposed at pre-identified disposal sites. These sites need to be designed in such a manner that it does not clog the natural drainage system or cause any other environmental hazards. Each family member in Rispa village was on average given ₹28,000 for construction/improvement of the houses.

Other aspects

Destruction of chilgoza (pine nut) trees

During the discussions with the villagers, they felt that the developer had not put forward a correct estimate of the number of trees to be affected. The detailed project report (DPR) of Tidong-I estimated a loss of around 13,916 trees in the area whereas sanction was taken only for 1,261 trees. The villagers indicated that more than 5,000 trees were destroyed during the construction and laying down of approach roads for the HRT of which over 60 per cent were the chilgoza pine trees. The compensation for destruction of chilgoza trees due to road construction was to be awarded by the hydropower company retrospectively from the year 2009 but the villagers have termed the compensation amount inadequate and the issue is yet to be settled in court. As per discussions with the panchayat, 80 per cent of the chilgoza trees have been destroyed due to blasting and debris dumping as a result of the HEP. The destruction of chilgoza trees has also reduced fodder for cattle and loss of revenue from sale of chilgoza. The villagers in Thangi, located upstream of the project, indicated that they used to fetch ₹8–10 lakhs on a yearly basis from the common chilgoza forests but have lost it all due to the destruction of the chilgoza trees by the hydro developer. The hydro developer is in the process of compensating the loss of Chilgoza crop to the villages having forest rights and has agreed to pay the villagers annually the existing market price for the next 40 years on NPV calculation, which comes to ₹840 per kg.

Destruction of apple crops

The project is yet to be commissioned but downstream impacts emanating from construction activity such as increase in dust generation is widely visible, which has destroyed the chilling factor required for apple growth and also affected apple colour and size. With apple being a major cash crop, people in both the upstream and downstream villages have expressed anguish against the project due to the decrease in yield as a result of increased air pollution, which has reduced precipitation and causing lack of moisture in the soil. The grazing area has also seen a reduction due to such activities, which was indicated by the villagers.

5.3.2 Case Study-2: Shongtong–Karcham hydroelectric project

Introduction

DEVELOPER: HIMACHAL PRADESH POWER CORPORATION LIMITED
TOTAL INSTALLED CAPACTY: 450 MW (AS PER DEVELOPER)
TOTAL DISPLACED: NO PHYSICAL DISPLACEMENT
AFFECTED PANCHAYATS: 4 (2 MORE TO BE ADDED)
LADA FUND APPROVED: 42.11 CR INR

The proposed Shongtong–Karcham HEP is being developed by the Himachal Pradesh Power Corporation Limited (HPPCL) on river Satluj in district Kinnaur of Himachal Pradesh. The diversion barrage site of the project will be located near the village Powari and the powerhouse will be located near the village Ralli. The project will have an installed capacity of 450 MW (3 × 150 MW). Catchment area considered for treatment under the project is 33,573 ha. Pending issues, including clearance, disagreement between developers and villagers over developmental works, had stalled the progress of the project for more than a year before the work resumed in 2014. HPPCL officials now are of the opinion that commissioning of the project will certainly get delayed than its expected commissioning date in September 2017. According to the data obtained from the HPPCL officials, four GPs viz. *Mebar (Ralli), Powari, Khawangi*, and *Barang* are so far declared as project-affected areas (PAA). Two more GPs, namely *Shudharang* and *Kalpa* are to be declared under PAA.

There are 120 main project-affected families (MPAFs), 144 affected title holders, and total 803 project-affected families in the four GPs. The status of land already acquired and land to be acquired is given in Table 5.1.

Table 5.1: Status of affected people and land acquisition

S. No.	Name of GP	Main Project Affected Family	No. of affected title holders	No. of Project Affected Families	Name of Up Mohal	Land Acquired (ha)		Forest Land (ha)	
						Pvt.	Forest	To be acquired	To be surrendered
1	Mebar	14	19	71	Ralli	1.2687	17.6927	0	0.6922
2	Powari	80	93	224	Powari	2.4273	18.8084	0.6459	0
					Tangling	3.2798	0.9544	4.4565	0
3	Khawangi	18	23	180	Khawangi	0.4016	15.6479	0	0
4	Barang	8	9	328	Usaring	NA	4.6553	0.296	0
5	Jangi	NA	NA	NA	Jangi	NA	1.85	0	1.85
6	Shudharang	NA	NA	NA	Rang©	0.546*	0.8928 NA	3.3421	0
					Yuvrangi	0.0472*		NA	
	Total	**120**	**144**	**803**	**Total**	**71.4721**		Net forest land to be acquired for surface activities = 6.1983 ha	

Source: Project Management Review Documents
Note: Shudharang and Kalpa panchayats are yet to be declared under PAA.
*Acquired for colony.

The TERI team conducted field visits to three affected villages, viz. Khawangi, Powari, and Ralli, to understand the viewpoint of the community vis-à-vis the project and the associated activities. The team also interacted with HPPCL officials involved in the project to understand their outlook. The process of interacting with the stakeholders involved KPIs and FGDs. This case study discusses the major issues that have cropped up so far during the construction of the Shongtong–Karcham hydroelectric project and the viewpoints of stakeholders regarding those issues. Following is an account of the issues observed at the project site.

Rehabilitation and resettlement

HPPCL has entered into separate agreements with the four GPs (Mebar, Powari, Khawangi, and Barang) promising to carry out more developmental activities in these panchayats. While the agreements have been made and the enlisted activities are already under operation, HPPCL believes such negotiations delay the primary task of project construction and create wrong precedence for other projects.

HPPCL officials also clarified that there has been no physical displacement from the PAA and the villagers have been duly compensated with ₹1.05 lakh per biswa for the land acquired from them. They were of the view that this rate was agreed upon by the villagers and the GP and was much more than what the actual land rates would have been when the agreement was made.

Local Area Development Authority

In case of Shongtong–Karcham, HPPCL has sanctioned ₹42.11 crores for LADA funding and have so far deposited ₹21.06 crores. HPPCL has also paid 500 days equivalent minimum wages in lieu of loss of forest rights of the villagers to the PAP, which amounted to ₹1.06 lakhs per land owner whose land was acquired. Officials at HPPCL mentioned that they have deposited ₹60.44 crores towards CAT plan, ₹5.69 crores as NPV, ₹1.74 crores towards Compensatory Afforestation Fund Management and Planning Authority fund, ₹1.4 crores for regeneration of equivalent forest land, and ₹86 lakh as the cost of trees. They have also promised to provide 100 units of free electricity per month to villagers from the date of commissioning of the project.

Villagers, however, indicated that they were dissatisfied with the compensation money they had received for the land lost. Villagers who had to give up their land had received ₹1.05 lakhs per biswa (1 biswa = 0.01 acre approx.) irrespective of the quality of land and felt that the amount was lesser than the market rate of ₹1.95 lakhs.

Employment

Villagers had concerns regarding the provision of employment to the affected families. Project developer has to provide employment to one member of each of the displaced families or adversely affected as a result of the acquisition of land for the project during construction of the project. However, there were many villagers who were willing to work but were not recruited. From the data we obtained from HPPCL, only 66 people have been employed from the 4 GPs declared as PAA while the number of MPAF itself is 120 in those places (see Table 1). On the issue of employment, HPPCL clarified that they had been recruiting as and when the need arises. They have also made provisions to fund those PAP who are willing to join Industrial Training Institutes (ITIs) and get trained on technical aspects, which might help them acquire necessary vocational skills for better employment prospects. However, for skilled work, most of the villagers still do not meet the desired qualifications and therefore employment is to be given to other eligible candidates outside the PAA (first preference to Himachalis and then non-Himachalis).

Tunnelling and blasting activity

Villagers also complained about the noise and vibration emanating from the blasting work carried out by the project proponent. They indicated that stated timings for blasting activity are not being followed and blasting done at night causes them discomfort, waking them up from their sleep every night. HPPCL, however, discredited their claim and stated that to monitor noise and vibrations emanating from the blasting, it has installed five seismographs in five different GPs (including the PAP), which also gather the time of the blasting. The monthly report of seismic activity generated is shared with the local administration and the villagers. HPPCL is also carrying out videography of the affected panchayats to create a baseline for the construction phase. This can be checked in future to settle any claims from villagers stemming due to damaging effects of tunnelling/blasting activity.

Other aspects

Other common issues in hydroelectric projects pertain to environmental degradation. HPPCL has taken measures to reduce dust generated from project activities and transportation by spraying water regularly on the roads being used for construction activity. They have erected wired boulder crate walls along the slopes at the sites suggested for muck dumping, which has also minimized dust generation.

Case Study-3: Karcham–Wangtoo hydroelectric project

Introduction

The Karcham–Wangtoo hydroelectric power (KWHEP) is a 1,200 MW run-of-the-river plant on the Satluj basin in the Kinnaur district of Himachal Pradesh owned by Jaypee Group. While the dam (98 m) is located near the Karcham village, the power station is located near the Wangtoo village. This plant was first commissioned in 2011 and has a catchment area of 49,000 km^2. As per the memorandum of understanding, signed between the Himachal Pradesh State government and the hydro developer, the panchayats that are affected by this

DEVELOPER:
JAYPEE GROUP
TOTAL INSTALLED CAPACTY: 1200 MW
(AS PER DEVELOPER)
PROJECT COST: RS. 6903 CR
TOTAL DISPLACED: 51 PERSONS
AFFECTED PANCHAYATS: 19
LADA FUND APPROVED: RS. 103 CR

project include *Nichar, Ramni, Panvi, Yangpa, Kafnoo, Katgaon, Yulla, Urni, Meeru, Chagaon, Mebar, Sapni, Shong, Roghi, Punang, Kilba, Brua, Chansu*, and *Kamroo*.

Of the four HEPs under consideration for case studies, this particular HEP was the only one commissioned and thus this study aims to analyse the upstream and downstream aspects of the Karcham–Wangtoo HEP. For this purpose, the team conducted meetings with a number of stakeholders in the region including the developers (Jaypee Group); local government officials; as well as Focus Group Discussions (FGDs) with the *gram sabha* heads and the villagers in Chagaon, Katgaon, Urni, Panvi, and Tapri villages. Issues that emerged from the discussion are discussed.

Rehabilitation and resettlement

Compensation for land also was another issue highlighted by the Project Affected Persons (PAPs). The villagers were dissatisfied with the compensation amount because they believed that it was way below the premium that is offered on circle rates. This perception stemmed from the fact that land losers at Rekong Peo were paid ₹104,000 per *biswa* and thus the circle rate of the entire *tehsil* was such. However, in our conversation with the stakeholder at Shongtong–Karcham, we were told that the compensation paid by developer was not decided based on circle rates and was based on an ad-hoc decision by the developer taking into account future appreciation and livelihood impacts. Hence, they believed that the rates offered in 2000, which ranged between ₹5,000–6,000 per *biswa* was much less. However this issue of compensation holds to be untrue since circle rates for 2015–16 for the *Nichar tehsil* continue to range between ₹150–3,900 per bigha (1 *bigha* = 20 *biswa*) (GoHP 2015), from which we can infer that rates in 2000–01 would either have been similar or less than present rates.

In the case of compensation under the FRA, it was reported that only Panvi village did not receive the FRA settlement. The liasoning officer stated that ₹75,000 per family against FRA was paid to the villagers.

Local Area Development Authority

The MoU for the Karcham–Wangtoo HEP was signed in 1993 before the provisions of the State or the central hydroelectric policy were in place. Therefore, monetary provisions were put in place on the basis of the EMP which details the compensation mechanism to be put in place in the Environment Impact Assessment (EIA). However, considering that the system of EIA and EMP approval themselves are inadequate; the monetary provisions detailed for this particular project were insufficient to begin with. Despite local opposition to the project, it was given a go-ahead and an amount of ₹2 crores was paid by the developer to the Kafnoo, Katgaon, and Yangpa panchayats for their consent for the HEP. In 2006, the State government initiated the Himachal Pradesh Hydropower Policy that stated that 1.5 per cent of the project cost must be paid in the form of monetary compensation to the PAAs for the development of the local community. This money will be held by LADA, and village development works by the panchayats must be approved by the LADA committees before sanction of the funds. The LADA committee constitutes district-level authorities, members of the local panchayats, etc. The formulation of this policy led to retrospective clauses for the Karcham–Wangtoo project related to LADA, which have led to a number of complications.

First among them is the determination of the exact cost of the project. During construction, the developer increased the capacity of the pressure shaft, which led to an increase in the load factor, thus leading to a total installed capacity of 1,200 MW instead of the approved 1,000 MW. This has led the HP State government to demand that the developer pay suitably adequate amount for the increased capacity as well as an increased amount for the EMP expenses, which is being contested by the developer. This has put a cloud on the exact cost of the project, which then led to a question of how much should the exact amount for LADF be. However, in a series of meeting with the State government officials, the developer did agree that the company will pay ₹103 crores as LADA compensation. They also stipulated that they have carried out a series of development works (establishment of school, hospital, training institutes, temples, cow sheds, etc.) in the area that should be assessed by the State government and their monetary value should be subtracted from the total LADA cost. Accordingly, the State government conducted field visits to ascertain these costs, which were tallied at about ₹5.67 crores. At this point, the company officials stated that further development activities to the tune of ₹16.68 crores had been done, which was left out of the assessment report and which should be added to the total cost. But neither the government nor the village communities agreed to this, which has led to the LADA issues remaining unresolved with the developer refusing to pay the remaining LADA fund without another audit. As on August 2014, the hydro developer had paid a total amount of about ₹53 crores (includes LADA + EMP) and refused to pay any more until another audit of the development works has been conducted as well as the addition of the ₹16.68 crores to the LADA activities has been agreed to by the State government and the villagers.

The villagers on the other hand were of the opinion that establishment of the school, the hospital, and the ITI facility while beneficial should not be counted under LADA activities, since the conception of these facilities had been for the benefit of the employees of the project rather than primarily for the villagers. Moreover, villagers also raised the point that none of these activities had been carried out with their approval or by asking their opinion and hence could not be counted as part of the development works under LADA for the betterment of the region. They also stated that during a visit to the hospital, any patient from a project-affected family (PAF) needs to bring a letter signed by the village head that he or she belongs to one of the PAAs, a point which the developers refused to agree to. Moreover, the villagers stated that apart from the most common medicines and the actual treatment, the rest have to be paid for by the patients, again something that was discounted by the company officials. The team could not verify either of the claims, though they were provided with an account of the subsidy provided by the company for the hospital.

In terms of the school, the complaint arose that the seats reserved for the PAFs were not sufficient and neither were the school fees subsidised, again something that was disagreed to by company officials. At this point, the team believes that some amount of bias could have crept among the PAFs who were questioned, since there were a few who stated that the school was indeed a boon for the area and the authorities did provide subsidized fees even if the number of seats reserved was limited. Another complaint that arose in connection with LADA was that the developer did not have consent of all the villages for the HEP. The team observed that the major reason of conflict between the village communities and the hydro developer was because there was little transparency in the entire LADA process. There was no independent audits being carried out and hence the blame continued to be shifted from one stakeholder to another. In the course of these events, it is always the environment and the ultimately the people living in the region who get affected.

The team would like to make an observation that retrospective clauses inserted within established contracts invariably lead to conflicts. Developing a power project and the surrounding infrastructure for the project is the responsibility of the developer, but providing infrastructure in the area as well as local area development falls under the purview of the State Government and the local leaders. Therefore, it was within company rights to disagree to LADA compensation, especially if it isn't part of the original MoU. But at the same time, it is unacceptable for the company to list each and every activity in the region, including those that were primarily for the benefit of the project employees as LADA. For example, even without LADA, the primary beneficiaries of the school and the hospital were the project employees and their families and not the villagers who came in as secondary beneficiaries. Moreover, considering the lack of independent audits for the LADF, it becomes impossible to understand the situation adequately. A revamp in the system has been suggested under National Policy Roadmap for Hydroelectric Power and submitted as part of this project.

Employment

Lesser employment opportunities were another major complaint among the PAFs. The developer in discussions with the team stated that this project dislocated only 51 people who were compensated under the existing rules. Further, the developers also stated that they had followed rules and employed about 1,800 people, following the policy of first offering the openings to the PAFs, then to *Himachalis* from other regions, and then to people from other parts of the country. However, the common complaint with not just this developer, but also the other case studies was that it was difficult to employ local people since often they did not meet the job requirements and demanded higher pay than outsiders. Moreover, the nature of HEPs was such that the rate of employment diminished as the construction of the project progressed, which led to discontent among the local people.

PAFs in turn alleged that the number of people from among the affected areas hired at Karcham–Wangtoo HEP was only about 30 per cent. Moreover, even those from the villages who were employed were not paid on par with other employees and were hired as contract labourers and not permanent employees. The team also witnessed case papers whereby a PAP was denied employment since he did not fall under the provision of a PAF, despite being from one such affected village, due to a technicality. The company however alleges that they have about 800 more people on their rolls than needed and that this was another tactic by the PAFs to prolong the conflict and add to the monetary compensation received by them.

While R&R laws as well as the Himachal Pradesh Hydro Power Policy mandates that hydro developers are required to provide employment to PAPs, by nature hydro power projects do not require as much labour once the dam has been commissioned. Thus, the team is of the opinion that skill development and thereby enhanced livelihood opportunities must be made part of project development as well as taken up by the Human Resource Department of the State government can help in building greater trust between villagers and hydro power developers.

Tunnelling and blasting activity

The impact of tunnelling and blasting on the villagers as well as on crop production (here apple) has been a major grouse of the people around Karcham–Wangtoo HEP. During the FGDs, the team visited several sites wherein the PAFs demonstrated household cracks caused by blasting. Upon being questioned, company officials stated that they had conducted blast vibration studies that showed that the blast impact did not exceed 10 peak particle velocity. Further complaints by the PAFs resulted in surveys by geologists and compensation being paid (₹13 crores) to a few of the affected villages (Chagaon) for damage to the apple crops. However, not all the villages were paid for compensatory damages, which have led to conflict. In fact at one of the village panchayats (Panvi), the team witnessed cracks that the villagers allege were due to the blasting at the power house even as the villagers stated that their village was unsafe due to subsidence. The team was also led to one such site where subsidence was taking place. However, in the interaction with the liasoning officer, it was mentioned that the developer did pay some compensation towards the cracks but not to all the affected zones.

Villagers complained that blasting and tunnelling activities also destroyed the natural springs but this point of view was discarded by the developers who had hired experts and attributed faulty irrigation techniques undertaken by the villagers as the cause. The Sutlej basin cumulative environment impact assessment (CEIA) report commissioned by Ministry of Environment, Forests, and Climate Change and the Department of Energy of Himachal Pradesh (2014) mapped the hydro geology of the entire area between *Khab* and *Kol* Dam. This report stated that tunnelling impact on ground water is not significant or on a large scale in hard rock areas. Most of the impacts are temporary or local in nature. Among other criticisms of this report, one of the major inadequacy highlighted was that no information was sought from the State Department of Irrigation and Public Health regarding natural springs in the project areas, seasonal data on spring discharge, or the impact of already constructed projects on the water discharge in these springs, despite data accessed under Right to Information (RTI) by the PAFs of the KWHEP. The RTI data for KWHEP showed that of the 167 natural water sources, 43 have completely dried up and flow reduced in case of 67 traditional water sources (Himdhara 2014). Moreover, in subsequent LADA meetings, village heads have spoken of dangers arising due to leakage in tunnels. While there has been a committee instituted to study the leakages, no such report has as yet been handed over the GPs.

The team observed that so far neither the government of Himachal Pradesh nor the developer sought to address the issue of impact of tunnelling and blasting on natural springs and on houses using both a scientific process as well as proper communication strategy. The CEIA study on the Sutlej basin was found wanting and lacked proper scientific methodology. The geologists called by the developers to ascertain the cracks took cognizance of only a few villages and left the others wanting. Moreover, unlike in one of other case studies (Shongtong–Karcham), no seismographs were installed by the developers to measure the level of blast activity. Without such proof or videography of before and after conditions of the houses in the affected zone, it has been impossible to prove claims by either party, which has led to widespread discontent. The State Government could make mandatory, the provisions of providing seismographs as well as conducting videography (documenting villages of the PAFs using camera/video recorder) before the project construction has commenced. A constructive communication strategy to explain these to the village community would help reduce the discontent faced by the developers.

Other aspects

Other issues that were raised by the village communities was the aspect of muck dumping along the river but on discussions with the developers, it was brought to light that the public works department was dumping debris into the river while undertaking construction works.

Case Study-4: Kashang (Integrated) HEP

DEVELOPER:
HIMACHAL PRADESH POWER CORPORATION LIMITED
TOTAL INSTALLED CAPACTY: 243 MW (AS PER DEVELOPER)
TOTAL DISPLACED: NO PHYSICAL DISPLACEMENT
AFFECTED VILLAGES: 4
LADA FUND APPROVED: STAGE I: 7.06 CRORE; STAGE II: 7.21 CRORE (10 PER CENT DEPOSITED)

Introduction

The Integrated Kashang Hydroelectric run of the river project is being executed by HPPCL with an installed capacity of 243 MW on Kashang Khad and Kerang Khad, both these are tributaries of the river Sutlej and are typical snow-fed hill rivulets that have steep gradient with 'step pools bed configuration'. It will be constructed in integrated stages as Stage I (65 MW), II–III (130 MW), and IV (48 MW). The total land requirement for the project is 85.73 hectares, of which 61.89 hectares is forestland and 23.83 hectares is private land. The Kashang Khad basin up to the proposed intake point (Stage I) constitutes a free draining catchment of 124.03 km^2 (including snow bound 30.96 km^2). The Kerang Khad basin up to the proposed intake point (Stage II) constitutes a free draining catchment of 400.04 km^2 (including snow bound 96.95 km^2) and a directly draining catchment of 53 km^2 as the intake point of Stage-IV. Kerang watershed also has Lippa–Asrang Wildlife Sanctuary that extends over 30.89 km^2 area. The case study presents field observations and stakeholder perspectives on the developments of the project particularly from the qualitative data collected from villages Jangi (upstream), Pangi (upstream), and Reckong Peo (downstream).

Rehabilitation and resettlement

About 480 farmers are said to be affected by the Kashang Stage-I project. The villagers whose land has been acquired have reportedly received compensation of the order of ₹104,000 per biswa of land,[1] even when the land circle rate is about ₹18,000 per biswa, the project authorities stated. They also added that a total of ₹16 lakhs has been provided to the villagers as compensation for damaged homes; however, the affected villagers have demanded ₹80 lakhs. Under the R&R grant, about ₹70 lakhs have been disbursed and another ₹30 lakhs are yet to be disbursed by the Kashang project to the villagers. The villagers of Pangi said to have demanded 5 per cent of the generation cost from the HEP developers post commissioning of the dam to compensate for the losses they have incurred. Villagers also opined that the policy awareness about R&R is limited to the village Pradhan at most times making the general understanding of the process weak amongst the villagers.

Local Area Development Authority

According to government norms, 1.5 per cent of the pre-project costs of the HEP should constitute the LADA funds to improve local area facilities of education, health care, infrastructure, and preservation of culture. In addition to this, the amount equivalent to 1 per cent of the electricity generated should also accrue to the GP for local development under the LADA funds post-commissioning of the project. According to the information provided by a senior official at HPPCL, the following was the fund disbursal to the GP under the LADA funds: Under Stage-I, total money of ₹7.06 crores has been planned under LADA, of which ₹6.39 crores has been deposited. Under Stage-II, total money of ₹7.21 crores has been planned under LADA, of which 10 per cent has been deposited. The amount stipulated for CAT plan for 10 years that is prepared by the State Forest Department is ₹30.51 crores during Stage-I and II. Of the stipulated amount, ₹13.03 crores has been deposited to the State Forest Department under the CAT plan.

Employment

The issue of not providing enough permanent jobs by the developers was one of the concerns raised by the villagers. As per the HPPCL records, 52 people were provided indirect employment through outsourced jobs, 106 people were provided employment though the contractor—Hindustan Construction Company (HCC), 46 people by M/S Patel Engineering.

[1] Data provided by Himachal Pradesh Power Corporation Limited official (HPPCL)

Tunnelling and blasting activity

Run of river (ROR) projects require diversion dams or barrages having a number of gates that are operated to control the amount of water that flows through them. The gates are used to divert the river through tunnels that are drilled through the mountains. The tunnels are also used to remove the muck. The villagers of Jangi opined that tunnelling was majorly responsible for water shortage for irrigation in their village, hampering their crop production, reducing the green cover that also in turn had reduced pastureland and livestock. They also believe that a tunnel has been constructed through the sanctuary area without a NOC being passed. According to them, the blasting and construction activities have been causing regular tremors and landslides and the resultant dust scatter and muck has also affected their horticulture crops (like apple). On the other hand, the project authorities informed the team that the seismic vibration in this particular area is one-tenth of the permissible limit, as studied by the national rock mechanics.

Kinnaur hills lack deep-rooted trees that can hold the soil together and hence these hills become even more prone to landslides. Activities such as tunnelling in such formative landscapes make them further vulnerable to landslides. Villagers of Pangi informed the team that about 40 farmers in the village have lost their land during the heavy tunnel blasting and that the affected farmers have not yet received any compensation. They shared their plight that the blasting activities have led to cracks in their village homes and in their terraced farms. The project authorities, however, are of the opinion that cracking of the land and the houses can be attributed to faulty irrigation and house constructions on high slopes, and not so much to HEP construction. The villagers claim to have actively and legally protested upholding their concerns against the tunnelling and blasting activities but no action to their satisfaction has yet been taken.

Other aspects

Stage-IV of the project is planned to be in close proximity to the Lippa–Asarang Wildlife Sanctuary (4–5 km), which in case it is, will be against the 10 km norm of the Forest Conservation Act. The sanctuary homes some of the most endangered species that also show up in the IUCN Red List of Threatened Species, namely, musk deer, snow leopard, ibex, goral, blue sheep, yak, brown bear, black bear, snow cock, and Monal (Himachal's State bird). There are also around 80 natural springs that face direct danger from the project development. The project authorities claim that there no such springs in the area of the project. The clearance for this stage of the project is still pending with the National Board for Wildlife. The HEP plans to plant 1.5 lakh trees on the dumping site and 2,000 trees near the intake side once the project construction is complete.

Jangi produces the maximum Chilgoza (pine nut) trees in the whole of Kinnaur where every household manages at least 200 kg of Chilgoza every year. The market value of Chilgoza is of the order ₹1,000–1,200 per kg, which can bring ₹2–2.5 lakh of annual earning per household. The villagers fear that HEP development activities could severely hamper their Chilgoza crops, endangering their healthy channel of livelihood.

The local Buddhist population is concerned about culture adulteration and destruction in the area.

5.4 Ways Forward

The solutions for the issues identified during the case studies have implicitly or explicitly been mentioned in the Hydro Power Policy of Himachal Pradesh. However, inadequate implementation practices have led to simmering discontent among both the developer as well as the village communities. A lot of these issues can be tackled on an individual basis, rather than only formulating a policy change at a macro level. This section attempts to tackle the aforementioned issues on a case-by-case basis. However, by no means are these suggestions exhaustive or the only way to resolve the issues at hand.

1. **LADA:** The case studies show that distribution and utilization of LADA funds is a major issue on both sides—the developer as well as village communities. At this point, it would be prudent to suggest an independent audit of the LADA funds (district wise) by the State Government with results being communicated via various mediums (one-to-one communication, group meetings, websites, etc.) to all the stakeholders involved. This will help instil trust in villagers towards developers regarding the amount of money committed by the developer towards local area development. Moreover, it will also provide information on the development activities accruing from these funds carried out by the villagers. It is recommended that this audit take place at least on a quarterly basis.

2. **Impact of tunnelling and blasting activities on houses:** The government along with the developer could set up a website that would aid in documenting the impact of tunnelling and blasting activities. This website should be set up before tunnelling and blasting activities take place. A team with members from the State government, district officials, representatives from the GP, and developer can facilitate the process of documenting images/videos in the catchment area. Once blasting takes place, the complainant can contact the said team with proof of the damage. If the proof holds then it makes the complainant's claim valid thereby facilitating a transparent compensation mechanism. This process can help root out genuine complaints from those that are fraudulent in nature, and moreover can also be used for complaints related to natural causes and loss of property.
3. **Employment:** The rate of employment opportunities at a hydropower project is inversely proportional to that of the progress of construction. Therefore, it must become mandatory for the State government along with project developers to include skill training and livelihood development opportunities as part of the project plan. This will help local communities as the HEP gets commissioned and employment opportunities dwindle.

5.5 References

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5.6 Annexures

Annexure 5.1: Key Features of Hydropower Policy of Himachal Pradesh

Sl. No.	Description	Summary
1	Title	Generation—Projects above 5 MW Capacity
2	Projects Classification	Projects above 5 MW to 100 MW installed capacity identified under category-I, for allotment for implementation in Private Sector Allotted through Memorandum of Understanding (MOU) route. Projects above 100 MW installed capacity are to be allotted through International Competitive Bidding (ICB) Route.
3	Eligibility	Any Private Investor /Co-operative Societies comprising of the bonafide Himachalis. • Not more than 2 projects to be allotted for implementation to an IPP; • Company/consortium to be selected on the basis of their equity in implementation of the project and company to retain their equity participation till three years after commissioning of Project; • IPPs to develop projects either as ROR schemes or Storage projects (SP); • For SP, approval of the State Government required to ensure minimum submergence of Habitations and Agricultural holdings.
4	Process of Allotment	To be advertised through Notice Inviting Proposals (NIP) for global invitation of bids • Developer can submit bids for one or more projects separately; • Bids as well as processing fee to be submitted separately for each project; • Allotment on the basis of tentative installed capacity as mentioned in NIPs through competitive bidding route; • Bidders to quote a fixed upfront charges of Rs.20.0 lakh per MW capacity of project and 'additional free power' at a uniform rate over and above royalty charges, in all the three time bands of royalty charges of 12 per cent, 18 per cent, and 30 per cent of the deliverable energy up to 12 years, next 18 years, and balance agreement period beyond 30 years.

Sl. No.	Description	Summary
5	Scope of Work	From concept to commissioning • Transmission system for evacuation of power to form part of project and included in DPR.
6	Capacity Enhancement	• Project developer need to obtain prior approval of the Government of Himachal Pradesh by submitting the proposal based on requisite studies and then enter into a supplementary agreement within two months of conveyance of the approval. • Developer has to pay capacity addition charges and additional free power (over and above the Normal Free Power Royalty) and 1 per cent additional free energy contribution to LADF. • For projects allotted with capacity above 5 MW i. Allotted through MOU route; capacity addition charges @ ₹20 lakh per MW is payable on capacity increase beyond allotted capacity. ii. Allotted through ICB route on the basis of quality upfront premium, capacity addition charges @ ₹20 lakh per MW or upfront premium quoted at the time of allotment (whichever is higher) is payable beyond increase in allotted capacity. iii. Allotted on the basis of paying fixed upfront premium; capacity addition charges @ ₹20 lakh per MW is payable beyond increase in allotted capacity. • Additional free power @ 3 per cent over & above the Normal Free Power Royalty shall be payable to the government on increasing capacity. • If capacity enhancement shifts the project from below 5 MW to above 5 MW category; 3 per cent additional free power shall be levied over & above the rates of Normal Free Power Royalty as per the policy applicable to projects above 5 MW category at the time of approval of capacity enhancements. • If capacity is reduced within 20 per cent, fixed upfront premium, if any, shall be charged/ refunded on pro-rate basis whereas the Normal Free Power Royalty & Additional Free Power, if applicable, will remain the same. • If capacity reduction is more than 20 per cent of allotted capacity, developer can either surrender the project with refund of upfront premium or can retain the project with refund of pro-rate upfront premium. • Developers can switch to provisions of this ***Notification No. MPP-F(10)-24/2011 dated 07-07-2012*** or can continue with existing provisions as agreed to in respective agreements signed earlier.
7	Self-Identified Projects	• Proposals to be examined and processed by concerned Agency • Agency to submit proposal to the State Government with their recommendations; • Evaluation to be done as per criteria set by HPSEB for allotment of projects under ICB; • The allotted elevations of projects will be indexed stream wise and uploaded on website of concerned agency proposals to be considered for allotment on 'first come first serve' basis; • If scheme is clashing / overlapping with any allotted project, proposal to be returned to identifier; • Identifier allowed to participate in bidding without any processing fee and bid document issued free of cost; • In case identifier is unable to quote highest bid in its offer under ICB, he will be offered project at highest bid received if his offer is short by 30 per cent of highest bid otherwise it will go to highest bidder; • Upfront premium of Rs.20 lakh per MW shall be charged from successful bidder as per the prevailing policy on ICB basis; • IPPs to be given 'two years" time for preparation and submission of DPR for according TEC, failing which allotment stand cancelled; • Government will be free to allot it to another IPP; • Amount to be reimbursed for PFR/DPR to be decided on project to project basis but restricted to a maximum of ₹25 lakh. • Upfront Premium @ Rs.20.00 lakh per MW to be paid by IPP within 30 days of issuance of letter of allotment; • For projects above 5 MW and up to 100 MW, rate of royalty to be 15 per cent for first 12 years, 21 per cent for next 18 years, and 33 per cent for balance period of 10 years;

Sl. No.	Description	Summary
		• Projects to revert back to the State Government, free from all encumbrances after 40 years from scheduled COD; • HPSEB has the right to first refusal for the power generated from all projects except where the IPP intends to use it for captive consumption within HP. (Amended via ***Notification No. MPP-F(2)-4/2005-III dated 12.11.2008 and Notification No. MPP-F(2)-4/2005-III dated 10.02.2009***).
8	Statutory Clearances	Concurrence of the competent authorities to be obtained as per the procedure applicable from time to time
9	Agreement Termination	• Agreement to remain in force up to a period of 40 years from COD • Thereafter, the project shall revert to the State Government free of cost and free from all encumbrances; • Any change in consortium/equity participation would terminate MOU /IA and Project to revert back to Government without any compensation; • Developer is permitted to withdraw from Project if not found techno-economically viable. The security and 50 per cent of the upfront premium deposited shall be refunded without interest.
10	Equity Participation	Company consortium to be selected on basis of their equity participation • Company to retain their equity participation till three years after commissioning of the project; • Government may consider the request of IPP for changing the name of Company or Consortium provided that Promoter(s) retain the controlling interest i.e. 51 per cent equity in the new entity; • In the event of any contravention, the State Government to terminate the IA forthwith at any stage; • Free transfer of shares permitted in the company's allotted projects; • Company permitted to incorporate a Special Purpose Vehicle (SPV) for implementation of Project with its registered office within HP with the same equity participation; • All rights and obligations under this agreement to be transferred to new company; • Company to ensure opening its office in the State.
11	R&R	• The Second Party, 'if ROR project', to ensure minimum flow of 15 per cent water immediately downstream of the diversion structure of the project throughout the year. • For determination of minimum discharge, the threshold value of not less than 15 per cent of the minimum inflow observed in the lean season shall be considered (amended via ***Notification No. MPP-F (1) 2/2005-VII dated 26.07.2011***); • However second party is at liberty to install mini hydel projects to harness such water for their captive use, subject to prior approval of the State Government; • Activities of Local Area Development Committee (LADC) during execution of the Project itself and developer to keep a provision of 1.5 per cent of the Project cost; • Amount for local area development to be paid to Dy. Commissioner/Chairman, LADC in equal instalments during construction of projects in First quarter of every FY starting from date of Financial closure; • Developer to keep Government informed of change in construction cost and release the instalments accordingly; • Govt. of HP in its ***Notification No. MPP-F(1)-2/2005-V dated 30-11-2009 and Notification No. MPP-F(1)-2/2005-V dated 15-3-2010*** has notified that the second party shall provide an additional 1 per cent free power over and above 12 per cent free power from hydel project for LADF. This will be over and above the rates of royalty agreed to in the Implementation Agreement/Supplementary Agreement. The government of Himachal Pradesh may also provide a matching 1 per cent from its share of 12 per cent free power.

Sl. No.	Description	Summary
		• Guidelines for management of LADF (***via Notification No. MPP—F (10)24/2011-III dated 26.05.2015***) mention that the revenue to be generated out of sale of 1 per cent additional free power on account of LADF shall be disbursed amongst the beneficiary families. • Fifty per cent of total LADF amount to be divided among all families in PAA equally, with BPL families getting higher amount. • Balance 50 per cent to be divided among families in the ratio of land acquired in their respective panchayat, with BPL families getting higher amount. • Company to provide employment to one member of each of the displaced families as a result of acquisition of their land for Project; • Company to provide training to the locals affected by Project.
12	Disposal of Power	• Developer shall be free to dispose-off merchant power as per Government of India Guidelines/provisions contained in Electricity Act-2003; • Government of Himachal Pradesh/HPSEB to have right of first refusal on sale of such power as remains after meeting commitments of Royalty in the shape of free power, additional free power, and merchant sale of power, on tariff to be determined by HPSERC and also for all SHP projects where IPP intend to use for its captive consumption within the State.
13	Transmission System and Evacuation	• Developer to make arrangements for evacuation of power from project to board's/PGCIL's substation (Interconnection Point) as per the provision in DPR; • Beyond Interconnection Point, developer to tie up the transmission system with HPSEB/PGCIL at mutually agreed wheeling charges.
14	Royalty	• Developers to provide royalty in the shape of free power to the Government of Himachal Pradesh in lieu of surrender of potential site @ 12 per cent of the deliverable energy of project for 12 years starting from date of synchronization of the first unit/scheduled COD, whichever is earlier; • Royalty to be 18 per cent for next 18 years and beyond that @ 30 per cent beyond 30 years.
15	Incentive for Early Commercial Operation of Project	If project's commercial operation is achieved before scheduled COD, the quantum of free power to govt. shall be as: • From date of first unit synchronization to COD of Project—12 per cent of deliverable energy; • From COD to scheduled COD (a) 12 per cent of deliverable energy less two-tenth (0.2) percentage points for each period of 73 days (or part thereof) falling between the COD and scheduled COD (b) 12 per cent of deliverable energy for a period of 12 years from scheduled COD
16	Disincentive for Delayed Commercial Operation of Project	If the project's commercial operation is delayed beyond scheduled COD, the quantum of free power to govt. shall be as: • From date of first unit synchronization to scheduled COD of the project - 12 per cent of deliverable energy; • Commencing from scheduled COD and the number of days COD is delayed beyond scheduled COD (a) 12 per cent of deliverable energy plus two-tenth (0.2) percentage points for each period of 73 days (or part thereof) falling between the scheduled COD and COD (b) From COD up to the date falling (12) years from scheduled COD of the project—12 per cent of deliverable energy (c) Developer to pay the amount of free power component as above (a and b) in 10 equal monthly instalments from actual COD in addition to normal free power due
17	Carbon Credits	• Sale of equivalent carbon credits by developer to be through competitive process amongst buyers

Sl. No.	Description	Summary
18	Employment Opportunities	• Company shall inform the local police station and the labour officer about the details of the labourers and other work force engaged, regularly; • Company to provide employment to the bonafide Himachalis whose names are registered in employment exchange located in the State, in respect of all the unskilled/skilled staff and other non-executives as may be required for execution, operation, and maintenance of the project; • On non-availability of the requisite/qualified manpower, company could recruit persons from outside the State after getting non-availability certificate from Labour Commissioner/ Director Employment; • Company to ensure employment to not less than 70 per cent of the total employees/officers/ executives from bonafide Himachali persons; • IPP to give an undertaking to the Fisheries Department of the local area that wherever feasible, rearing of fish shall be promoted by the IPP in consultation with the Fisheries Department in the Project area at the time of final implementation of the Project.
19	Monitoring of Projects	• A multi-disciplinary committee to review, on quarterly basis, the implementation of project, employment, relief & rehabilitation , time & cost overruns of project (if any) , payments, implementation of CAT plan, compensatory afforestation, environmental management plan, environmental impact assessment plan, etc. In case of default, the Himachal Pradesh Government shall have the right to cancel the MOU; • Projects assets to be maintained by the developer in a condition that would ensure a residual life of the project at the rated capacity for at least 30 years at any point of time; • During the Tenth, Twentieth, Thirtieth, and Thirty-Fifth years of operations, the Government or its agency to carry out a mandatory inspection of the Project site. If the Project capacity or life is being undermined by inadequate maintenance, the Government may seek remedial measures from the developer; • If the developer fails to comply with the requirement, the Government shall have the right to take over the commercial operation of the Project and have full right the sale of power including developer's share; • Cost on account of suggestive remedial measures to be deducted from the sale of developer's share of metered power including the operation and maintenance cost for such a period till the project's assets are restored; • Thereafter, the project shall be handed over to the developer.
20	Disaster Management	• To overcome any kind of natural calamity, company to prepare disaster management plan and its implementation and include in DPR; • Company to ensure that the material excavated from site shall be dumped in the area approved by Ministry of Environment and Forests, GoI/State Pollution Control Board.
21	General Conditions	• Developer to reimburse to HPSEB the amount spent by Board on investigations and infrastructure works of project, up to signing of IA with compound interest @ 10 per cent/ annum within three months of signing of IA; • Any difference and/or disputes arising at any time to be resolved by the parties hereto by mutual negotiations, failing which the matter to be referred to the arbitrator. However, all disputes shall be settled within the jurisdiction of Courts of Himachal Pradesh; • Company to make financial provisions for mitigation of adverse impacts as per the approved EIA plan, EMP, etc. at the project cost; • Company to ensure to protect the water rights of the local inhabitants for drinking and irrigation purposes. **Note**: Govt. of HP in its ***Notification No. MPP-F(1)-2/2005-V dated 30-11-2009 and Notification No. MPP-F(1)-2/2005-V dated 15-3-2010*** has notified that the second party shall provide an additional 1 per cent free power over and above 12 per cent free power from hydel project for LADF. This will be over and above the rates of royalty agreed to in the Implementation Agreement/Supplementary Agreement.

Sl. No.	Description	Summary
22	Transferring Ownership of HEP	• Developers can transfer ownership by selling/transfer equity stakes of principal promoter beyond 51 per cent after allowing stabilization period of 6 months from the date of commercial operation of the project. • If unable to go ahead with implementation of the project, the principal promoters can also sell/transfer their equity beyond 51 per cent in the name of any 'competent' third party by fulfilling conditions mentioned in the ***Notification No. MPP F(1) 2/2005-IX dated 01-06-2015***. • While allowing change/transfer of equity of principal promoters, a fee @ ₹50,000 per MW subjected to a maximum of ₹50 lakh is to be deposited at the time of signing Tripartite Agreement for transfer of project along with necessary liabilities/responsibilities in the name of the new entity.
23	Change of location/ elevation of HEP	For projects allotted through MoU route, domain change may be allowed if: • Change of location doesn't interfere with other allotted or existing upstream/downstream projects unless they are also undergoing a shifting of domain and proposed changes are for optimization of potential. • Free flow of water is not hindered • Un-allotted projects do not become infeasible/unviable and there is no adverse impact on revenue or environment. • Change is environmentally/ socially beneficial. For projects allotted through bidding route, domain change that increases the head beyond 10 per cent of the original specification is not permitted. ***Amendment via Notification No. MPP-F(2)4/2010 dated 15.06.2010***

Source: Based on Hydro Power Policy—2006 and Amendments—Jan 2008, Jan and Feb 2009 (Above 5 MW)

Annexure 5.2: Overview of Local Area Development Authority

The LADA is a committee where the Deputy Commissioner (DC) shall be the Chairman while the concerned sub-district magistrate shall be the member secretary. The committee will also consist of other sub-divisional officers, affected area panchayat pradhans, and a representative of the project developer. The hydro developer will make a provision of 1.5 per cent of the final cost of the project as per the Himachal Hydropower Policy 2006, which will fund the activities of LADA.

The responsibilities of LADA include those in the PAAs, restoration of facilities, implementation of the R&R plan and CAT plan, as well as compensatory afforestation. Overseeing other associated local development activities pertaining to agriculture, horticulture, fisheries, rural development, and social and cultural activities in PAAs also come under the ambit of LADA. The committee meets periodically to finalize development activities, review the progress of activities, and other issues associated with the utilization of the fund.

The notification released by the department of MPP and Power, Government of Himachal Pradesh, in May 2015, stating the revised guidelines for the management of LADF mentions that LADF will be administered by a committee called the LADC, which shall be constituted for each project separately, immediately after signing of the implementation agreement. All the LADCs constituted within the district shall function under the overall superintendence and control of the Local MLA/ DC. It also outlines the structure of the district level LADC for projects in Kinnaur district, which is as follows:

1.	Deputy Speaker, HP, Vidhan Sabha	Kinnaur Constituency	Chairman
2.	Deputy Commissioner	Kinnaur	Vice Chairman
3.	AC to Deputy Commissioner	Kinnaur	Member Secretary
4.	District level officers of PW, IPH, Forest, Rural Development, Health, Horticulture Department	Concerned Area	Members
5.	Chairman and Vice—Chairman, Zila Parishad (for District Level allocation only)	Concerned Parishad	Members
6.	Chairman and Vice—Chairman Panchayat Samiti (for Block level allocation only)	Panchayat Samiti	Members
7.	Panchayat(s) of all affected GP(s) Samiti	Concerned Area	-do-
8.	Representative of the project developers	Concerned Project	-do-

Source: Department of MPP & Power, Government of Himachal Pradesh, Notification No. MPP-F(10)24/2011-III, dated 26.05.2015.

Annexure 5.3: *Perception from villagers–*

Problems of Hydro Power Projects under study in Himachal Pradesh (Villagers Perception)								
		Issues						
Names of HEPs	Villages Visited (Panchayats)	Compensation for Land and R&R	Employment Opportunities	LADA Compensation	Tunnelling & Blasting Activities (Impact on Houses)	Tunnelling & Blasting Activities (Impact on Horticulture/ Environment (Muck Dumping)/Natural Springs/Landslides)	FRA Compensation	Aid from Local leaders
Shontong–Karcham	Khawangi (Khawangi Panchayat)	– –	++	– –	+	–	– –	– –
(Under construction)	Powari (Powari Panchayat)	– –	++	– –	–	–	–	–
	Ralli (Ralli Panchayat)	– –	++	– –	– –	–	– –	– –
Karcham–Wangtoo	Tapri (Tapri Panchayat)	– –	+	++	+	+	– –	+
(operational)	Panvi (Panvi Panchayat)	– –	++	++	++	++	+	+
	Chagaon (Chagaon Panchayat)	– –	+	++	++	++	– –	+
	Urni (Urni Panchayat)	– –	+	++	++	++	– –	+
	Katgaon (Panvi Panchayat)	– –	+	++	–	–	– –	– –

Problems of Hydro Power Projects under study in Himachal Pradesh (Villagers Perception)								
		Issues						
Names of HEPs	**Villages Visited (Panchayats)**	**Compensation for Land and R&R**	**Employment Opportunities**	**LADA Compensation**	**Tunnelling & Blasting Activities (Impact on Houses)**	**Tunnelling & Blasting Activities (Impact on Horticulture/ Environment (Muck Dumping)/Natural Springs/Landslides)**	**FRA Compensation**	**Aid from Local leaders**
Tidong I	Ripsa (Rispa Panchayat)	– –	++	++	+	++	–	– –
(Under construction)	Thangi (Thangi Panchayat)	– –	++	++	+	++	– –	– –
	Moorang (Moorang Panchayat)	– –	++	+	+	++	–	– –
Kashang (Integrated)	Jangi (Pooh Panchayat)	+	++	+	+	++	– –	– –
(Under construction)	Pangi (Pangi Panchayat)	+	++	+	++	++	– –	–
	Rekong peo (Kalpa Panchayat)	+	++	–	–	–	– –	– –

Legend

++	**Issue Significantly Relevant**
+	**Issue Relevant**
–	**Issue Less Relevant**
– –	**Issue Irrelevant**

Annexure 5.4: Perception from industry

Industry perception of Hydro power projects under study in Himachal Pradesh			
	Issues		
Names of HEPs	**Statutory clearances**	**External interference**	**Compensation for villagers**
Shontong Karcham (Under construction)	– –	–	+
Karcham–Wangtoo (operational)	– –	++	++
Tidong–I (Under construction)	–	–	+
Kashang (Integrated) (Under construction)	– –	–	+

Legend

++	**Issue Significantly Relevant**
+	**Issue Relevant**
–	**Issue Less Relevant**
– –	**Issue Irrelevant**

Climate Resilient Green Growth Strategies for Himachal Pradesh

Towards an Inclusive Development Agenda

This document is prepared under the project—Initiative on Green Growth and Development—implemented by The Energy and Resources Institute (TERI) in collaboration with the Global Green Growth Institute (GGGI) and nodal support from the Department of Environment, Science & Technology (DEST). TERI conducted the climate modelling, soil and water assessment, power sector analysis, and case studies. The report benefited immensely from the stakeholder interaction and nodal support from DEST and facilitation from Directorate of Energy and Economics and Statistics Department.

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