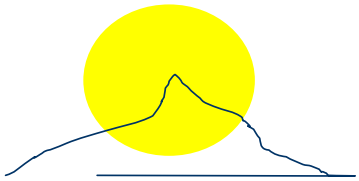

HighNoon Delivery Report D 6.1

Title	Report on outline of CS and description of stakeholders
Work Package Number	WP 6
Delivery number	D 6.1
Relative task(s)	o Detailed outline of the case studies o Description of the stakeholders
Authors and organization	**TERI**: Arabinda Mishra, Suruchi Bhadwal, Sreeja Nair, Sneha Balakrishnan, Sambita Ghosh, G. J. Lingaraj **IITK**: Dr. Ashok Mishra **IITD:** Dr A K Gosain **Alterra**: Catharien Terwisscha van Scheltinga, Annemarie Groot, Christian Siderius
Function	
Related to deliverable number(s)	D 6.1
Date of completion	Modification of the report submitted on 30 April 2010
Name Work Package Leader	TERI
Submission Date	1 November 2010

To complete by the Coordinator

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Date of listed	2 December 2010

Abstract

The objective of Work Package 6 is to develop multi-sectoral adaptation measures with the participation of identified stakeholders. WP6 with a focus on stakeholder consultations seeks o draw inputs from all other work packages to meet its stated objectives.

The current deliverable of the project provides an introduction to the work package, the various inter-linkages with other work packages, selection of the case studies and a detailed description of each selected site. It also provides a brief description of the stakeholders identified in the case study sites.

In all four case study sites have been identified keeping in mind a broad criteria that serves the purpose of their selection. While Delhi (Case study 1) and Udham Singh Nagar (Case study 2) are located in the upstream areas of the basin, Allahabad (Case study 3) is located in the mid stream and the districts of Purulia, Bankura and West Medinapur (Case study 4) represent the downstream parts of the basin.

D 6.1 (Final)

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List of Abbreviations

BSES	Bombay Suburban Electric Supply
CS	Case Study
DJB	Delhi Jal Board
FSI	Forest Survey of India
GSDP	Gross State Domestic Product
ICFRE	Indian Council of Forestry Research and Education
IIT	Indian Institute of Technology
NCR	National Capital Region
NDPL	North Delhi Power Limited
NGO	Non Government Organisation
NIH	National Institute of Hydrology
PSI	People's Science Institute
TERI	The Energy and Resources Institute
UJVNL	Uttarakhand Jal Vidyut Nigam Limited
USN	Udham Singh Nagar district
UP	Uttar Pradesh
UPCAR	Uttar Pradesh Council of Agricultural Research
WALMI	Water and Land Management Institutes
WII	Wildlife Institute of India
WP	Work Package
THDC	Tehri Hydro Development Corporation Ltd

Chapter 1 Introduction

The principal aim of the High Noon project is to bring together information, and develop further knowledge on the retreat of the Himalayan glaciers and corresponding changes in rainfall patterns and its consequent impacts. The study with a focus on the Ganges basin would seek to capture the spatial and temporal distribution of water resources both in the present day context as well as under an enhanced climatic situation.

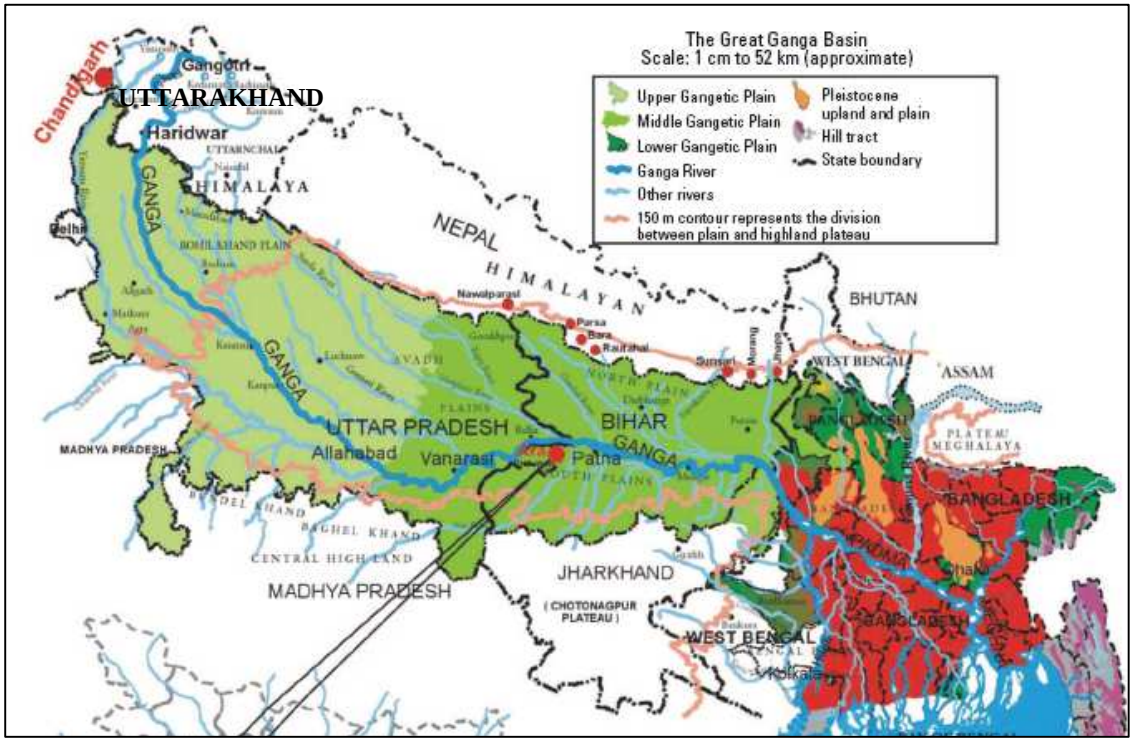
Impact of climate change will be studied through simulations using tools related to hydrological modeling and the scenarios generated by the regional climate modeling in Work Package 1 and 2. The study would further provide recommendations for appropriate and efficient response strategies using a participative approach involving identified stakeholders, further strengthening the cause for adaptation to climate change including extremes.

The principal objective of Work Package 6 is to develop multi-sectoral adaptation measures with the participation of identified stakeholders. The current deliverable of the project provides an introduction to the work package, the various inter-linkages with other work packages, selection of the case studies and a detailed description of each selected site. It also provides a brief description of the stakeholders identified in the case study sites.

1.1 Description of the Ganges basin

The Ganges basin covers over 12,500 sq. km in Northern India and ranks among the largest in the world in drainage basin area and length. It is bounded on the north by the Himalayas, on the west by the Aravallis as well as the ridge separating it from Indus basin, on the south by the Vindhyas and Chhotanagpur Plateau and on the east by the Brahmaputra ridge. Its catchment lies in the states of Uttar Pradesh and Uttarakhand (2,94,364 sq. kms), Madhya Pradesh (1,98,962 sq. kms), Bihar (1,43,961 sq. kms), Rajasthan (1,12,490 sq. kms), West Bengal (71,485 sq. kms), Haryana (34,341 sq. kms), Himachal Pradesh (4,317 sq. kms) and Delhi (1,484 sq. kms). The river basin can be broadly divided into three regions, Upper, Middle and Lower Ganga. The map in Figure 1 highlights the three regions discussed above.

Figure 1: Upper, Middle and Lower regions demarcated in the Ganges Basin



The river is constituted of many large and small rivers and has two main rivers the Bhagirathi and the Alaknanda that feed into the Ganges. The Bhagirathi flows from the Gangotri glacier situated at an elevation of about 7010-m above mean sea level, in the Uttarkashi district of Uttar Pradesh. The Bhagirathi is joined by the Alaknanda at Deoprayag and the combined stream under the name Ganga flowing through the mountain region debouches into the plains at Rishikesh. Farther downstream, the river is joined by a number of other Himalayan rivers, the Yamuna, Ghaghara, Gomti, Gandak and Kosi. However, the Ganga and its major tributaries, the Yamuna, Ram Ganga, and Ghaghara are the only Himalayan Rivers that have significant base and flood flows. After its total run of 2,525 km, its drains into the Bay of Bengal.

The basin comprises mountainous regions of the Himalayan ranges with dense forests, sparsely forested Shivalik hills and the fertile Gangetic plains. The Central highlands lying to the South of the Great plains consist of mountains, hills and plateaus intersected by valleys and river plains. They are largely covered by forests. The important soil types found in the basin are sand, loam, clay and their combinations such as sandy loam, silty clay etc.

The Ganges Basin is the most populous river basin in the world (having a population of around 356.8 million.) and vital for sustaining approximately 440 million people in India. It remains the main source of freshwater for half the population of India and Bangladesh and nearly the entire

population of Nepal. Agriculture, however dominates the use of freshwater resources in the basin.

The annual surface water potential of the basin has been assessed as 525.0 km3. Out of this, 250.0 km^3 is utilisable water. Culturable area of the basin is about 58.0 M.ha, which is 29.5% of the total culturable area of the country. Live storage capacity in the basin has increased significantly since independence. From just about 4.2 km3 in the pre-plan period, the total live storage capacity of the completed projects has increased to 37.8 km3. In addition, a substantial storage capacity of over 17.0 km3 would be created on completion of projects under construction. An additional storage to the tune of over 29.6 km3 would become available on the execution of projects under consideration.

Over 29 cities, 70 towns, and thousands of villages extend along the banks of the river in India. The important cities and towns situated on the banks of the Ganga are Haridwar, Kanpur, Allahabad, Varanasi, Patna, Bhagalpur etc.

The river is an important source of power generation that is supplied to the states of Uttarakhand, Uttar Pradesh, Delhi, Haryana, Chandigarh, Rajasthan, Jammu Kashmir, and Himachal Pradesh amongst others. The hydropower potential of the basin has been assessed as 10,715 MW at 60 % load factor.

The Upper Ganga Canal and the Eastern and Western Yamuna Canals built during the nineteenth century, are among the oldest major projects in the basin. The Upper Ganga Canal is an important irrigation channel that feeds the alluvial tract lying between the Ganga and Yamuna rivers. The Upper Ganga Canal flows into the Lower Ganga Canal near Aligarh and flows to Kanpur before returning to the parent stream. Some of the other important projects constructed since independence are Gandhi Sager Dam, Rana Partap Sagar Dam, Narora Barrage, Rajghat Dam, Rihand Dam, Gandak Barrage, Tenughat Dam, Maithon Dam, Kangasabati Dam etc.

The water related issues of the basin are both due to high and low flow. Uttar Pradesh, Bihar and West Bengal are the states affected by floods. Many of the flood problems are caused by northern tributaries of Ganga such as Kosi and Mahananda. Besides, these problems are also caused by southern tributaries.

Large-scale urbanisation and industrial development brought in its wake the problem of pollution of river water. More than 1.5 million cubic meters of raw sewage, industrial effluent, and agricultural discharge are released into the Ganges every day as the river flows through the Indian states of Uttar Pradesh, Bihar and West Bengal. Scientists argue that the reach of the river from Kannauj to Allahabad is particularly vulnerable to human induced pollution. The Central

Pollution Control Board estimates that the main sources of pollution along the reach of the river are urban liquid waste (sewage/sullage), industrial liquid waste, large scale bathing of cattle, throwing of dead bodies in the river, surface run-off from solid waste landfills and dumpsites, and surface runoff from industrial solid waste landfills or dumpsites. It reports that three-fourths of the pollution of the river comes from the discharge of untreated municipal sewage, of which 88% is created in Class-I cities (cities with populations above 100,000). The industries represented in this river basin are sugar and paper mills, cloth (woolen, cotton and rayon) mills, tanneries, ordinance factories, battery industries, thermal power houses, chemical plants, metal and steel factories, distilleries, and fertiliser corporations. Heavy metals such as cadmium, zinc, nickel, lead, chromium and copper are concentrated in the river water and the sediments.

The rivers of the Ganges basin drain the southern slopes of the Great Himalaya and carry one of the largest sediment loads on earth. Deglaciation at the headwaters of tributaries that form the Ganga, human-instigated forms of erosion such as tree felling, farming, and construction of settlements all contribute to the river's discharge and concentrations of pollution.

1.2 Specific Objectives

The specific objectives of WP 6 as outlined in the proposal aims;

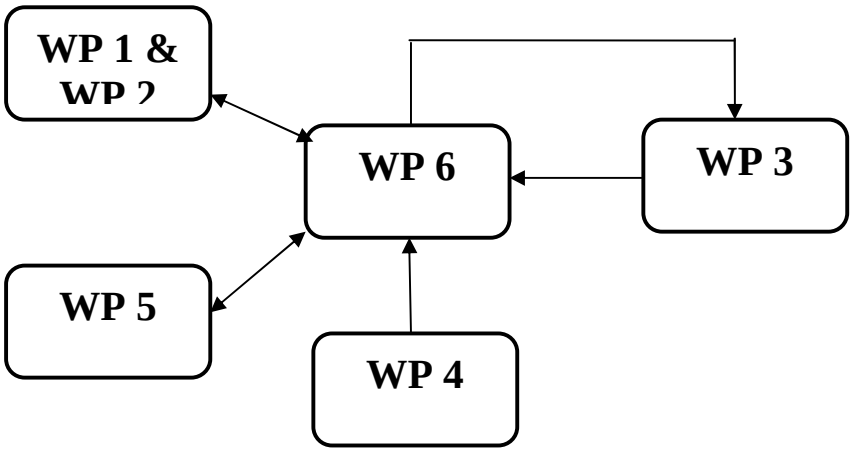
1 To develop and to provide adapted participatory planning structures
2 To determine for each relevant sector (water supply, hydropower, agriculture, ecosystems and health) suitable adaptation measures at all relevant scales through multi-stakeholder interactions that are site specific – and to determine related boundary conditions in the domain indicated above
3 To investigate different sets of adaptation options including the impact for water resources and water management (including possible traditional modes of adaptation if any)
4 To guide the selection of adaptation options, to support the consensus building and to support the revision of applicability
5 To integrate the boundary conditions obtained and the results of participation processes into the selection and design of adaptation measures
6 To assess the impacts of measures being employed to adapt and its influence in local, regional and national contexts
7 To disseminate the research outputs to wider fora

1.3 The Broad Framework

The Work Package (WP) 6 of the project seeks to develop multi-sector, adaptation strategies through a participatory approach with multiple stakeholders identified both at the institutional and the community level helping to identify set(s) of adaptation measures that are site specific and take into account the views and priorities of local people, including gender concerns.

WP 6 assumes a central position in the working of the entire High Noon project, with inputs from other WPs feeding into it and outputs from WP6 feeding into other WPs. These inter-linkages have been illustrated in Figure 2. Since a cyclic process of interactions is involved, outputs from WP 3 will feedback into WP 6, wherein the socio economic situations shall be varying over time. Any developments for adaptation will then have to consider the influence on the local/regional/national conditions as well as on the feedback into the national and global contexts. Results from the modelling exercises carried out in WP 1 & 2 will be used to inform stakeholders of the possible future scenarios of climate and changes in hydrology in the Ganges basin. Using the indicator system elaborated in WP5, the impact of measures on water quantity, water quality, socio-economy and adaptive capacity will be formulated. Results from WP6 will also be reconsidered in a feedback loop at WP1, WP2 and WP3.

Figure 2: Inter-linkages between Work Package 6 and other Work Packages



1.4 Case Study Approach

To be able to meet the objectives outlined, a case study approach has been undertaken in this work package. Four case study sites have been identified for this purpose located at the upstream, mid-stream and downstream parts of the Ganges Basin. The selection of case studies has been based on extensive stakeholder consultations at the state and district levels. Moreover, relevant secondary data has been explored. WP 6 for this purpose draws inputs on methods and its application from WP 4.

The case studies have been selected keeping in mind the following broad criteria;

1) location in the basin - representative of upstream, mid-stream and down stream areas of the basin
2) sectoral focus - mainly on the agriculture and water sectors, besides looking at linkages on other aspects including health and power generation
3) comparability aspects – maintaining some degree of homogeneity in the selection of the sites for comparison purpose but at the same time also having some elements of heterogeneity in order to capture a broader spectra of underlying issues and responses

For each of the identified sites, sectors of focus, impacts, vulnerabilities and the various interventions, will be contextaulised (water supply, hydropower, agriculture, health, ecosystem) based on the selected sites and in close consultation with experts and other stakeholders therein.

While case studies 1, 2 and 3 in the Upper and the Middle Ganga region is being undertaken by TERI, IIT Kharagpur is taking forward the case study in the Lower Ganga region (Case study 4).

Description of Case Study 1, 2, 3 and 4 follow the broad outline, as indicated below:

- Rationale for selection of case study sites
- Boundary conditions
- Study area description (climatic, hydrological, land-use, socioeconomic profile (including livelihoods) – links to WP 3 have to be established, review of relevant policies - these may not be separate headings but need to be covered to set the context)
- Inputs from WP 4 - stakeholders identification and mapping
- current vulnerabilities
- current coping and adaptive practices
- climate related projected impacts in the area inputs from WP 1 and WP 2 ; for different sectors
- potential adaptation options with respect to regional conditions, current vulnerabilities and projected impacts

For stakeholder identification, a preliminary list of stakeholders was developed based on methods outlined in WP4 and D6.2. Careful attention has been paid to account for diverse set of issues through our choice of stakeholders. The list contains stakeholders from across all levels of government namely: union, state, local, people from the academia, the industry, civil society including NGOs, user associations and communities.

Chapter 2 Detailed description of Case Study 1 (CS1): Delhi/ NCR region (to capture the implications of changes in water supply and hydropower generation from Tehri Dam)

Tehri Dam[1] is the only major dam in the Ganges basin and one of the largest dams in the world. It is situated in Tehri Garhwal district (coordinates 30°22′40″N 78°28′50″E) of Uttarakhand, 200 miles north east of Delhi. It is the fifth tallest dam in the world with a height of 260 meters (855 feet). Completed in 2006, the Tehri Dam withholds a reservoir of 2.6 billion cubic meters for irrigation, municipal water supply and hydro electricity generation. The dam is expected to provide 2000 MW of electric power, additional irrigation to 270,000 hectares, stabilization to existing irrigation on 600,000 hectares and 270 million gallons of drinking water per day to Uttarakhand, Uttar Pradesh and Delhi. In terms of priority list for water allocation the National Water Policy 2002, drinking water would be the first priority followed by irrigation and hydropower.

2.1 Rationale for selection of Delhi/ NCR

Delhi was included as a case study based on the discussions we had with the Managing Director of the Tehri Hydropower Coop ltd. It was realised during the consultation that the consumption of drinking water and power from this hydropower unit is largely in the National Capital Region (NCR) region and in Uttar Pradesh (UP) and therefore any impacts on water availability would affect the water situation in the NCR and parts of UP. The state of Uttarakhand in turn receives 12 % of the power generated from the plant.

The inclusion of Delhi as a case study site therefore is primarily because of the following reasons:

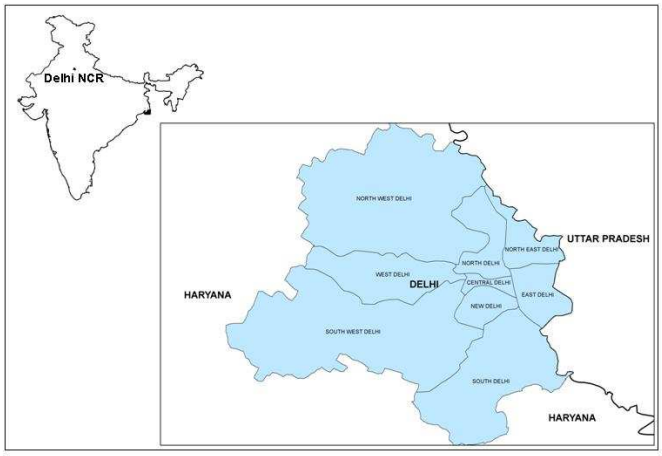
- Delhi is one of the key benefactors of the Tehri hydro project. Substantial part[1] of drinking water and electricity of the city is sourced from Tehri hydro project. Impacts of variations in precipitation and glacial retreat could have serious implications for the water availability in the dam which in turn could affect water supply for electricity generation, irrigation and drinking in this region
- Yamuna River from which, considerable amount of water is drawn for drinking is a major tributary of the Ganga and is glacier fed.
- Socio economic drivers like population growth, urbanization, changes in living standards, migration could multiply[2] demands for drinking water and electricity.

2.2 Boundary conditions

[1] More details will be provided in the subsequent sections
[2] The demand projects will be elaborated in the later sections

National Capital Territory (NCT) of Delhi as known in the administrative records is the capital city of India. The city is located in northern India between the latitudes of 28°-24’-17"and 28°-53’-00"North and longitudes of 76°-50’-24"and 77°-20’-37"East (Figure 3). Delhi shares its border with the States of Uttar Pradesh and Haryana.

Figure 3: Location of CS2, City of Delhi



2.3 Area description

Delhi is a part of National Capital Region (NCR) (Map1) which is a name for the conurbation or metropolitan area which encompasses the entire National Capital Territory (NCT) of Delhi as well as urban areas in neighboring states of Haryana, Uttar Pradesh and Rajasthan (Figure 4). With a total area of about 33,578 km^2 (12,965 sq m), Delhi stands to be the world's ninth largest urban agglomeration.

Figure 4: Map depicting the NCR region

Source: National Capital Region Planning Board[3]

National Capital Region (NCR) comprises of a total area of 33,578 sq. km. including areas of Delhi (1483 sq. km), Haryana (13,413 sq. km), Uttar Pradesh (10,853 sq. km) and Rajasthan (7829 sq. km). The case study site would focus only on Delhi, the capital city of India, which is spread over an area of 1,484 km2 (573 sq mi).

Delhi is characterized by humid subtropical climate. Summers are long and extremely hot and winters are foggy and can get very cold. Extreme temperatures have ranged between −0.6 °C (30.9 °F) to 46.7 °C (116.1 °F)[4]. The average annual rainfall in Delhi is 714 mm, three-fourths of which falls in the months of July, August and September[5].

2.4 Socio Economic Profile

As per 2001 Census[6], Delhi had a total population of 13.8 million that corresponds to 1.34% of the All-India Population. The annual growth rate of population of Delhi during 1991-2001 is 3.85% and the decennial growth rate during 1991-2001 is 47.02[7]%. The density of population in

[3] Available at http://ncrup.up.nic.in/ last accessed on 22-10-10
[4] Weathrt Base 2010, Weather Base Historical Records available at http://www.weatherbase.com/weather/weather.php3?s=28124&refer=&units=metric , Last accessed on 21- 10-10
[5] JNNURM City development plan 2006, Ministry of Urban Development, Government of Delhi, Delhi
[6] Details available at www.censusindia.net Last accessed on 21- 10-10
[7] Economic Survey of Delhi, 2007–2008. Planning Department, Government of National Capital Territory of Delhi, Delhi

Delhi is the highest among all states/UTs 9340 persons[8]. Delhi is highly urbanized with 93.18% of its population living in urban areas as against the national average of 27.81[9]%. Migration has been a major driver in the population increase in the city with over 2.75 lakh migrants in 2006 alone[10].

Gross State Domestic Product (GSDP) of Delhi at current prices was of the order of Rs.1252.82 billion (US$ 27.84 billion) during 2006-07 depicting 18.4 % growth over the previous year. The analysis of sector wise growth in Gross State Domestic Product reveals that contribution of primary sector[11] is showing declining trend, where as the contribution of secondary sector[12] and the contribution of tertiary sector[13], also called the service sector are showing mixed trend in the economy of Delhi. Delhi has witnessed a phenomenal growth of small-scale industries over the past few decades. In 1951, there were 8160 such industrial units in Delhi. By 1971, the number of small-scale industrial units had increased to 26,000. And by 2001, there were close to 129,000 such industrial units operating in Delhi.

The per capita income of Delhi at was Rs.78690 in 2007-08 as compared to Rs.70238. The city also fares well in human development indicators (Table 1) with a good literacy rate and low infant mortality rate which are much higher than all India figures.

Table 1: Brief socioeconomic profile of the city

Indicators	Delhi	India
Life expectancy at birth (years)	69.6	62.9
Adult literacy rate (% 15 years and above)	86	56.5
Combined gross enrolment ratio (%)	73.7	56
Infant mortality rate	28	60
Human Development Index	0.74	0.57

Source: SHDR[14] 2006

[8] 324 persons per sq. km being the national average
[9] Urban India 2006 available at http://urbanindia.nic.in/urbanscene/levelofurbanisation/urblevel.htm Last accessed on 21- 10-10
[10]Economic Survey of Delhi, 2007–2008. Planning Department, Government of National Capital Territory of Delhi, Delhi
[11] Primary sector comprises of agriculture, livestock, forestry, fishing, mining & quarrying
[12] Secondary sector comprises of manufacturing, electricity, gas, water supply and construction
[13] Tertiary sector comprises of trade, hotels and restaurants, transport, storage, communication, financing & insurance, real estate, business services, public administration and other services
[14] Delhi State Human Development Report 2006 available at http://planningcommission.nic.in/plans/stateplan/sdr_pdf/shdr_del06.pdf last accessed on 20-10-10

In 1999–2000, an estimated 1.15 million people—8 per cent of Delhi's population—lived below the income poverty line—considerably lower than the all-India proportion of 26 per cent. Although in terms of *gini coefficient*[15], Delhi is one of the lowest[16] in the country, a lot needs to be done in terms of bridging the gap of provision of basic services and establishing distributional equity[17]. On one side Delhi's aggregate per capita daily water supply is around 255 litres, one of the highest for any city in the country on the other 24.67% of the households did not have access to piped water. Further, 22.04% of households in the city had no access to toilets and 7.14 % of the households had no electrification. State human development reports estimates that around 50,000 and 70,000 persons in the city are homeless. At the end of the Ninth Five-Year Plan (1996–2001), there were 1080 *jhuggi and jhopdi*(JJ) clusters[18] with population of over 3 million estimated by Slum and J.J. Department or about 22 per cent of Delhi's total population.

2.5 Status of drinking water and electricity

The per capita availability of water is one of the highest among urban areas.[19] The water supply in Delhi is managed by the Delhi Jal Board (DJB). As of 2006, it supplied 650 MGD (million gallons per day) of water, while the water demand for 2005–06 was estimated to be 963 MGD[20]. Surface water contributes to over 86% of Delhi's total drinking water. It is sourced from three major sources (Table 2) Yamuna river, Bhakra storage and Upper Ganga canal from the Tehri dam. The average water consumption in Delhi is estimated at being 240 liters per capita per day (lpcd), the highest in the country.

Table 2: Sources of drinking water

Source	Total Quantity(MGD[21])	Total Quantity(MLD[22])
Yamuna	210	950
Bhakra Storage	200	905
Ganga	100	450

Source: Economic survey of India[23]

[15] Gini coefficient is a measure of the inequality of a distribution and is commonly used to measure inequality of income and wealth

[16] Vanneman, R and Dubey, A 2010 Horizontal and Vertical Inequalities in India, Inequalities and status of middle class – Lessons from Luxembourg income study, 28 – 30 June, Luxembourg

[17] Delhi State Human Development Report 2006 available at http://planningcommission.nic.in/plans/stateplan/sdr_pdf/shdr_del06.pdf Last accessed on 21- 10-10

[18] jhuggi and jhopdi clusters are essentially slums

[19] JNNURM City development plan 2006, Ministry of Urban Development, Government of Delhi, Delhi

[20] Chapter 13: Water Supply and Sewerage. *Economic Survey of Delhi, 2005–2006*. Planning Department, Government of National Capital Territory of Delhi. pp. pp147–162. available at http://delhiplanning.nic.in/Economic%20Survey/ES%202005-06/Chpt/13.pdf. Last accessed on 21- 10-10.

[21] Million Gallons per Day

[22] Million Liters per Day

[23] From Delhi Transco Ltd. (DTL) data

Delhi is highly energy intensive owing to its high seasonal variation of temperature demanding cooling during summers and heating during winters. Delhi has the highest per capita power consumption of electricity among the States and Union Territories of India which is about 1,265 kWh but actual demand is much more[24]. 98.74% of the total households were dependent on electricity for their lighting needs. Delhi peak energy demand in 2008-09 was 4,034 MW and the energy consumption was 21,738 million kwh. The per capita consumption of electricity in Delhi has increased from 1259 units per annum in 2000-01 to 1615 units in 2007-08. (National average was 717 units in the year 2007-08.) The power demand in Delhi is growing at the rate of 5-6% per annum. From a peak demand of only 27 MW in 1951, the demand has increased to 4036 MW in 2007-08[25].

Since adequate power is not generated within the city (Table 3), to meet the city's demand and borrows power from India's Northern Region Grid of which substantial portion is sourced from Tehri hydro project.

Table 3: Sources of electricity

Availability from Delhi's own plants	1116 MW
Availability from Central Sector Stations	2115 MW
Availability from other states through bilateral arrangements	369 MW
Total demand met	3600 MW

Source: Economic survey of India[26]

Delhi faces acute power shortage resulting in frequent load-shedding, especially during the summer season when energy demand is at its peak. Several industrial units in Delhi rely on their own electrical generators to meet their electric demand and for back up during Delhi's frequent and disruptive power cuts. The distribution of electricity in the city is carried out by companies run by NDPL and BSES.

2.6 Factors affecting the vulnerability of city

Changes in both supply and demand side, act and interact with each to influence the vulnerability of the city to the impacts of climate change on the Ganga basin. Below we identify important factors contributing to the vulnerability of region.

2.6.1 Supply Side Factors

[24] Chapter 11: Energy. *Economic Survey of Delhi, 2005–06.* Planning Department, Government of National Capital Territory of Delhi. pp. pp117–129. http://delhiplanning.nic.in/Economic%20Survey/ES%202005-06/Chpt/11.pdf. Last accessed on 21- 10-10

[25] Planning Department 2009, Government of National Capital Territory of Delhi, Delhi Secretariat, Delhi

[26] From Delhi Transco Ltd. (DTL) data

While the amount of drinking water from the current sources could decrease because of climate change, the supply of energy is altered due to the changes in runoff affecting the storage of dams like the Tehri dam from which hydro electricity is produced. Reliance on climate sensitive sources for water and energy increases the sensitivity of the region to climate change. Delhi sources its drinking water from three sources out of which two are from the Ganga basin. Yamuna River from which, considerable amount of water is drawn for drinking is a major tributary of the Ganga and is glacier fed. Second important source is the Tehri Dam (Box 1) from which significant amount of drinking water and electricity is obtained to the city.

2.6.2 Demand Side Factors

Various policy documents like Delhi Master Plan 2021 and Economic survey of Delhi provides for peak energy demand projections as well as the projections of total water demand in 2021. While the peak energy demand in 2021 (Table 4) is expected to be 8800MW[27] as opposed to 4310MW in 2006-07, the total water demand (Table 5) in 2021 is expected to be 6272 MLD[28] as against 4090 MLD in 2006-07.

Table 4: Peak energy demand projections

Year	PEAK DEMAND (MW)
2 003-04	3648
2 004-05	3860
2 006-07	4310
2 011-12	5659
2 016-17	7397
2020-21	8800

Source: Delhi Master Plan[29]

Table 5: Projection of total water demand

Category of Demand	Water Demand MLD			
	2005	2006	2011	2021
Domestic	2880	3099	3689	3673

[27] Mega watt
[28] Million liters per day
[29] As per 16th Electric Power Survey of India given in National Capital Region Planning Board Regional Plan 2021 National Capital Region, Master plan for Delhi—with the perspective for the year 2021, Ministry of Urban Development, Delhi

Commercial & Institutional	161	178	248	367
Industrial	722	813	1244	2232
Total Net Demand	3763	4090	5181	6272

Source: Delhi Jal Board, Economic survey of Delhi, 2005-2006

The changes in demand is largely due to two important factors, population growth and changes in standards of living. We elaborate on these two factors below.

- **Population growth**

Delhi is growing at a startling rate of 3.8 which is almost double the national average. The population of Delhi is expected to cross 23 million by 2021. If we account the entire NCR (Table 6) in this, the Delhi urban agglomerate would be touching 64 million by 2o21. This would pressure the already stress civic amenities in the region.

Table 6: Population projections for NCR

Year	NCR total	NCT- Delhi		Haryana		Uttar Pradesh		Rajasthan	
	Total Population	Population	% of total	Population	% of total	Population	% of total	Population	% of total
2001	37.1	13.85	37.33	8.69	23.42	11.57	31.19	2.99	8.06
2011	48.62	17.99	37	11.76	24.18	15.08	31.02	3.79	7.8
2021	64.14	23.49	36.62	16.02	24.97	19.83	30.92	4.81	7.49

Source: Census[30] 2001

- **Changes in living standards**

Water and energy consumption has a direct functional relationship with standard of living. Delhi has seen a consistent decrease in poverty rates since 1951, which is further expected to go down in the next few decades. A substantial percentage of people are homeless and considerable populations do not have access to electricity and safe drinking water. One of the key objectives of the Delhi Master Plan 2021[31] is to extend these basic amenities to all populations of the city. This would require very high magnitude of resources to achieve which would alter the demand significantly.

Rising population density, growing urbanization, improvements in living standards, falling groundwater level, industrialization and migration amongst other things could exacerbate already stressed water and energy resources of the city. The impacts of climate change on the rainfall and

[30] Census of India and Study Group Report on Policy zone, demography and settlement pattern; page 26, Table 4.12, Regional plan-2021, National Capital region by NCRPB (National Capital Region Planning Board), Ministry of urban development, Government of India

[31] National Capital Region Planning Board Regional Plan 2021 National Capital Region, Master plan for Delhi—with the perspective for the year 2021, Ministry of Urban Development, Delhi

glaciers could further aggravate the scarcity which could have serious implications on the city. Inter-linkages between different sectors would have a ripple effect on the entire economy.

2.7. Stakeholder Identification

Table 7 lists the stakeholders to be prioritized and consulted for CS2.

Table 7: List of stakeholders

Stakeholder	Stakeholder Affiliation	Role
NDMC	Government	Implementation
MoWR	Government	Planning
DJB	Government	Implementation
DERC	Government	Planning
THDC	Public Sector Undertaking	Producer
RWA	Community	Consumer
Water users	Community	Consumer
NTPC	Industries	Consumer
WRPM, TERI	Academia	Research
IITD	Academia	Research
NDPL	Corporate	Implementation
BSES	Corporate	Implementation
EEA, TERI	NGO	Awareness
MoUD	Government	Planning
DSDP	Government	Planning
BEE	Government	Planning
CWC	Government	Planning
DSIDC	Government	Planning

Details of each stakeholder group and their relevance in the consultation are as follows:

a. Delhi Jal Board (DJB)

Delhi Jal Board[32] (DJB) is the government agency responsible for supply of potable water to the most of the National Capital Territory region of Delhi, India. Delhi Jal Board was constituted on 6 April 1998 through an Act of the Delhi Legislative Assembly incorporating the previous Delhi Water Supply and Sewage Disposal Undertaking. DJB is also responsible for treatment and disposal of waste water.

b. Bombay Suburban Electric Supply (BSES)

[32] More details available at http://www.delhijalboard.nic.in/ last accessed on 22 – 10 – 10

It is India's largest private sector enterprise in power utility[33] formerly known as Reliance Energy. BSES[34] is entrusted with power distribution through its two companies BSES Yamuna Power Limited (BYPL) and BSES Rajdhani Power Limited (BRPL). These two company distribute electricity to 26.32 lakh customers in two thirds of Delhi.

c. North Delhi Power Limited (NDPL)

It is a joint venture of Tata Power, India's oldest and largest private sector power utility with the Government of Delhi. NDPL[35] services over one million consumers spread over 510 sq. kms in the North Delhi area, which is about one third of the total power distribution.

d. Ministry of Water Resources (MoWR)

MoWR[36] is the nodal ministry of the Government of India concerning water resources. The Ministry is responsible for laying down policy guidelines and programmes for the development and regulation of country's water resources.

e. Resident Welfare Associations (RWA)

RWAs are an association of people in a given locality aimed to promote the interests of inhabitant of the locality. RWAs facilitate management of key services, promote cooperation amongst residents and represent their concerns[37]. RWAs act as an interface between government agencies and people.

f. New Delhi Municipal Corporation (NDMC)

NDMC[38] is one of three local bodies in Delhi. NDMC area comprises of the territory that has been described as Lutyen's Delhi and which has historically come to be regarded as the seat of central authority in Union of India. Lutyen's Delhi in which NDMC operates has one of the highest per capita consumption of water in the country.

g. Delhi Electricity Regulatory Commission (DERC)

DERC[39] was constituted because of the Electricity Regulatory Commissions Act, 1998 (No.14 of 1998) enacted by the Govt. of India. The objectives of DERC are in consistency with CERC the Central electricity regulatory commission and concerns rationalisation of electricity tariff,

[33] More details available at http://www.rel.co.in/Rel/aboutus/relatglance.jsp last accessed on 22 – 10 – 10
[34] More details available at http://www.bsesdelhi.com/index.html last accessed on 22 – 10 – 10
[35] More details available at http://www.ndpl.com/ last accessed on 22 – 10 – 10
[36] More details available at http://www.wrmin.nic.in/ last accessed on 22 – 10 – 10
[37] For a list of RWAs in Delhi please visit http://dccentral.delhigovt.nic.in/development.htm accessed on 22-10-10
[38] More details available at http://www.ndmc.gov.in/ last accessed on 22 – 10 – 10

[39] More details available at http://www.derc.gov.in/ last accessed on 22 – 10 – 10

transparent policies regarding subsidies, promotion of efficient and environmentally benign policies.

h. Delhi State Industrial and Infrastructure Development Corporation (DSIDC)

Government of Delhi establised the Delhi State Industrial And Infrastructure Development Corporation Ltd. (DSIIDC) in February 1971 to plan, assist, finance and aid the interests of industries in Delhi. DSIIDC[40] acts as a pressure group to foster industrial interests of the state.

i. Delhi State Planning Department (DSPD)

The Planning Department[41] is responsible for preparation of Five Year Plan and Annual Plans of NCT of Delhi the jurisdiction of Govt. of NCT of Delhi. The planning department formulates plans for the most effective and balanced utilization of scarce resources; natural, human and financial.

j. National Thermal Power Corporation (NTPC)

NTPC[42], India's largest power company, was set up in 1975 to accelerate power development in India. NTPC was ranked 317th in the '2009, Forbes Global 2000' ranking of the World's biggest companies. NTPC has big power generating capacity at Badarpur in Delhi. NTPC requires substantial amounts of water for its operations.

k. Municipal Corporation of Delhi (MCD)

MCD[43] one of the three municipals bodies operating in Delhi, the other two being New Delhi Municipal Council and Cantonment board. It is among the largest municipal bodies in the world providing civic services to more than estimated population of 13.78 million citizens in the capital city. MCD comprises approximately 96 per cent of the area and population of the Union Territory of Delhi.

l. Tehri Hydro Development Corporation Ltd (THDC)

THDC[44] is a Joint Venture Corporation (JVC) of the Govt. of India and Govt. of U.P It is entrusted with developing, operating and maintaining the Tehri Hydro Power Complex and associated Hydro Projects in Uttarakhand.

m. The Energy and Resources Institute (TERI)

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[40]More details available at http://dsiidc.org/cms/ last accessed on 22 – 10 – 10

[41] More details available at http://www.delhi.gov.in/wps/wcm/connect/DoIT_Planning/planning/home last accessed on 22 – 10 – 10

[42] More details available at https://www.ntpc.co.in/ last accessed on 22 – 10 – 10

[43]More details available at http://www.mcdonline.gov.in/ last accessed on 22 – 10 – 10

[44] More details available at http://thdc.gov.in/Projects/English/Scripts/Prj_Introduction.aspx?vid=132 last accessed on 22 – 10 – 10

TERI[45] is a independent, not-for-profit, research institute focused on energy, environment and sustainable development, devoted to efficient and sustainable use of natural resources. TERI works on a wide range of issues and its activities range from pure and applied research, awareness generation and action research.

n. Indian Institute of Technology Delhi (IITD)

IIT Delhi[46] is one of the premier technology institutes in the country. The institute has been at the forefront of research concerning wide gamut of issues including, water resources and energy.

o. WaterAid

WaterAid[47] is an international non governmental organization working with the mission to transform lives by improving access to safe water, hygiene and sanitation in the world's poorest communities. In India Water Aid has developed practical techniques to help ensure the country's poor gain access to safe, sustainable and affordable water, sanitation and hygiene education through project work, research and advocacy. Water Aid works with a diverse set of stakeholders starting from high level officials in the central government to slum dwellers.

p. Bureau of Energy Efficiency (BEE)

BEE[48] was set up as a statutory body under Government of India under the provisions of energy conservation act of 2001. The primary objective of the bureau is to promote energy efficiency and reduce energy intensity of the Indian economy.

[45] More details available at www.teriin.org last accessed on 22 – 10 – 10
[46] More details available at http://www.iitd.ac.in/ last accessed on 22 – 10 – 10
[47] More details available at http://www.wateraid.org/india/default.asp last accessed on 22 – 10 – 10
[48] More details available at http://www.bee-india.nic.in/index.php last accessed on 22 – 10 – 10

Chapter 3 Detailed description of Case Study 2 (CS2): Udham Singh Nagar (USN) in the state of Uttarakhand

3.1 Rationale for selection of USN

Based on a review of the literature and several consultations with stakeholders, the district of Udham Singh Nagar was selected as CS 1 confined within the boundaries of Uttarakhand. It was selected on the basis of certain criteria that met the study objectives. This includes;

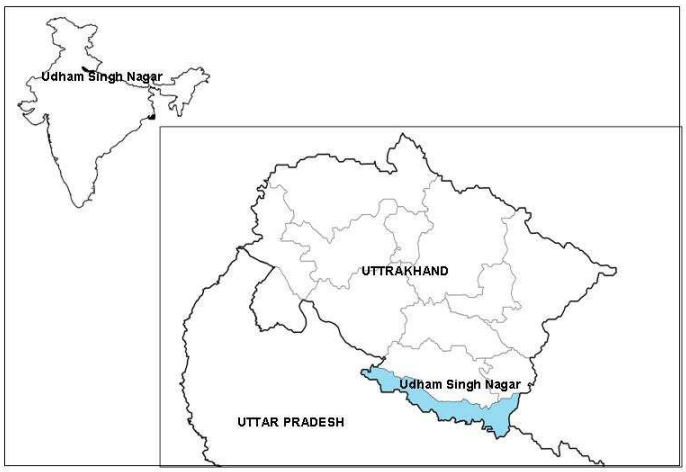
1. its location in the upstream stretch of the Ganges basin
2. exposure to extreme events like floods etc.
3. the amount of land being cultivated and
4. the number of dependents on agriculture as a source of livelihood

Also, the district is classified as the food bowl of the State and is famous for its agriculture and irrigation on synchronized patterns and productivity rates.

3.2 Boundary conditions

The area of USN lies between 28°40'41.49"N to 29°22'15.61"N and laterally extends between 78°43'45.43"E to 80° 9'37.15"E (Figure 5). The district is bounded by Nainital and Champawat districts of Uttarakhand on the north, Moradabad, Rampur, Bareilly and Pilibhit districts of Uttar Pradesh on the south, Bijnor district of Uttar Pradesh on west and Nepal on the east. The Sarada River forms the international boundary between India and Nepal.

Figure 5: Location of the USN in Uttarakhand



3.3 Area description

One of the 13 administrative districts of Uttarakhand, Udham Singh Nagar is a newly formed district in 1995, constitutes the southernmost district of the state, sharing boundaries with the state of Uttar Pradesh in the west, and bordering the country of Nepal in the east (Figure 6). Udham Singh Nagar district falls in the Tarai region of Kumaon Division. The geographical area of the district is 3055 Km^2 and ranks 9th in terms of area.

Figure 6: Administrative map of Udham Singh Nagar

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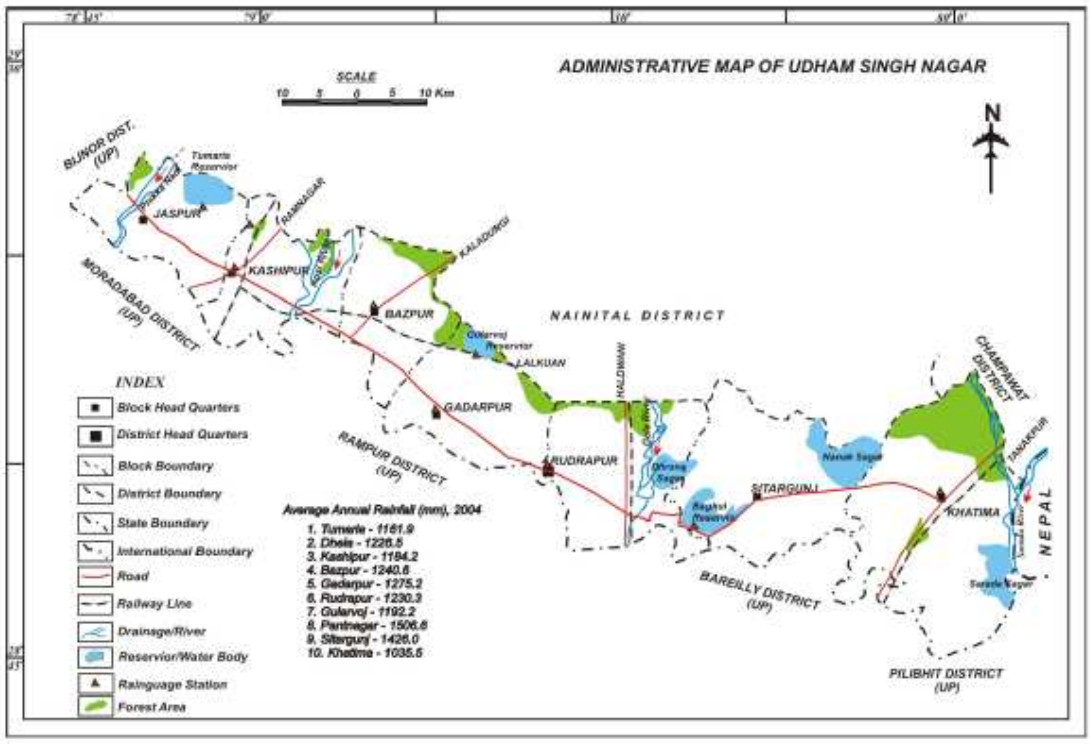


An introductory summary of the district is provided in Table 8.Udham Singh Nagar has a total of 17 towns, 669 villages of which 656 are inhabited. For administrative convenience, the district has been divided into four sub-districts and 7 developmental blocks and 7 tehsils. Sitargunj block is the largest (325 km^2), whereas Kashipur is the smallest block (185 km^2).

Table 8. District Summary

Neighboring Districts of UdhamSinghNagar	Bijnour, Moradabad, Rampur, Bareilly, Pilibhit ,Champawat, Nainital
Neighboring Country	Nepal

District Type	Tarai
Tehsils in UdhamSinghNagar(7)	Khatima, Sitarganj, Kichha, Gadarpur, Bazpur, Kashipur, Jaspur
Blocks in Udham Singh Nagar(7)	Khatima, Sitarganj, Rudrapur, Gadarpur, Bazpur, Kashipur, Jaspur
Nyaya Panchayats	27
Number Of Villages	688
Nagar Palika Parishads(8)	Jaspur, Kashipur, Bajpur, Gadarpur,. Rudrapur, Kichha, Sitarganj, Khatima
Nagar Panchayats(6)	Mahua Dabra, Mahuakheraganj, Kelakhera, Dineshpur, Sultanpur Patti, ShaktiGarh
Water Availability	At 10 meters
Population of Udham Singh Nagar	12 lakhs+
Language of district	Hindi, English and Punjabi

Source: http://usnagar.nic.in/history.htm

The climate of the district varies from sub-tropical and sub-humid observing three distinct seasons i.e. summer, monsoon (rainy) and winter. Winter rains are generally experienced in late December or early January, which brings down the temperature rendering December and January as the coldest months in the district. The months of the May and June are the warmest of the year. The maximum temperature in the district goes up to 42ºC during the summers and the minimum temperature is between 1 and 4ºC. Further northwards, the temperatures come down to 0.4ºC in the winter season.

Rainfall is found to vary spatially across the district depending upon the altitude. Rainfall trends show that the intensity of rainfall increases from south to north and the amount of rainfall decreases in generally from west to east. About 90% of the rainfall is received during the monsoon period. The average annual rainfall was observed as 1297 mm in 2004. The following table 9 depicts the distribution of rainfall by blocks.

Table 9. Rainfall variation in the district

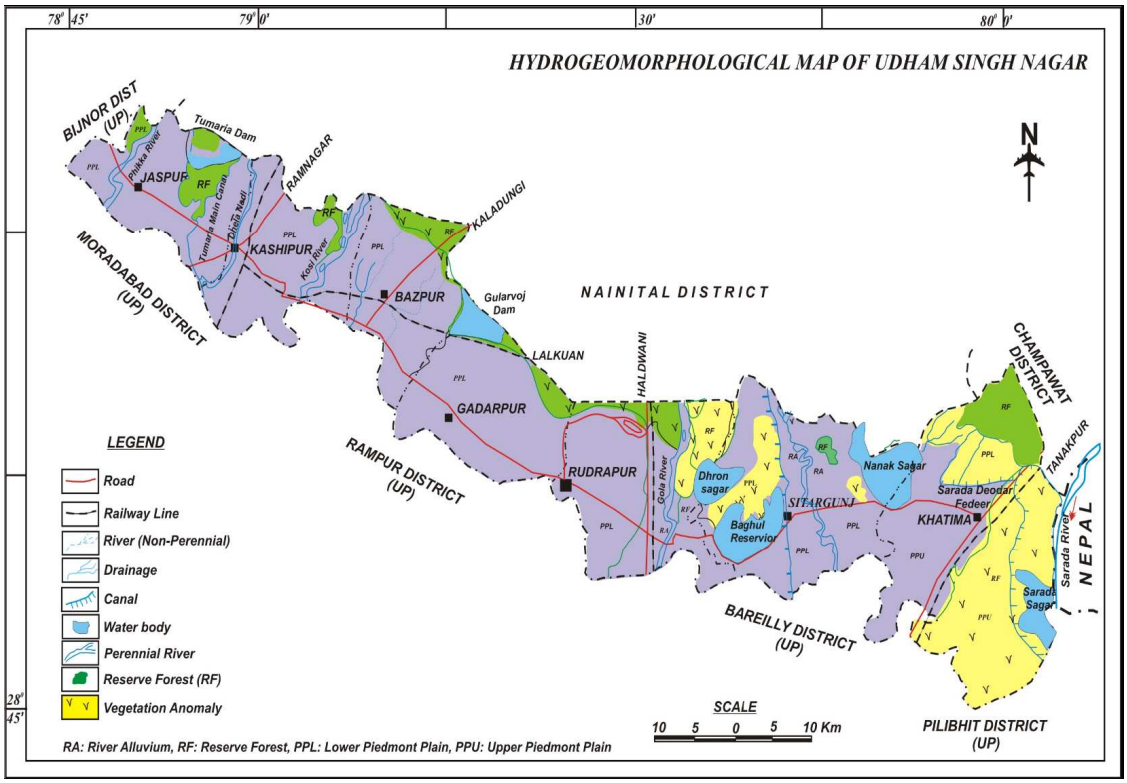
S. No	Raingauge station	Name of block	Rainfall (mm)
1	Tumaria	Jaspur	1154
2	Kashipur	Kashipur	2122
3	Dhela	Kashipur	1137
4	Bazpur	Bazpur	1317
5	Gadarpur	Gadarpur	1121

6	Gularboj	Gadarpur	1105
7	Rudrapur	Rudrapur	1154
8	Pantnagar	Rudrapur	2035.1
9	Sitargunj	Sitargunj	1122
10	Khatima	Khatima	1035.5

(Source: Irrigation Department, 2005, District Udham Singh Nagar)

The district has a dense network of drainage. The rivers of the district belong to the Ganges drainage system. Of these, Sarada, Kosi, Gola and Phikka river along with their tributaries Sawaldeh, Bour, Nandhour, Bhak, Kailash etc. drain the district. Most of these rivers flow from north to south or from northeast to southwest till they reach the Ganges (Figure 7). The major rivers are perennial in nature, whereas the tributaries are ephemeral and remain dry during the non-monsoon seasons.

Figure 7: Hydro-geomorphological Map of USN



3.4 Socio-economic profile

USN is the third most populated district of Uttarakhand. The population density is 405 persons/km^2. The overall literacy rate is 65 %. The total population of the district is 1.2 million (Census: 2001) with almost equal sex ratios (Table 10).

Table 10. Block and Tehsil wise population and area

S.No.	Name of Block	Area (Km^2)	Name of Tehsil	Population (Census 2001)	Villages		
					Inhabited	Uninhabited	Total
1	Jaspur	232	Jaspur	98279	100	5	105
2	Kashipur	185	Kashipur	86831	75	2	77
3	Bazpur	286	Bazpur	102143	113	3	116
4	Gadarpur	233	Gadarpur	104201	69	-	69
5	Rudrapur	307	Kichha	109730	90	-	90
6	Sitargunj	325	Sitargunj	146584	120	2	122
7	Khatima	324	Khatima	161291	89	1	90
	Forests	1103		23541			
	Urban	60		403014			
	Total	3055		1235614	656	13	

(Source: District statistical Diary, 2005, district Udham Singh Nagar)

Agriculture remains as the primary occupation with about 64% of the total workforce engaged in agriculture. Nearly 50 % of the land area in the district is under agriculture with the net sown area reported to be around 0.149 Mha and gross sown area 0.246 Mha. The two major crop growing seasons are Kharif and Rabi. Rice, soyabean, urd, moong and sesame are the main crops grown in the *Kharif* season and wheat, barley, gram, masoor, mustard and sunflower are the crops that are grown in the *Rabi* season. The rice crop is grown in all three seasons thrice in a single year. Sugarcane is also grown intensively in the district for its economic value.

Irrigation is largely through a network of major rivers and canals cutting across the district. The prominent canals like Kosi, Gola and Sarada irrigate a large area of the Tarai belt along with other canals like the Tumaria, Nathanpir. The total length of the canals of 924 kms caters to the irrigation needs of the district. The total irrigation potential created/utilized through minor irrigation schemes, through groundwater and surface water schemes amount to 144 and 73 Mha, respectively. There are 24703 shallow tube wells and 400 deep tube wells tapping multiple aquifers in the district.

3.5 Current and Projected Vulnerabilities

Constituting the plains of Uttarakhand, USN is a low lying district exposed to the threat of floods, flash floods. In 2010, the district had been affected by floods causing huge damages to

property and infrastructure. It was recognized as the third most affected district on the basis of the losses incurred to livestock and houses damaged. Around 10000 people residing in 15 villages were affected. Besides, losses to crops and other livelihood activities were reported to be additional. As a result, majority of the workforce relying on agriculture gets affected during such events affecting the overall economy of the district as such.

Given that the nature of extremes and the changes expected in the future with the frequencies and intensities of many events aggravating further, the district of USN may be placed in a situation wherein it is exposed to more frequent occurrences of such events. Also, the rate at which many glaciers in the Himalayan region are being reported to be melting in the literature, there is a high likelihood of over-spill from reservoirs in the upstream areas that might contribute to frequent flooded situations in the plains. Higher frequency of related extreme events, also likely to get exacerbated includes cloud bursts, hailstorms, heavy intensity rainfall events and land slides.

3.6. Stakeholder Identification

Table 11 lists the various stakeholders that can be engaged for the consultations in the study.

Table 11: List of suggested stakeholders

Stakeholder	**Stakeholder Affiliation**
Agriculture	State Government
Forest	State Government
Watershed	State Government
Irrigation	State Government
Rural development	State Government
Hydropower	State Government
Tubewells Division	State Government
PSI	NGO/ CBO
Wadia Institute	Academic
WII	Academic
FSI	Academic
IIT Roorkee	Academic
NIH	Academic
THTD Ltd	Joint venture
Agriculture Department	Local Government
Rural Development Department	Local Government
Water Resource Department	Local Government
Irrigation Department	Local Government
Planning Department	Local Government
Zila Parishad	Local Government

Details of each stakeholder group and their relevance in the consultation are as follows:

a. Agriculture Department

It is the principal department in the state that is involved in making policy decisions and in the planning and implementation of all activities related to the agriculture sector. The department is key in implementing both central and state agriculture schemes and has a vast network of district and block level departments and agricultural universities in its domain.

b. Forest Department

Forest Department in Uttarakhand is responsible for managing some of the richest forests and biodiversity in India. The forest department is primarily conservation oriented but also responds to the contemporary needs of the citizens. The management priorities of the department are: conservation of forests including wildlife and its habitats, providing ecological services to the citizens including conservation of soil and water regime, maintenance and enhancement of tourism values, production and harvest of forest produce on scientific lines, Generation of employment and participation in developmental initiatives of the Government through activities like land transfer for developmental projects, plantation of bio-fuel species, etc.

c. Watershed

The directorate performs the work of coordination, operation and evaluation for all watershed projects carried out in the state. The directorate is the nodal department for all projects related to watershed management. The directorate has been in operation since 2005.

d. Irrigation

The Department of Irrigation oversees the works in surface and groundwater irrigation in the state.

e. Rural Development

The Department of Rural Development is engaged in many fold developmental schemes which have a participatory grounding in the state. The department is also engaged in the implementation of different rural development and poverty alleviation programmes.

f. Hydropower

Uttarakhand Jal Vidyut Nigam Limited (UJVNL) was formed in 2001. UJVNL is a wholly owned Corporation of the Government of Uttarakhand set up for managing hydro power generation at existing power stations and development, promotions of new hydro projects with the purpose of harnessing, the known, and yet to be known, hydro power resources of the State.
UJVNL operates hydropower plants ranging in capacity from 0.2 MW to 376 MW, totaling up to 1306 MW. Though the State is more or less sufficient in its energy generation to meet its own

requirements, it is committed to develop its huge hydro power resources in an early and efficient manner for economic well-being and growth of the State and its people.

g. Tubewells Division

The Tubewells divison of the Department of Irrigation monitors the ground water levels and situation and also attends to the irrigation needs through ground water supply in the state.

h. People's Science Institute

PSI is a public interest research and development organization composed of young professionals dedicated to the task of nation building. Founded by Dr. Ravi Chopra, PSI seek to eradicate poverty through the productive, sustainable and equitable use of human and natural resources.

Established in 1988 with a start-up grant from ICA, the Institute has pioneered creative ways to use science and technology in the service of the poor. They believe that the active participation of the villagers in planning, managing, and implementing development programs is crucial for the success of any project. PSI promotes practical research, communication, and training

i. Forest Survey of India (FSI)

Forest Survey of India (FSI) was created in June, 1981 with the objective of monitoring periodically (10 years cycle) the changing situation of land and forest resources and presents the data for national planning; conservation and management of environmental preservation and implementation of social forestry projects.

j. Wadia Institute of Himalayan Geology

The Wadia Institute of Himalayan Geology is an autonomous R&D institution under the Department of Science and Technology, Government of India. The institute carries out research in Himalayan geology and related fields.

k. Wildlife Institute of India

Wildlife Institute of India (WII) was setup at Chandrabani, Dehra Dun in 1982 with a mandate to train government and non-government personnel, carry out research, and advise on matters of conservation and management of wildlife resources. WII was accorded autonomy in April 1986

l. Tehri Hydro Development Corporation Ltd (THDC)

THDC[49] is a Joint Venture Corporation (JVC) of the Govt. of India and Govt. of U.P It is entrusted with developing, operating and maintaining the Tehri Hydro Power Complex and associated Hydro Projects in Uttarakhand.

[49] More details available at http://thdc.gov.in/Projects/English/Scripts/Prj_Introduction.aspx?vid=132 last accessed on 22 – 10 – 10

m. Indian Council of Forestry and Education

The Indian Council of Forestry Research and Education (ICFRE) is an autonomous body under the Ministry of Environment and Forests, Government of India. The Council is the apex body in the national forestry research system to develop holistic forestry research through planning, promoting, conducting and coordinating research, education and extension on all aspects of forestry for ensuring scientific management of forest, tree improvement, forestry productivity through scientific and biotechnological research, bioremediation of degraded land, efficient utilization of forest produce, forest based value addition, conservation of biodiversity, effective agro forestry models for various agro ecological zones , policy research, environmental impact assessment and integrated pest management and disease. The Council has the following eight Institutes and three Centres situated under different agro ecological regions of the country

n. Indian Institute of Technology Roorkee

Indian Institute of Technology - Roorkee is among the foremost of institutes of national importance in higher technological education and in engineering, basic and applied research. Since its establishment, the Institute has played a vital role in providing the technical manpower and know-how to the country and in pursuit of research. The Institute ranks amongst the best technological institutions in the world and has contributed to all sectors of technological development. It has also been considered a trend-setter in the area of education and research in the field of science, technology, and engineering.

o. National Institute of Hydrology (NIH)

The Institute was established in 1978 as a research organization at Roorkee, India. Since inception, the Institute has carried out research studies covering almost all areas of hydrology, and has established contacts with national and international organisations of repute. The Institute is now well equipped to carry out computer, laboratory & field oriented studies with a team of 80 well qualified & trained scientists with excellent academic background and well equipped laboratories and facilities.

The Institute has actively participated in technology transfer activities. With these activities, over the years the Institute has positioned itself as the premier organization and centre of excellence for research & development in the area of hydrology in the country.

p. Tehri Hyropower Development Corporation

The THDC ltd. is a joint venture between the Government of India and the Government of Uttar Pradesh and is vested with the responsibility of executing the 2400 MW hydro power plant at Tehri.

Chapter 4 Detailed description of Case Study 3 (CS3): District Allahabad in the state of Uttar Pradesh

4.1 Rationale for selection of Allahabad district

Based on a review of the literature and consultations at the state level, district Allahabad was selected as case study 3 under the study. The criteria for selection of the district include;

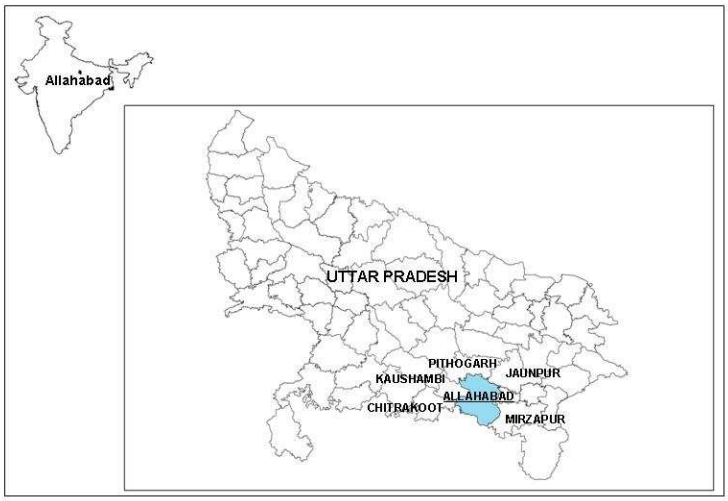
1. location of the district in the mid-stream of the basin
2. exposure to extreme events including drought and floods
3. water quality and implications on agriculture and health
4. very high dependence on agriculture

4.2 Boundary conditions

The district of Allahabad is located between 24°47' N and 25°47' N latitudes and between 81°19'E and 82°21'E longitudes (Figure 8). It covers an area of 5246 km^2. This district lies in the southern part of the state in the Gangetic plain and adjoining Vindhyan Plateau of India. Allahabad district is surrounded by district Bhadohi and Mirzapur in the East, Kaushambi and Banda in the west, Pratapgarh and Jaunpur in the North and Banda and Madhya Pradesh are in the south.

To its south west lies the Bundelkhand region, to its east and south east is the Baghelkhand region, to its north and north east is the Awadh region and to its west is the (lower) do a of which it itself is a part[50].

Figure 8: Location of Allahabad district within the state of UP



[50] http://districtcourtallahabad.up.nic.in/district.htm

D 6.1 (Final)

Allahabad is located in the southern part of the state and stands at the confluence of the rivers Ganga (Ganges) and Yamuna. The district of Allahabad consists of 7 Tehsils and 20 development blocks. The district comprises of eight tahsils, namely Sadar, Soraon, Phulpur, Handia, Bara, Karchana, Koraon and Meja.Tahsil The tehsil of Meja is the biggest in terms of the area characteristics while Tahsil Sadar is the densest in terms of population. The district has 20 development Blocks, 2715 villages and 10 towns.

The district is characterized by a tropical climate constituting of long and hot summers, fairly pleasant monsoons and cold seasons. The winter usually extends from mid-November to February and is followed by the summer which continues till about the middle of June. The south-west monsoon then ushers in the rainy season which lasts till the end of September. October and the first half of November constitute the post-monsoon season.

The rainfall of Allahabad district generally decreases from the south-east to the north-west. About 88 percent of the annual rainfall is received during the monsoon season. The months during which the district receives the maximum rainfall are July and August. The normal rainfall in the district is 975.4 mm. (38.40”) with significant variations from year to year. On an average there are about 48 rainy days in a year, with little or no variation within the district.

From about the middle of November, the temperatures begin to fall rapidly and in January (the coldest month) the mean daily maximum is 23.7°C. In association with cold waves in the wake of western disturbance passing eastwards, the minimum temperature may go down to a degree or two above the freezing point of water and slight frosts may occur. Temperatures rise rapidly after February. The heat in the summer season-particularly in May and the early part of June is intense. May usually being the hottest month of the year with the mean daily maximum temperature at 41.8°C and the mean daily minimum at 26.8°C. The hot dry and often dusty westerly winds (locally known as loo) make the heat more intense during the daytime especially in the trans-Yamuna tract due to the radiation from the stony outcrops.

Majority of the population lives in urban areas. Net area under cultivation is 3,26,000 hectare, out of which 2,40,286 ha area is irrigated. The district is endowed with good soil, adequate ground water and all three growing seasons, rabi, kharif and summer.

Two important rivers, namely Ganga and Yamuna, divide the district into three physiographic regions.

1. Trans Ganga Region
2. Doab Region &
3. Trans Yamuna Region.

In tehsil Handia, the water table is high and the water in excess, collecting in numerous lakes which form the most noticeable feature of the area, especially in northern part.

The rivers of the district belong to the main system of Ganga and comprise several subsystems of which the most important are the Yamuna and the Tons, other including the minor systems of the Varuna and the Sai.

The district has ground water reserves in the unconsolidated alluvium as well as in the weathered and jointed sandstone areas which are underlain by consolidated hard rocks. In the unconsolidated or alluvial formation ground water occurs in unconfined and confined conditions in the shallow and deeper aquifers, respectively. The depth of water ranges from 2-20 metres in the pre-monsoon period to 1-18 metres in the post monsoon period. In the consolidated formation (Vindhyans) water table ranges between 3.00 and 10.00 mbgl during pre-monsoon period and 2 to 8 mbgl during the post-monsoon period. Seasonal fluctuations range from 1 to 4 metres.

4.3 Socioeconomic profile

The district has a total population of 62, 36,447 as per 2001 census (density:859 persons/sq.km.). The total population of the district was 4, 941, 510 as per the 1991 census. The total population consists of 2, 315, 638 females and 2,625, 872 males. Percentage literacy among males is 77.13% whereas the percentage literacy of females stands at 46.61%. The total percentage literacy of the district is 62.89%.

According to the population assessments from WP3, the population of the district is likely to decrease to a total population 4882759 composed of a rural component of 3508997 and an urban population of 1989705. On comparison with the urban rural ratio in 2001 it is observed that the urban population is likely to increase whereas the rural population is likely to decrease.

Every year approximately 5, 80,398 hectare is put under various crops with cropping intensity of about 157% and has 8.05 lakh cultivators. Wheat is the main crop, followed by paddy. Bajra, pulses, vegetables, potato, guava, mango, cucurbits and banana are other important crops. The northern part of Allahabad district popularly known as Gangapar is endowed with good fertile soil for cultivation of food grains, pulses, oil seeds and vegetables. The southern part of Allahabad, known as Yamuna-par is partly hilly and agriculturally backward.

They follow mix farming for additional income. Dairy activities are being undertaken in the district as a subsidiary occupation. The socio-economic conditions in the district necessitate promotion of dairy activity as an additional source for employment and income. This activity holds more importance when perceived from the point of nutrition for rural poor.

The irrigation of the district takes place through the Ganga Canal network system, lift irrigation systems & tubewells.

4.4 Current and projected vulnerabilities

Located in the mid-stream of the Ganges basin, the district Allahabad holds immense cultural value with the confluence of three major rivers, the Ganges, Yamuna and the Saraswati confined within the boundaries of the district. The district is known to lie below the Kanpur stretch of the basin and the river is known to be severely polluted beyond this stretch.

The change in flows of water and impacts on water availability in this region is likely to affect the availability of water for various purposes including irrigation and other uses. Also predicted are impacts due to deteriorating water quality, to further aggravate if the flows are to be affected with implications on both crop and human health.

4.5 Stakeholder Identification

The list of stakeholders identified for Allahabad includes (Table 12);

Table 12: List of stakeholders for district Allahabad

Stakeholder	**Stakeholder Affiliation**
Agriculture	State Government
Forest	State Government
Environment	State Government
UP Jal Nigam	State Government
Irrigation	State Government
Rural Development	State Government
Planning	State Government
UPCAR	Academic/ Research
WALMI	Academic/ Research
Agriculture Department	Local Government
Rural Development Department	Local Government
Water Resource Department	Local Government
Irrigation Department	Local Government
Planning Department	Local Government
Zila Parishad	Local Government

Details of each stakeholder group and their relevance in the consultation are as follows:

a. Agriculture Department

It is the principal department in the state that is involved in making policy decisions and in the planning and implementation of activities related to the agriculture sector in the State. It monitors the area, productivities and yields of crops that are grown in the region.

b. Forest Department

The primary function of this department is protection, conservation and management of forests in the Uttar Pradesh State. It is responsible for formulation of work plans and policies for the forest resources in the state.

c. Directorate of Environment

The directorate of environment was established following the prime ministers directive in 1976 to address the environmental issues and problems related to sir, water, soil, mining, pollution and other environmental problems. The role of the directorate is to study and bring to the attention of the Government and Parliament instances, causes and consequences of environmental degradation and to establish an environmental intelligence and early warning system. The directorate is entrusted with the overall environment management in the state, environmental clearance of projects, preparing the State of Environment reports and managing the Environment Information System in the State.

d. UP Jal Nigam

The Uttar Pradesh Jal Nigam deals with the drinking water supply in the state, accounting for both surface and groundwater resources. It is also responsible for water quality monitoring at tubewell and borewell sites.

e. Irrigation Department

The Department of Irrigation oversees the works in surface and groundwater irrigation in the state. The projects that are undertaken by the irrigation department include river valley projects, diversion projects and also dams and reservoir projects.

f. Rural Development

The department of rural development aims at achieving various development and poverty alleviation goals through the operation of various schemes. The department also involves Panchayati Raj institutions in the implementation of these schemes.

g. Planning Department

The Department of Planning in the State Government is primarily responsible for making a development plan for the State, to initiate and undertake necessary exercises for this purpose and oversee and take an over-all view of the implementation of the plan, without diluting in any manner the role of different departments of the State government in the formulation and implementation of their respective plans.

h. UP Council of Agricultural Research (UPCAR)

The UPCAR functions as the "Technical Advisory Body" to the Government of U.P. on matters relating to agriculture, policy planning, priority setting with reference to agriculture research and education, and act as a "Think Tank" for policy and long term perspective planning.

i. WALMI

Water and Land Management Institutes in the country were established to bring reforms in Irrigated Agriculture Sector as a sub-set of Water Sector. U.P. WALMI was also established with this aim under World Bank Aided Upper Ganga Irrigation Modernization Project (UGIMP) in 1984. Since then it is imparting training to farmers, NGO’s and various line agency officials, besides taking up research, evaluation studies and consultancies in the area of water & land management.

Chapter 5 Detailed description of Case Study 4 (CS4): Districts Purulia, bankura, West Medinipur in the state of West Bengal

5.1 Study Area (CS4)

Kangsabati River Basin, a part of lower Ganga basin, mainly covers Purulia, Bankura and West Medinipur districts of West Bengal, India. Kangsabati river and its main tributaries originate from Chotanagpur Plateau. After flowing in South-Eastern direction, Kangsabati River falls in the Hooghly River through other rivers in the state. Kangsabati reservoir was constructed at the confluence of two rivers (Kangsbati and Kumari) in Purulia District, West Bengal at 22° 57' 30" N latitude and 86° 45' 30" E longitude. The Kangsabati river basin has an area of about 6000 km^2 (Fig. 10), out of which the area upstream of the Kangsabati reservoir has the catchment of about 3428 km^2. The gross command area of the reservoir is around 5568 km^2 and located between 22° 08' and 23° 13' N latitudes, and 86° 45' and 87° 47' E longitudes. The elevation of the river basin ranges from 110 to 600 m above mean sea level (m.s.l). The average elevation of the region is approximately 200 m. The basin experiences very hot summer with maximum temperature exceeding 45°C in May and June, and cold winter with minimum temperature around 10°C during the month of December.

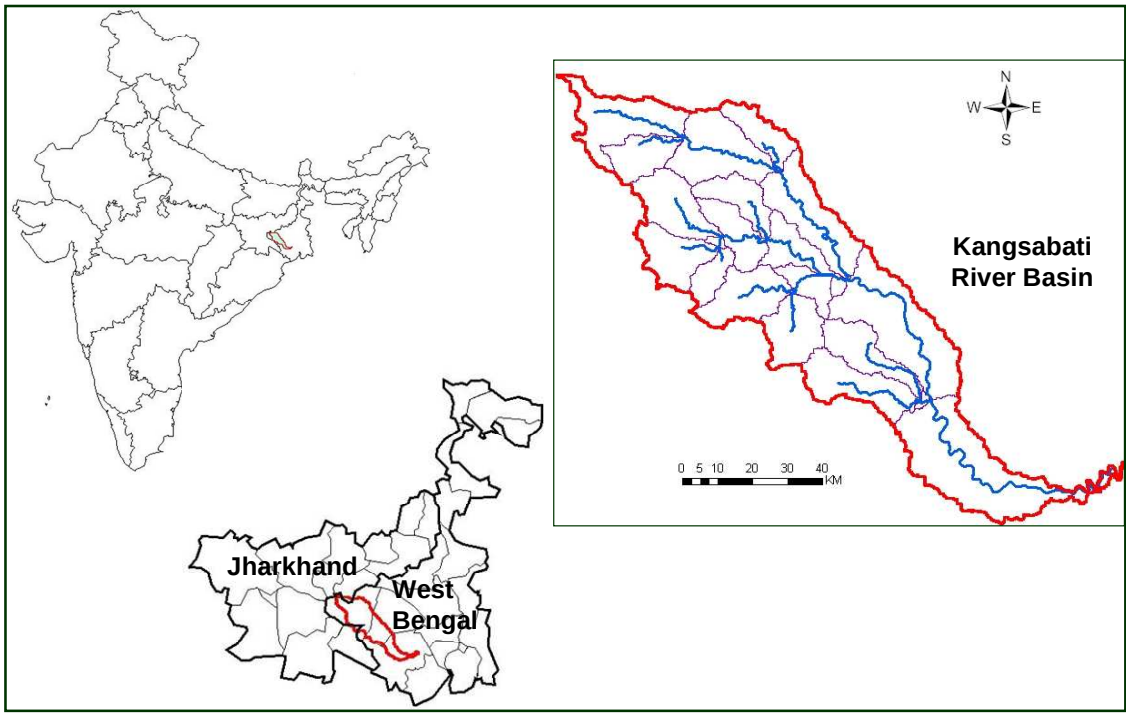


Fig. 10. Location map of Kangsabati River Basin.

5.2 Geology of the Area

The geology of Kangsabati Basin covers terrain formed of hard rocks comprising a rolling topography having (i) Pre-Cambrians, exposed mainly in Purulia district and along the western margins of Bankura and East Medinipur districts, (ii) Gondwana rock formations in the districts of Purulia and Bankura.

The Precambrians are represented by the rocks of Chotonagpur Gneissic Complex which show the presence of a variety of rock types comprising of grey banded biotite gneiss, migmatites, hornblende gneiss, porphyritic granite gneiss, various types of granites, pegmatites, aplite and quartz veins with bands of amphibole, mica schist, calc-granilite, anorthosite and gabbro.

The Gondwanas rest unconformably over the Precambrians. Subsequently the rocks have suffered a series of block faulting. The coalfield has a faulted contact with the Precambrians. A boulder bed, at the base of the sequence is considered to be of glacial origin. Rocks belonging to Tertiaries, represented by pebbly grit, ferruginous sandstone, red shale, rare mottled clays and gravels are reported in the districts of Bankura and East Medinipur.

5.3 Agro-ecology of the Area

According to National Bureau of Soil Survey & Land Use Planning (NBSS & LUP), Kangsabati basin encloses two different agro-ecological regions, (i) sub-humid ecosystem in the western part (Purulia district) of the basin, (ii) humid to perhumid in the eastern part (Bankura and East Medinipur districts).

The western part experiences hot summers and cool winters, with a rainfall of 1000 to 1600 mm, which covers about 80 per cent of the PET leaving demand deficit of 500 to 700 mm of water per year over 150 to 180 days of growing period. The soils are red loamy, non-calcareous and lateritic soil. Seasonal drought and severe soil erosion limits optimum crop yields. Rainfed farming is the traditional practice with cultivation of rice, pulses (moong, blackgram and pigeon pea) and groundnut. In rabi season, rice and wheat are cultivated mostly under irrigated condition.

The eastern part of the basin has hot summers and mild to moderately cool winters, with the rainfall ranging from 1400 to 2000 mm. The growing period is more than 270 days. The soils are alluvial derived and slightly acidic. Flooding, water logging and acidity are the major problems. The water balance shows that precipitation exceeds PET from June to October, followed by a period of utilization till mid-February in most of the years. In view of the high rainfall, the rice-based cropping system is common in this part of the basin. Rice and jute are main crops grown

in rainy season under rainfed condition. Rice, jute, pulses, oilseeds (mustard) are grown on residual soil moisture in rabi season.

Agriculture forms the prime contributor to the economy of the area. Majority of the irrigation requirement is fulfilled by Kangsabati canal system. It provides irrigation potential of 3,48,477 ha in the districts of Bankura and Medinipur. The project, though originally planned for Kharif and limited Rabi, also provides irrigation water for Boro cultivation (rice cultivation as summer/zaid crop) over an area of about 27,944 ha (Irrigation and Waterways Department, West Bengal). The ground-water supports supplementary irrigation. The groundwater management and maintenance of environmental flow are the vital factors for promoting agriculture and sustainable environment. Recent studies have shown that stream-flow and reservoir operation performance are highly sensitive to both precipitation and temperature changes (Guobin et al., 2007; Li et al., 2009 and Ghosh et al., 2010). Present study can be used as a reference to maintain the agro economy of the region and environmental flow of the Kangsabati River under variable climatic conditions. Adaptation measures for mitigation of hydrologic impacts in terms of performance criteria would be suggested for future scenarios.

5.4 Economical status of the study area

Districts of Purulia, Bankura and West Midnapore contributes majority of the land area covered under the Kangsabati watershed. Agriculture in these districts is largely dependent on the monsoon. Drought constitutes a major hazard in these districts. Intermittent gaps of precipitation and moisture stress during the monsoon give rise to serious set back in production during the Kharif, which is the main season of agriculture in these districts. The climate variability would significantly affect the water resource availability in Kangsabati River. The extreme weather conditions such as delay and intense monsoon rains causing drought or floods due to unavailability of water during growing season would have direct consequences on agriculture and socio-economic sector in these particular districts.

In case of Bankura, the district is characterized by an agro-economic base with low level of industrialization and less urbanization. The eastern alluvial tract is well cultivated and most of the area is double cropped. Uncultivable wastelands are not usually found in this part, except in the slopes and banks of drainage channels, which are not suitable for cultivation due to sheet and gully erosion. The district has a low income index at 0.26 with a combined Human Development Index of 0.52, making it among the poorly performing districts in West Bengal.

Similarly, the Purulia district does not fare well on the income index with only 0.18 and a combined Human Development Index of a mere 0.42 making it among the worst performing districts in West Bengal. Cultivation of this district is predominantly mono-cropped rice. The

crops are grown mostly under rainfed condition, generally with low fertilizer consumption per unit area. Thus, per hectare production is also low as compared to other districts of West Bengal.

West Midnapore district has 63 percent of the net cultivable area under irrigation. Kangsabati, Silabati, Subarnarekha, Dulongs, Keleghai and their tributaries are the main rivers of the district but the Kangsabati canal system is the main irrigation scheme. Irrigation is provided to both kharif and rabi crops. The income index is 0.45, which is more than the state average and the Human Development Index is 0.62 making it a comparatively better off district within West Bengal.

5.5 Biophysical Indicators of Vulnerability and Adaptive Capacity

The water available for agriculture production includes soil moisture or water stored in the soil profile, surface water and groundwater (Table 13). Various indicators can be used to monitor the changes in water availability. This study deals specifically with biophysical indicators for vulnerability and adaptive capacity of soil profile, surface and ground water to the changing climate.

Table 13: Selected indicators commonly used to characterise sustainability of water availability under climate change scenarios

Soil profile	**Surface water**	**Groundwater**
Rainfall quantity, intensity and distribution	Rainfall quantity, intensity and distribution	Rainfall quantity, intensity and distribution
Storage capacity of soil	Presence of reservoir	Groundwater depth
Bedrock	Water level in the reservoir	Sustainable level of yield (irrigation and domestic use)
Water infiltration	Total area irrigated from the reservoir	Runoff (water depth, volume, peak runoff)
Ground slope	Water available from stream and its utilisation (seasonal and long-term) to maintain the Environmental flow	Lithology and structural factors (surface water-groundwater interaction)
Soil surface configuration	Runoff (water depth, volume, peak runoff)	
Land use pattern		

Source: El-Ashry 1991; Farroukhi 1995; Hazell *et al* 2001 and Bolaji 2005

Other proposed sub-indicators for increasing the efficiency of rainfed farming include rainfall use efficiency, the amount of water stored in the root zone, total rainfall per growing season, crop transpiration etc.

5.6 Technological Indicators of Vulnerability and Adaptive Capacity

The greater the percentage of irrigation water applied at high efficiency, lesser will be the amount wasted and lower will be the risk of adverse climate change effects. It is important to take into account the share of the irrigated area while considering irrigation as an indicator. The increase in the share of the irrigated area as a proportion of total cultivated land will increase the potential environmental impacts of irrigation technologies. This indicator measures the importance of irrigation in agriculture and shows the vulnerability of agriculture sector to water stress under variable monsoon trends. Other suggested sub-indicators for irrigation management include soil moisture, irrigation scheduling, reservoir inflow etc

5.7 Identification and Description of Stakeholders

In the process of stakeholder identification, three different groups of stakeholders are identified as beneficiaries from this research project. These groups (stakeholders) may also contribute to learn about the impact of climate variability mainly on the water resources and agriculture sector in the Kangsabati River Basin. The survey taken from these stakeholders will be used in identification of technically feasible and politically acceptable adaptation measures that will work to the benefit of local farmers/end users. These groups are-

1- Farmer organizations and NGOs
2- Research Institutions/Extension Centres
3- Government Agencies
    a. Village/Block level agencies
    b. District level agencies
    c. State government agencies, and
    d. Country level organizations

A brief description of these stakeholders is given as below:

a. Farmer Organisations and NGOs

The participation of stakeholders including NGOs and local farmers is based on local knowledge and networks. Farmers' Organizations as a form of "civil society organizations" have the potential to play an important role in the promotion of agricultural production, food security and sustainable utilization of natural resources. It (farmers' organization) has a potential to offer capacity building support especially at village, block and district levels. Especially the group of farmers can explain better the local problems, their causes and possible solution which may not

be possible to formulate within the local resources. However, a two way interaction among end user and solution seekers will emphasize to bring up technically feasible sustainable solution. In the area, a few villages have men and women groups, formally called as 'Self Help Groups', which are involved in raising the group fund through members contribution. This raised fund is used to help the members during the crisis in the form of small loan on a nominal interest. Other groups are involved to solve the local resources problems like water etc.

In the area, NGOs are working as a link between the end user and government to implement/introduce the solutions to the local problems. They are also collecting the information about location specific problems and trying to bring up the solutions from different sources like research institutions and/or extension centres of the government. A few NGOs working in the CS4 are – (NGO – place of working)

- Seva Kendra – West Midnapore, Bankura
- Nivedita Gramin Karma Mandir – West Midnapore
- Shri Ramkrishna Vivekanand Society - West Midnapore, Bankura
- Seva Bharti – Bankura
- Pradan – Bankura , Purulia
- Gramin Vikash Trust (GVT) - Purulia

b. Research Institutions/Extension Centres

It is necessary to formulate ways of making research processes more relevant and meaningful to end users and beneficiaries. This project will address the fundamental component of local innovation where researchers can interact with farmers and design a local knowledge system to solve climate change related problems.

The major research institutions located in and around the study area of Kangsabati River Basin are:

- Agriculture and Food Engineering Department, IIT Kharagpur
- Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, West Bengal
- Agricultural Technology Information Centre (ATIC), Nadia, West Bengal

A number of demonstration cum extension centres, like Krishi Vigyan Kendra (KVK) are located in the study area. These work for community integration through linking advancement of learnings with life at grass-root. KVK is a project of Indian Council of Agricultural Research (ICAR) for testing and transfer of Agricultural technologies to bridge the gap between production and productivity, and to increase self employment opportunities among the farming communities. It offers skill and knowledge oriented trainings in multidisciplinary areas like crop production, plant protection, horticulture, animal sciences, fisheries, home science etc.

Kangsabati River Basin (CS4) area has KVKs in all of its districts (Table 14), which provides a platform to develop strategic partnerships amongst the farmers themselves as well as with research institutions where farmer community can share knowledge and exchange information. It builds partnership for the development and implementation of activities that efficiently address issues that concern the improvement of the agricultural system.

Table 14: Various KVKs located in the study area

District	**KVKs**	**Regulating Authority (Funding and Monitoring)**	**Functions**
Bankura	Krishi Vigyan Kendra, Sonamukhi	Indian Council of Agricultural Research (ICAR), New Delhi Zonal Project Directorate, ICAR , Kolkata	Technology assessment and refinement through on-farm testing Training of farmers, farm women, rural youth Frontline demonstration on different crops Quality seed production
West Midnapore	Seva Bharati Krishi Vigyan Kendra		
Purulia	Krishi Vigyan Kendra, Bongabari		

c. Government Agencies

Different governmental agencies are involved at National, State, District and Block levels. The roles of these agencies can vary from a source of grant funding to policy formulation to planning assistance. A few agencies, working in the CS4 are listed as below-

Table 15: Different governmental agencies involved at different levels

Government Agency	**Regulating Authority (Funding and Monitoring)**
National Bank for Agriculture and Rural Development (NABARD)	Department of Agriculture & Co-operation
Indian Council of Agricultural Research (ICAR)	Department of Agriculture
District Agriculture Department	State Government
District Soil Conservation Department	State Government
Irrigation and Waterways Department	State Government

These agencies are involved in helping the community through resources conservation in an integrated manner with other local, governmental or non governmental organizations. These are

working either on watershed basis for resources management like water conservation or on village level. These agencies select some specific area for development and to solve complicated problem related to water, crop and other social aspects.

6. Conclusion

In this report four case study sites have been identified keeping in mind a broad criteria that serves the purpose of their selection. While Delhi (Case study 1) and Udham Singh Nagar (Case study 2) are located in the upstream areas of the basin, Allahabad (Case study 3) is located in the mid stream and the districts of Purulia, Bankura and West Medinapur (Case study 4) represent the downstream parts of the basin.

Delhi has been selected, as the state is one of the key benefactors of the Tehri hydro project as the state receives a major part of its drinking water and electricity of the city is sourced from Tehri hydro project. Impacts of variations in precipitation and glacial retreat could have serious implications for the water availability in the dam which in turn could affect water supply for electricity generation, irrigation and drinking in this region. The second site Udham Singh Nagar was selected based on its exposure to extreme events like floods etc, the amount of land being cultivated and the number of dependents on agriculture as a source of livelihood. Also, the district is classified as the food bowl of the State and is famous for its agriculture and irrigation on synchronized patterns and productivity rates. District Allahabad was selected as case study 3 under the study. It is located in the mid-stream of the basin, and is exposed to extreme events including drought and floods, water quality and implications on agriculture and health, very high dependence on agriculture. Districts Purulia, Bankura and West Medinapur were selected as districts lying towards the lower end of the basin. Agrarian based, these districts are largely drought affected. All three districts constitute case study 4 under the study.