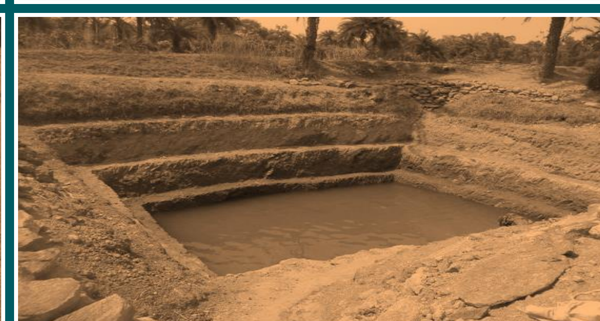

ENHANCING ADAPTIVE CAPACITY AND INCREASING RESILIENCE OF SMALL AND MARGINAL FARMERS OF PURULIA AND BANKURA DISTRICTS, WEST BENGAL TO CLIMATE CHANGE

Enhancing Adaptive Capacity and Increasing Resilience of Small and Marginal Farmers of Purulia and Bankura Districts, West Bengal to Climate Change

School of Oceanographic Studies
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Report 2017

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Summary

The two districts Purulia and Bankura of West Bengal, India are prone to recurrent droughts. The community also perceives drought as a major recurring disaster in it's life and livelihood. With rising winter temperature and increasing variability of rainfall due to climate change, the vulnerability of agriculture sector will exacerbate in future. The present study has been undertaken in collaboration with Development Research Communication and services centre (DRCSC) with funding support from National Bank of Rural Development (NABARD) to increase the resilience of marginal farmers to Climate Change and Climate shocks.

It is for the first time that a micro level drought analysis has been carried out in 40 selected villages of Bankura (Chhatna Block) and Purulia (Kashipur Block) utilizing Geospatial techniques. The objective of the study is to use Geospatial technology to identify the specific problems related to water availability and livelihood at the village level, and to develop a spatial decision support system to formulate strategies to reduce the vulnerability to climate change through effective drought preparedness and proactive management. In the first two years of the project, a data inventory was prepared using GIS based micro-water shed analysis, study of topography, geomorphology, slope, contour, soil and rock types, land-use and land-cover change, ground water table, study of surface water, perennial and non-perennial ponds, wells and tube wells. Meteorological drought analysis at micro level was carried out using drought indices like SPI, NDVI, VCI and MSI. Water resources were identified with the help of Remote Sensing with ground validation. Future domestic water demand was estimated from demographic analysis and per capita water requirement. Crop Water demand was assessed using CROP WAT open source software. Aman paddy happens to be the major crop of Kashipur and Chhatna blocks. The crop Water requirement (610 MCM) and irrigation water requirement (121 MCM) were estimated for Aman cultivation. Monthly crop water demand is found to be maximum in July to September, which reduces considerably during the Rabi and pre Kharif season. The water deficit during monsoon and winter months needs to be met by irrigation, which is hardly present in the villages.

Analysis of rainfall data of 114 (1901-2014) years in Kashipur and Chhatna blocks indicate that the both maximum and minimum temperatures are increasing in the region, the former with

faster rate. Rainfall decreased during the pre-monsoon and post-monsoon seasons in Kashipur. While no significant change is observed in the annual precipitation in Chhatna. Increase in monsoon rainfall with decreasing pre-monsoon and post-monsoon rainfall can be inferred from seasonal analysis. Observing the monthly rainfall pattern, which varies over time and space, is thus important while analysing the deficit in rain water availability affecting monthly drought incidence and crop production.

Spatial analysis using Geospatial techniques could identify areas susceptible to draught of variable magnitudes. While mild to moderate drought prevails in the north, east and north-west part of the study area (villages like Rangamati, Lapara, Patpur, Kashipur, Suaria, Malanch etc.), the southern part (villages like Gopal Chak, Balarampur, Kustor, Jamkiri, Lari etc.) is severely drought prone. **Extreme droughts occur generally in the south-western part (Sunra, Seja, Kashidi, Shampur, Gopalpur, Saharbera villages)** of the study area. **It has been observed in recent years, along with drought severity, drought frequency has also increased in the area**. From 1901 to 1990 the area witnessed one or two moderate to severe drought in every 10 years. Between 1991 to 2010, five severe and one extreme drought occurred in the region. The District administration should step up their drought preparedness planning in the perspective of climate change.

A preliminary Climate Modelling with MPI ECHAM5 using A1B scenario of IPCC indicates that in both Kashipur and Chhatna area temperature will rise in all months during 2020-2050 compared to the average base line of 1961-90. While monsoon rainfall is likely to increase in the months of August, September and October, it will decrease in the sowing season of June and July, as well as during the Rabi season of December, January and February. It can therefore be inferred that the **pre monsoon and post monsoon draught preparedness and risk reduction is going to be the main activity for climate change adaptation in the region.**

It is observed in the study, that incidences of most severe droughts in the area coincide with the '*El-Nino*' conditions in the southern ocean. Since 2000, four droughts in the years 2002, 2005, 2009-10 and 2015-16 of severe magnitude have occurred in the area coinciding with strong '*El-Nino*' conditions, while no such pronounced Nino effect was observed in 2007. '*El-Nino*' conditions have a potential to adversely affect the monsoon rainfall in India resulting in meteorological and consequently agricultural droughts. Therefore, study of **evolving '*El-Nino*' phenomena can be useful for advanced drought warning** and preparedness in Bankura and

Purulia districts. Based on the present trend, it can be inferred that a possibility of increase in '*El-Nino*' events as a result of climate change can aggravate drought situation further in the study area.

In the absence of any viable irrigation (surface/subsurface) facility, the crop production in the area is entirely dependent on rainfall and any deviation from normal rainfall pattern can lead to reduction in crop-production. Differences were observed in crop responses in two drought-prone districts of Bankura and Purulia. It is important to study the impact, separately on a local scale. The Block level study found the Kashipur block of Purulia to be worse affected than Chhatna, Bankura. A strong correlation is found, between amount of rainfall during the months of July and August and success of Kharif crop production. This study also points to the fact that the impact of one drought can have a negative impact on successive years and it withdraws very slowly as the capacity of the vegetation to recover from drought is different for different crops**.** This can be ameliorated by **cultivating less water intensive crops and fodder** which are being actively popularized through this project by DRCSC among the farmers of the area. Practice of **alternative sustainable livelihood** like rearing of livestock and dairy farming to supplement the loss from drought are also being taken up to increase the resilience of the farmers to climatic shocks.

Scarcity of water leads to non-viability of agricultural practice and **low population growth rate** (6% in Kashipur and 15% in Chahatna compared to 17.71% for the state) and pattern of **out migration of marginal workers**. In the two blocks of Bankura and Purulia districts, out migration of people is of serious concern. In both the districts of Purulia and Bankura, **female migration is significantly higher than male migration.** On analysis of data of 3000 surveyed household (1500 in Kashipur and 1500 in Chhatna) it is observed that the maximum numbers of people (39%) who migrate are daily labourer. The next categories are agricultural labourer constituting about 31% of the total population. 5% of the workers migrate to other places for extra income. **The number of migrants from widowed female headed household is 81%** while from married female headed household is 15% in Kashipur. All the pointers indicate the situation as **'migration under distress' rather than by choice in the perspective of water stress and climate change.** Remittance from migration is a major source of income in female headed households. It is therefore not only necessary to reduce the climate risk at micro level and adapt by changing the agricultural and water use practices through a **gender**

sensitive community based planning but also it is necessary to pro-actively address the issue of migration and remittance as an adaptation option in the region for the benefit of marginal communities.

To address the issue of recurrent, often perpetual drought in the villages, the project took up the task of micro water shade identification and water resource study through high resolution mapping using Geo informatics. Village level land use maps were prepared with high resolution satellite data and community involvement. While a positive change is observed in land conversion to forest and agriculture land in a decadal scale, the increase in water bodies, however, falls far short of the requirement. Predictive land use modelling with cellular automata indicates continuation of similar trend of land use change till 2021, unless some policy interventions are made.

In order to plan such interventions, **micro level elevation maps at one (1) meter contour interval** have been prepared for the 40 villages under study along with identification of perennial and non-perennial water bodies, dug wells and other water sources. Using this elevation data, soil types, geological frame work and lineament pattern, micro water shade planning has been initiated for augmentation of water resource.

Agriculture is the main source of livelihood in the region. However, not all of the available agricultural land, (little over 16 KM^2 in the selected villages of Kashipur and around 22 KM^2 in those in Chhatna), are equally productive. Productivity increases in the order of 'Baid' to 'Kanali' to 'Bahal' with decreasing slope and increasing water holding capacity of the soil types. In a unique attempt using object oriented classification of satellite data and Digital elevation model (DEM), a **classification of Agricultural land on the basis of slope, water availability and soil type at the village level** was produced and validated using GPS. It is found that most productive 'Bahal' land are hardly 15% of the agricultural land in the villages of Kashipur, and 24% of that in the villages of Chhatna block. Less productive 'Baid' land constitutes 45% of the agricultural land of the villages in Kashipur and 36% of that in Chhatna. It is therefore imperative that one of the major activities to improve the **drought resilience in the area would be to convert Baid land to comparatively more productive Kanali land by** improving the water availability at appropriate level using ditches and dug wells. Though this spatial decision support system (SDSS), over **250 proposed sites for excavation of ponds, dug wells and ditches work identified and scrutinized** after consulting slope, soil type and water availability in nearby ponds, wells and ditches. Where ever necessary, alternative locations were suggested. Some of these locations would be helpful in transforming Baid land to more productive Kanali land and often making Kanali land suitable to produce more than one crop through augmentation of water supply in the post monsoon. It is further observed that the water available from existing water sources of ponds, dugwell and river lift irrigation (RLI) falls short of the crop, domestic and ecological water demand of the area. An integrated water use plan for the villages should therefore be taken up with creation of additional of water resource by various rain water harvesting and management techniques.

DRCSC already implemented some of the practices in rain water harvesting, drought resistant agricultural practices and training of local people through community based network. Efforts of soil and water conservation, alternative livelihood generation, supply of energy efficient oven, biogas, low cost water filters are showed good results. **Six automated weather stations were installed at Kashipur (Kroshjuri, Nutandi, Ranjandih) and Chhatna (Beriathol, Chachanpur, Jhunjhka)**. Further DRCSC initiated short term **weather forecast and agro-meteorological advisory service** for the farmers of the villages. It is a mechanism to apply relevant meteorological information to help the farmer to make the most efficient use of natural resources, with the aim of improving quality and quantity of agricultural production. DRCSC started Block level quantitative weather forecast up to 5 days from 1st January, 2016. They arranged for communication of this data to the farmers with the help of **SMS to their mobile phones** and also arranged to put it up at the notice boards of DRCSC office and community centers in the area. Forecasts that are provided to farmers through local stations and mobile network have a **success rate of 90%.** Climate based advisories with Sloan Digital Sky Survey (SDSS) support were provide to farmers which proved to be successful in better crop planning.

Finally, to change the agricultural practice of the area and to make the people resilient to climate change, DRCSC took up extensive plantation on barren pediment or Tnar land, initiated mixed cropping practices, winter cropping, organic farming and multilevel cropping system. Seed bank and fodder banks are being installed at selected villages and soil and water conservation measures using step ponds, semi-circular bunds, check dams, gully plugs and infiltration ditches are being implemented. Initiatives on alternative livelihood generation are producing promising results. The interim report summarizes the results of these activities of the last two years (2015-2017).

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Abbreviations

AWS	Automatic Weather Station
BIS	Bureau of Indian Standards
BPM	Buried Pediment Moderate
BPS	Buried Pediment Shallow
CD	Community Development
CGWB	Central Ground Water Board
CM	Cubic Meter
DEM	Digital Elevation Model
DI	Drought Index
DMS	Database Management System
DRCSC	Development Research Communication and Services Centre
DSS	Decision Support System
GIS	Geographic Information System
GOWB	Government of West Bengal
GPS	Global Positioning System
IFS	Integrated Farming System
IMD	India Meteorological Department
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
ISMR	Indian Summer Monsoon Rainfall
ULC	Land Use and Land Cover
MCM	Million Cubic Meter
Ministry of I&B	Ministry of Information and Broadcasting
MODIS	Moderate Resolution Imaging Spectro-Radiometer

MPI-M	Max Planck Institute for Meteorology
MSI	Moisture Stress Index
MSL	Mean Sea Level
NBSS	National Bureau of Soil Survey and Land Use Planning
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NGO	Non-Governmental Organizations
NIR	Near Infrared Band
NRDMS	Natural Resources Data Management System
PDSI	Palmer Drought Severity Index
PHED	Public Health Engineering Department
PRA	Participatory Rural Appraisal
RLI	River Lift Irrigation
SD	Standard Deviation
SDSS	Spatial Decision Support System
SPEI	Standardized Precipitation Evapotranspiration Index
SPI	Standardized Precipitation Index
SWI	Standardized Water Level Index
TCI	Temperature Condition Index
TRMM	Tropical Rainfall Measuring Mission
VCI	Vegetation Condition Index
VF	Valley Fills
VHI	Vegetation Health Index
WB	West Bengal

Background and Context

1. Introduction

Once a part of the erstwhile Manbhum district, Purulia came into existence on 1st November 1956 when the Manbhum district was divided into West Bengal and Bihar. This makes it one of the oldest districts in West Bengal. Purulia shares its western boundary with the district of Bankura while it is flanked by Burdwan District on the northeast and a part of Midnapore district on the southeast. The major part of Purulia bounded by Hazaribag, Singbhum, Dhanbad, Ranchi, Jamshedpur and Bokaro districts of Jharkhand, on its three sides.

	PURULIA	BANKURA
Total Area	6,259 km^2	6,882 km^2
Total Population	29,27,965	35,96,292
Density of Population	470/km^2	520/km^2
Literacy	86.35 per cent	70.95 per cent
Sex ratio	955	914
Average Annual Precipitation	Varies between 1,100mm and 1,500mm	1,400 mm
Highest Point	Ajodhya Hills (855 m or 2,805 ft)	Biharinath (448 m or 1,470 ft)
Longest River	Kangsabati River	Dwarakeswar River
Climate	Sub-tropical climate characterized by high evaporation and low precipitation	Dry and hot summers with moderate monsoons, winters are cool
Terrain	W&S : Rugged hilly terrain the master slope is towards the east and south-east	W&S: Lower edge of Chota Nagpur plateau E and NE: Alluvial plains
Sources	Census, 2011 IOSR Journal of Environmental Science, Toxicology and Food Technology.Volume 9, Issue 8 Ver.I (Aug. 2015) https://en.wikipedia.org/wiki/Purulia_district	

This western most district of West Bengal lies between 22.60º and 23.50º north latitudes and 85.75º and 86.6º east longitudes. Compass declination is 0º22' W. The geographical area of the district is 6259 km². Traversed by the Tropic of Cancer, Purulia has pan India significance because of its tropical location, its topography and funnel like shape. It funnels not only the tropical monsoon current from the Bay to the subtropical parts of North-West India, but also acts as a gateway between the developed industrial belts of West Bengal and the hinterlands of Orissa, Jharkhand, Madhya Pradesh and Uttar Pradesh.

With the second highest concentration of schedule tribe population in West Bengal

(Census, 2011) Purulia lags behind the other districts in terms of economic and human development, but is one of the richest in terms of culture and heritage.

The Bankura district is described as the "connecting link between the plains of Bengal on the east and Chotanagpur plateau on the west. "The areas to the east and north-east are low-lying alluvial plains while to the west, the surface gradually rises, giving way to undulating country, interspersed with rocky hillocks. It is situated between 22°38' and 23°38' north latitude and between 86°36' and 87°46' east longitude. It has an area of approximately 6,882 square kilometres (2,657 sq.mt.). To the north and north-east, the district is bounded by Bardhaman district, from which it is separated mostly by the Damodar River. The district came to be known as Bankura from 1881 and since then the administrative and judicial jurisdictions of the district have been coterminous with the geographical boundaries of Bankura.

- A predicted loss to agriculture in India was 50 % during the drought of 1957-58. The drought of 2002, registering the steepest fall of 29 million tonnes in food grains production, resulting in 25% and 16% reduction in rice and oilseed production, (Ministry of Information and Broadcast Govt. of India).
- In India the infant mortality was high, with infants succumbing to host of diseases mostly due to poor quality of drinking water. There was high rate of mother and child morbidity due to low intake of calories, much below the energy spent for hard labour in relief work during the drought.

The Purulia and Bankura of West Bengal, India are prone to recurrent droughts, often continuing for years. These two districts also rank pretty low in comparison to other districts of West Bengal in terms of composite human development index. As the UN report (UN-WATER, 2006) points out, water development is linked closely with poverty reduction especially in low income countries that are highly dependent on rural economy. Hence it becomes imperative to identify the causes of water scarcity of these two districts that are heavily dependent on rural economy, to bring about both economic as well as human development.

Droughts are categorized as hydro-meteorological risks as they have an atmospheric or hydrological origin (Landsberg, 1982). Although droughts are related to a decrease or absence of precipitation, they are complex natural phenomena without a general and commonly accepted definition (Wilhite, 1993). In contrast to other extreme events such as floods, which are typically restricted to small regions and well-defined temporal intervals, droughts are difficult to identify in time and space, affecting wide areas over long periods of time. It is very difficult to isolate the beginning of a drought, as drought development is slow and very often not recognized until human activities or the environment, is affected. Moreover, the effects of one drought occurrence can persist over many years after it has ended (Changnon and Easterling, 1989).

Purulia district ranks first in vulnerability to drought hazards within the state of West Bengal. Thus the district is called "Ahalya Bhum"- the land with a stony heart. While in Bankura, the land being undulating, lateritic and porous, it results in poor subsoil moisture which becomes a potent threat to the crop. Seasonal precipitation varies translating into even higher variability in crop production. The seasonal drought frequency and intensity in Bankura, Purulia and Midnapur, according to standard precipitation index (SPI) values are 9,10 and 9 respectively in pre-monsoon, 3, 3 and 5 respectively in monsoon and 4, 4 and 2 respectively in post monsoon period (Kar, B. and Saha, J. 2013).

The usual impact of agricultural drought is generally manifested in terms of loss of crops, malnutrition of human beings and livestock, land degradation, loss of other economic activities, spread of diseases, and migration of people and livestock. The drought not only adversely affects the food security at the farm level but affect the national economy and overall food security as well.

With the agricultural production falling down to 65%, Purulia is the most affected by drought occurrences followed by Bankura and Birbhum, where production has fallen to 30% and 33% respectively in 2009 (Ministry of Information and Broadcast Govt. of India, Hindustan Times, Aug 2010).

It has also been observed that there are specific geographical concentration of backwardness and poverty in drought-prone areas. Incessant degradation of natural resources, severe erosion, depletion of ground-water reserves, low productivity etc., are some of the endemic problem in these areas (District Human Development Report, Bankura).

The present study has been undertaken in collaboration with DRCSC with funding support from NABARD to increase the resilience of marginal farmers to Climate Change and Climate shocks.

1.1 Location

The present research is focussed on two administrative blocks of Bankura and Purulia district of West Bengal. The Kashipur block, situated in the south eastern part of the Purulia district. The study area falls between latitude 23°26'54.50"N and 23°21'26.92"N, longitude 86°34'20.84"E and 86°49'50.78"E, with an area of 433.62 km^2. Around 40 villages are selected to enhance the drought resilience of the marginal community for adaptation to Climate Change.

The Chhatna block, is situated on the northern part of the Bankura district. The block is bounded by latitude 23°27'8.37" N - 23°18'2.90" N and longitude 86°49'27.18"E - 87°0'34.08" E, with an area of 449.32 km^2.

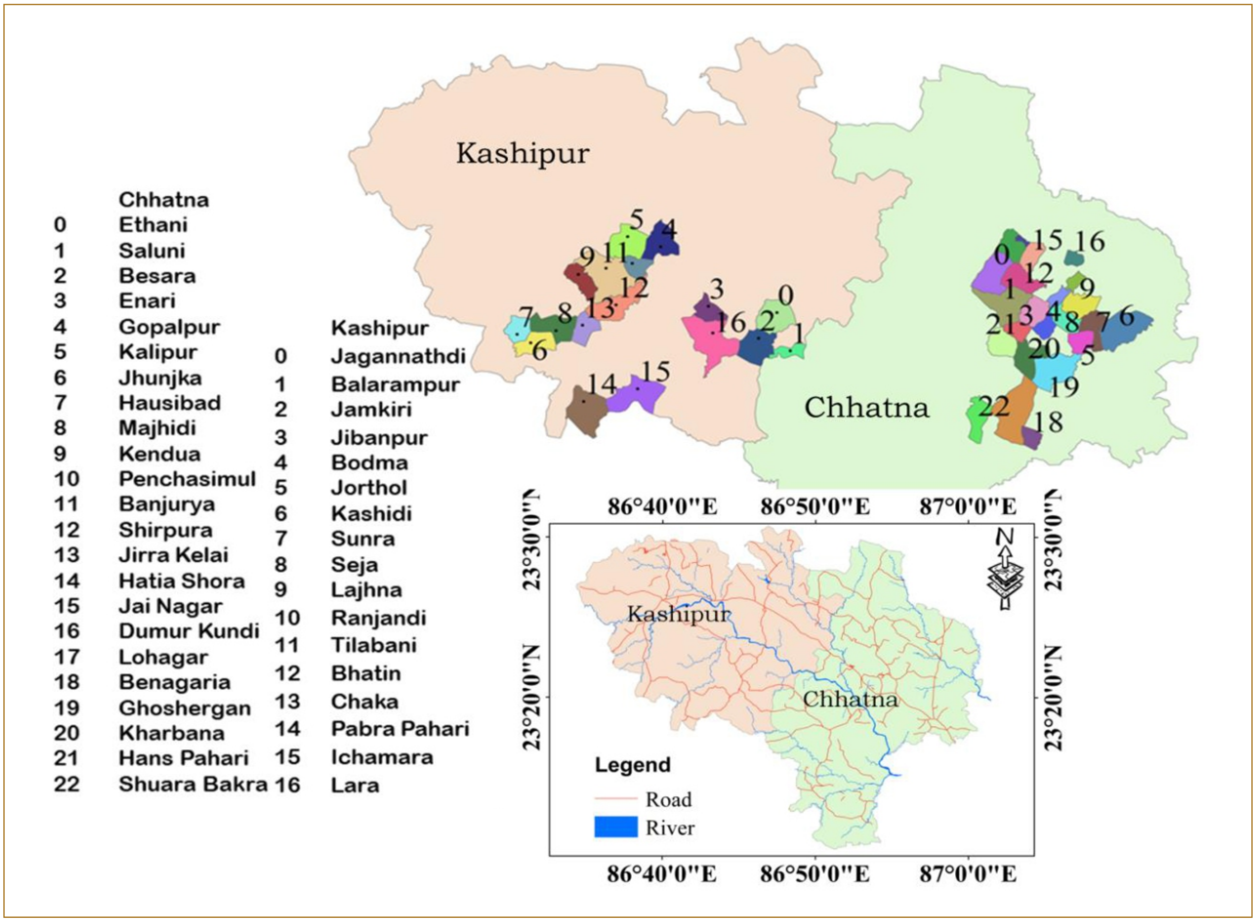


Fig 1.a Location of Study Area and Villages

1.2 Geology

The Chhatna block comprises of Pre-Cambrian crystalline basement and recently deposited alluvium connected by an intervening tract. The area is predominantly a Precambrian gneissic terrain. The Kashipur is mainly a hard rock terrain comprising of crystalline gneiss occurring at a very shallow depth. Geologically, Kashipur and Chhatna blocks are dominated primarily by Granite Gneiss rocks of Chotonagpur Plateau. Proterozic hard granite gneiss, Proterozic soft, flaky phyllite and mica schist belonging to the Singhbhum Group, composed of quartz, muscovite and biotite mica, are the dominant rocks in this area. Regionally, the area is a part of Chotanagpur Gneissic Complex of Eastern Indian Peninsular Shield, lying to the north of the Singhbhum Craton. China clay occurrences of Purulia district are invariably associated with Granitic rocks and metasediments of the Chhotanagpur Gneissic Complex of Precambrian age (Dunn and Dey 1942).The area is mostly covered by laterite soil and represents undulating topography with moderate to gentle slopes. The general E-W strike of the formations is prevalent in this region. The rocks usually dip at moderate to high angle in the northerly direction. The regional structure consists of close isoclinal folds, in which the fold axes are either horizontal or plunge at low angles, towards the east or west.

1.3 River

The Dwarakeswar River is one of the largest rivers in this area, flowing from northwest to southeast, almost dividing the Chhatna block into two equal halves and flowing through Kashipur block from west to east.

1.4 Climate

Purulia and Bankura are drought prone districts of West Bengal. The sub-tropical climate of the districts are characterized by high evaporation and low precipitation. Temperature soars in the summer months and dips in the winter with the seasonal variation ranging from 12 degrees in winter to 45 degrees in summer, making it moisture deficient. South-west monsoon is the principal source of rainfall in the districts, while some amount of winter rain is not uncommon. Average annual rainfall varies between 1100mm to 1500 mm. The relative humidity is high in monsoon season, being 75% to 85%, but during dry summer months it comes down to 25% to 35%.

1.5 Soil

Soil of Purulia and Bankura districts can be broadly grouped into three principal types namely (1) Red Soil (2) Alluvial Soil and (3) Lateritic Soil (Groundwater Resources Assessment and Management of the Bankura District, CSME, 1993). Red and Lateritic soil dominate the landscape and gradually merge with old alluvium towards east. Gravelly soil is also found in patches in the vicinity of the hills. In general, the soil is thin, coarse grained, poor in organic matter and very poor in water holding capacity.

1.6 Natural Vegetation

Natural vegetation of the blocks consists of tree, shrubs, grass and weeds. The major tree species are Sal, Mahua, Palas, Kend, Arjun, Shimul, Pipal etc. Some important shrubs and herbs are Lal Bharenda, Nishinda, Maranphal, Ghetu etc. The grasses found in the field are Sar, Kans, Mutha, Kansira etc.

1.7 Hydrogeology

The crystalline rocks of Chhatna and Kashipur are usually very hard, massive and compact in nature but are generally fractured, jointed and traversed by veins of quartz and pegmatite. These rocks become disintegrated and decomposed near the land surface commonly referred to as “weathered zone” or “weathered residuum”. This zone and fracture zones within the hard rocks serve as the main ground water storage in the area. However, due to high content of Apatite in Pegmatites and other fluoride bearing mineral in the crystalline gneisses, ground water is often polluted with Fluoride much above the permissible limit.

1.8 Demography

As per the 2011 Census of India, in the Chhatna block, the total population was 1,95,038, out of which 51.62% were males and 48.97 % were females. Kashipur had a total population of 2,00,083 of which 51.1% were males and 48.75% were females. Population below 6 years in Kashipur was 11.86%. Percentage of Literacy in Kashipur was 62.45% and in Chhatna it was 57.65%. In Chhatna block the working population was only 39.58% out of the total population (77212 person) of which 40,212 (20.16%) were main workers and 37,000 (18.97%) were marginal workers. There were 82,995 workers (41% out of the total population) in Kashipur, of which about 37,495 (18.25% out of the total workers) belonged to main workers and 45,500 (22.45%) to the marginal workers. Most workers were from the marginalized sections of society and a large number of them were agricultural labourers.

1.9 Major Objectives of the Project

Delineation of Drought Affected Villages and Drought Severity Assessment

- Spatial analysis and relative vulnerability assessment of the study area using Remote Sensing and GIS.
- Drought frequency and severity assessment.
- Analysis of pre and post-monsoon drought.

Analysis of Meteorological /Climatic Factors Responsible for Drought Phenomena

- Rainfall and temperature pattern analysis of drought prone area for the last decade and establish a relationship between drought severities with climatic factors.
- To assess the net water availability and soil condition.
- Analysis of other local physical phenomena for drought assessment.

Analysis of Effect of Drought on Agricultural Economy of the Drought Affected Districts

- To study the agricultural practice of the area and the impacts of drought on agricultural production and water resource analysing the appropriateness of such practices.
- Pre and Post Monsoon drought stress on vegetation / crop growth pattern.
- Estimation of drought effected population.
- Crop productivity loss estimation in the severe and extreme drought affected areas.

According to the recent Economic Times report, The Irrigation and Waterways Department, Govt. of West Bengal, has chalked out a projects worth Rs.30 crore to ensure water supply to 35,000 acre of agricultural land in the drought-prone Purulia district. The plan includes restoration of canals and repair of embankments. The department has already created 89 check dams in neighbouring Bankura district and work to construct another eight is on. (https://economictimes.indiatimes.com/news/politics-and-nation/west-bengal-chalks-out-irrigation-plan-for-drought-prone-puruliadistrict/articleshow/58259486.cms).

This is a timely study to understand the impact of future climate change on the drought prone Purulia and Bankura districts with special emphases to and agricultural productivity. The coping mechanisms of the affected population with an aim to building their resilience to such adverse events is another major objective of the study.

2. Land Use and Land Cover

Village level Land Use and Land cover maps have been prepared from high resolution satellite images using Remote Sensing and GIS.

2.1 Land Use and Land Cover Analysis

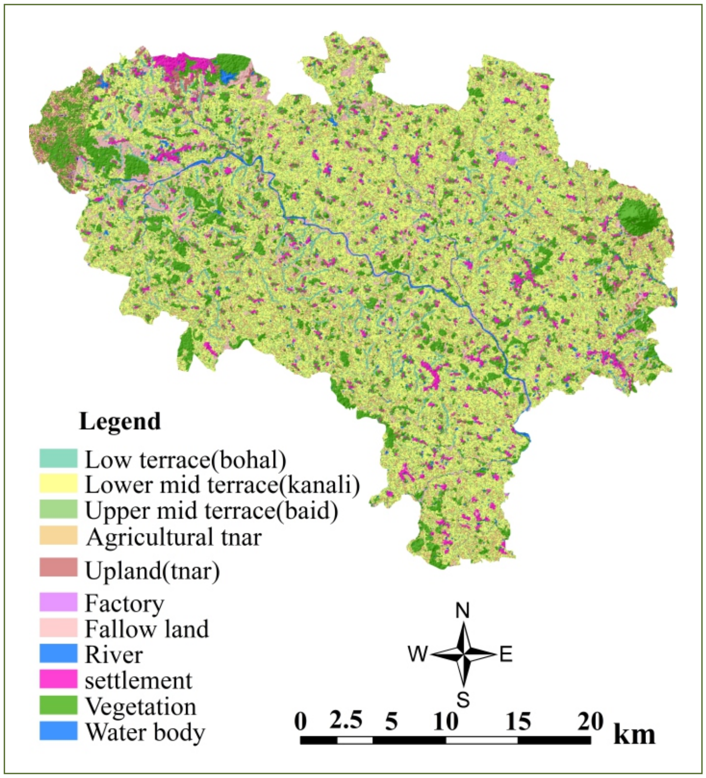


Fig 2.a Land Use/Land Cover Map of Kashipur and Chhatna Blocks (2015)

Land use and Land cover types and their change play a significant role in the development of resources of an area. It controls many hydrogeological processes in the water cycle viz., infiltration, evapo-transpiration, surface runoff etc. Surface cover provides roughness to the surface, reduces discharge thereby increasing infiltration. In the forest area, infiltration is more and runoff is less, whereas in hilly area, rate of infiltration may decrease. Land use/Land cover maps of 2015 have been prepared for the 40 villages and two CD Blocks from high resolution (LISS IV) Remote Sensing data. Supervised classification with adequate field validation has been done for the Land Use/Land Cover classification.

In 2015, the most extensive land use/land cover category of the Kashipur block was forest and vegetation, which comprised 185.81 Sq.Km. (42.97%). The second extensive land use category was pediment, which covered 91.12 Sq.Km. (21.07%). Agricultural land was around 84.58 Sq.Km (19.56%) but a dominant portion of it (10.12%) remained unavailable for cultivation (43.73 Sq.Km).

The Chhatna block also exhibited the same trend. The forest and vegetation was the major land use/land cover type comprising and area of 177.17 Sq.Km. (39.43%). The second most extensive land use/land cover category was agricultural land, which comprised 126.34 Sq.Km. (28.12%) of land. The pediment covered 86.02 Sq.Km (19.14%) and the fallow land cover was of 31.23 Sq.Km. (6.95%). Water bodies like ponds, streams and rivers are noticed in both the blocks. A healthy trend of increase in forest cover and agriculture land at the expense of barren pediments has been noticed in the area because of various initiatives taken by the Government bodies and Non Governmental Organizations.

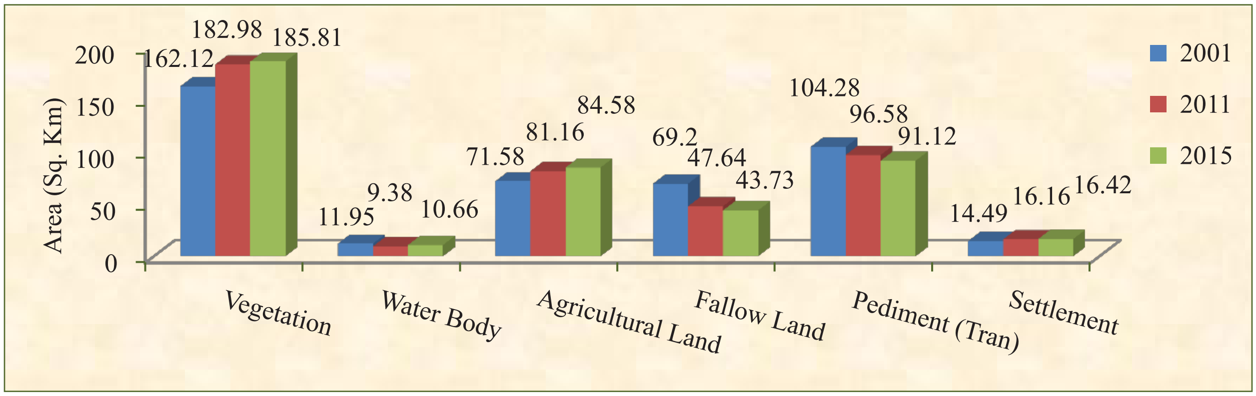


Fig 2.b Land Use/Land Cover Area of Kashipur in 2001, 2011 and 2015

2.2 People's Perception on Land Use and Land Cover Mapping

In addition to the high resolution mapping using Remote Sensing techniques land use/land cover mapping in the village level has also been done through a participatory approach involving the local people. The women, who are found to be better aware about the natural resources (including water) of the villages are particularly involved in this process. In the PRA mapping exercise conducted by the DRCSC, villagers could draw a map of the natural resources as well as the available utilities. Participatory mapping was found to be an important communication tool for promoting further discussions on resource management plans to enhance drought resilience.

Participative (PRA) Land Use and Land Cover Mapping: Jagannathdih (Kashipur)

2.3 Land Use/Land Cover Change

The comparative study of maps for two years (2001 and 2015) reveales the geographical distribution and changing nature of different land use/land cover categories in the study area, which has been summarized below:

Conversion of Pediments to Agriculture

- The area under forest land has increased from 138.59 Sq.Km. in 2001 to 177.17 Sq.Km. in 2015 in Chhatna and from 162.12 Sq.Km. in 2001 to 185.81 Sq.Km. in 2015 in Kashipur, showing a net increase of 38.58 Sq.Km. and 23.69 Sq.Km. in Chhatna and Kashipur respectively.

- Between 2001-2015, in Kashipur, the fallow land and pediment has decreased from 69.2 Sq.Km. to 43.73 Sq.km and 104.28 Sq.Km. to 91.12 Sq.Km. respectively. Chhatna, also showed a decrease in the fallow land and pediment from 45.62 Sq.Km. in 2001 to 31.24 Sq.Km. in 2015and 126.73 Sq.Km. in 2001 to 86.03 Sq.Km. in 2015, respectively.

- It has been seen that agricultural land has also increased from 71.58 Sq.Km. in 2001 to 84.58 Sq.Km. in 2015, in Kashipur and from 114.8201Sq.Km. to 126.34 Sq.Km. in Chhatna.

- During this period (2001–2015) negligible changes have occurred in water bodies, which have increased from 9.01 Sq.Km. to 12.67 Sq.Km. in Chhatna and from 10.66 Sq.Km. to 11.95 Sq.Km. in Kashipur.

- Land use/land cover change maps of Kashipur and Chhatna between 2001 and 2015 indicate that settlement, agricultural land and forest area have gradually increased at the expense of fallow land and barren pediment.
- Up land has mostly been converted into forest and vegetation in Kashipur (15.98%) and Chhatna (10.62%).
- Fallow land has been converted into agricultural land, in Kashipur (15.6%) and Chhatna (10.7%).
- Few conversions of forests into settlements have also occurred.

2.4 Trend of Land Use/Land Cover Conversion

The conversion among different land use/land cover categories is shown in Table.1 for the period 2001 to 2015. The change in the areal extent of a particular category is linked to the change in the areal extent of one or more categories in the study area.

Table 1: Land Use/Land Cover Change Matrix

Land Use Change (2001-2015)	Kashipur (%)	Chhatna (%)
No change	49.65	53.69
Fallow to Agriculture	15.6	10.07
Fallow to Settlement	0.82	1.41
Fallow to Vegetation	6.48	3.4
Fallow to Water Body	0.06	0.22
Upland to Agriculture	2.58	5.42
Upland to Fallow	0.74	1.41
Upland to Settlement	0.93	0.9
Upland to Vegetation	15.98	10.62
Vegetation to Agriculture	2.66	4.9
Vegetation to Water body	0.03	0.58
Vegetation to Fallow	0.65	0.42
Vegetation to Settlement	1.14	1.1
Agriculture to Fallow	0.35	0.3
Agriculture to Settlement	0.12	0.21
Agriculture to Vegetation	0.55	3.35
Agriculture to Water Body	0.68	0.89
Water body to Agriculture	0.05	0.37
Water body to Fallow	0.3	0.17
Water body to Settlement	0.02	0.03
Water body to Vegetation	0.61	0.55

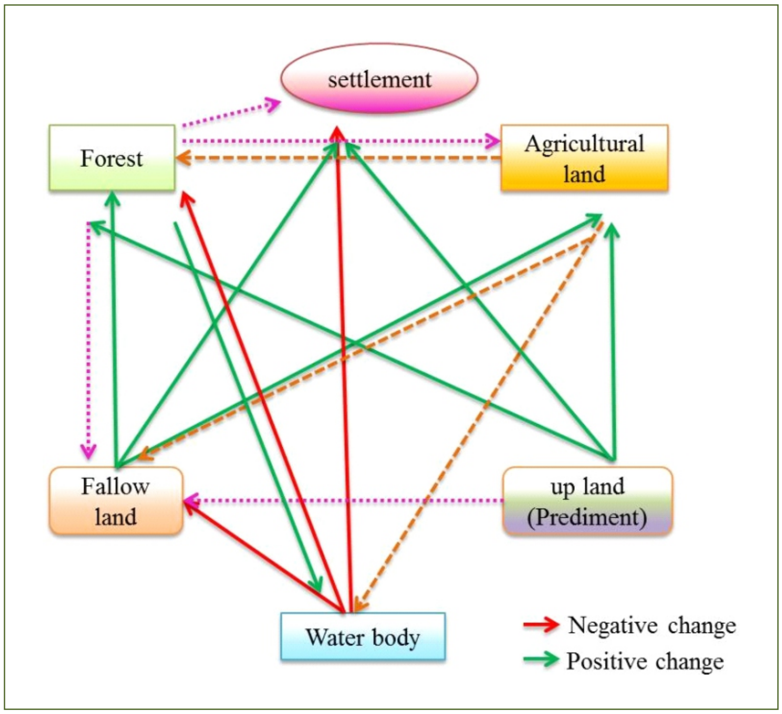


Fig 2.c A Schematic Model of Land Use/Land Cover Change in Kashipur and Chhatna

A schematic model has been prepared for the study area (Fig.2.c). The model shows that fallow land has been converted to forest (6.48% in Kashipur and 3.40% in Chhatna) due to social forestry and cultivation (15.60% in Kashipur and 10.07% in Chhatna) and settlement (1.41%) due to population growth. Similarly, the upland has been converted to agricultural land, forest and settlement (22.26 % in Kashipur and 18.23 % in Chhatna) due to the demand for agriculture, social forestry and the increasing demand of land for settlement. In some areas, agricultural land has been converted to fallow land (0.35%) and water bodies have been converted to vegetation (0.61%) or fallow land (0.35%) due to lack of soil and water conservation. However, about 50% of the area that is about 439.25 Sq.Km., has remained unchanged over 15 years.

Plantation on Pediments/Waste Land (Tnar)

2.5 Predicted Land Use/Land Cover

Since 2001, due to a slow pace of development, the Land Use and Land Cover Change (LULC) of Kashipur and Chhatna blocks have changed marginally. Future LULC in Kashipur and Chhatna have been simulated and predicted using the CA-Markov model for understanding the dynamics of land cover change in these two blocks to act as a reference for further planning. Land use maps in 2000 and 2010 were defined as input data to simulate 2021 and 2031 land-use scenarios. According to the prediction results shown in Figure 2.d, the vegetation and agricultural area would increase, mostly at the expense of pediment and fallow land. The increase in settlement would result in loss of some vegetation and upland. Water bodies are projected to increase slightly, unfortunately much below the demand of increased population, while unused land remained unchanged in the future too, under business as usual scenario.

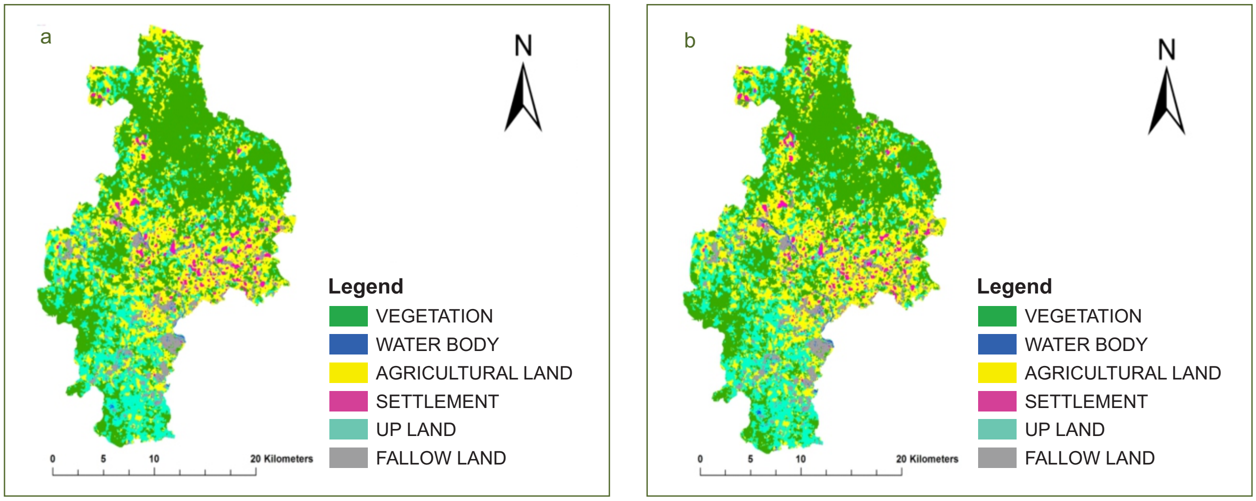


Fig 2.d A Predicted Land Use/Land Cover Area of Kashipur and Chhatna in (a) 2021 and (b) 2031.

Table 2: Predicted Land Use/Land Cover Area of Kashipur and Chhatna in 2021 and 2031

	2001	2011	2021	2031
Vegetation	138.59	173.45	184.54	188.16
Water Body	9.01	8.16	10.36	11.75
Agricultural Land	114.82	119.78	122.86	125.48
Fallow Land	45.62	33.72	22.95	20.28
Pediment (Tnar)	126.73	99.01	93.62	87.11
Settlement	14.88	15.54	17.31	18.73

Water is the most abundant substance on earth, the principal constituent of all living things, and a major force constantly shaping the surface of the earth. It is also a key factor in air-conditioning the earth for human existence and in influencing the progress of civilization (Chow, 1988). As has already been discussed, in the study area, water is under severe pressure due to growing population and limited availability. The disparity between increasing demand of water and limited water availability creates a gap leading to water scarcity. Scarcity of water affects all sectors and is indispensable for almost all economic activities, including agriculture, energy production, industry and mining. Along with land use, assessment of water use and water availability is therefore a prerequisite for implementation of any strategy for increasing resilience to climate change.

3. Geomorphological Analysis

Delineation of micro-watersheds through morphometric analysis in blocks has been attempted through integrated use of remote sensing and GIS techniques.

3.1 High Resolution Contour Mapping (1m interval)

In cartography, a contour line joins points of equal elevation (height) above a given level, such as mean sea level. A contour map is a map illustrated with contour lines, for example, a topographic map, which shows valleys and hills, and the steepness of slopes. From the contours, it is possible to determine the catchment area and hence the quantity of water flow at any point of *nalla* or river can be estimated. This study is very important in locating bunds, dams and also to find out flood levels and the capacity of reservoirs. For the 40 villages in the study area, contour maps at 1meter interval have been prepared using GPS and Geo informatics. This can be used more advantageously for micro-level planning of water resources over the available contour maps at 10/20 meter interval.

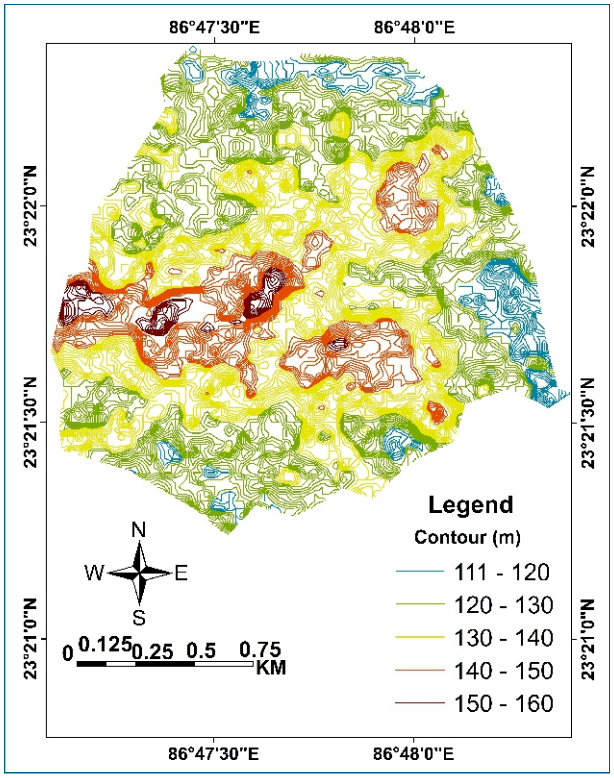


Fig 3.a High Resolution Contour Map of Jagannathdih Village

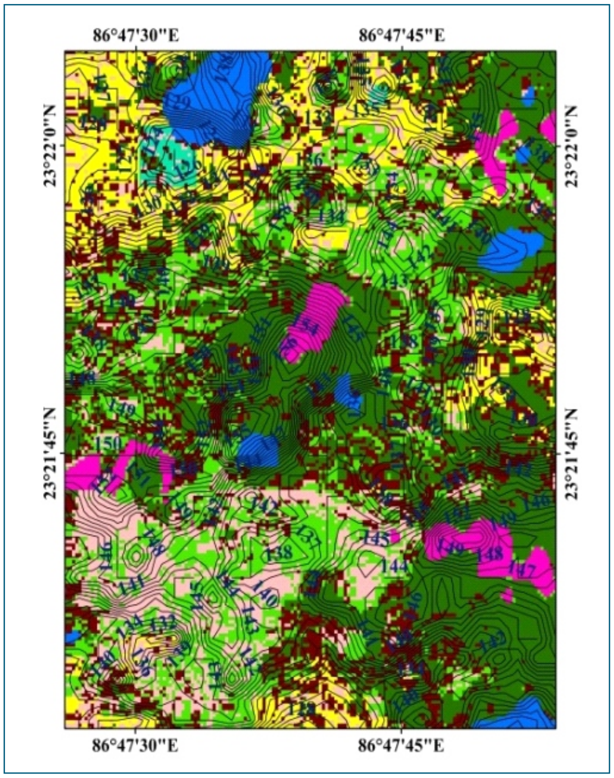


Fig 3.b Contour with Land Use/Land Cover of Jagannathdih

3.2 Slope

The slope or gradient of a line is a number that describes both the direction and the steepness of the line. A higher slope value indicates a steeper incline. The slope is denoted by the letter “m”, $m=\Delta y/\Delta x=\tan\theta$ where y referred to as "rise" and x refers to the "run" between two points on a line. In other words, it is the ratio of the altitude change to the horizontal distance between any two points on the line. Generally, flat and gently sloping areas promote infiltration and groundwater recharge, and steeply sloping grounds encourage run-off with little or no infiltration. The slope map of the study area has been prepared from digital elevation model (DEM). The slope of the area ranges between 0-40^{0}with the maximum value of slope being in the Shusunia Hill area in Chhatna block, Bankura.

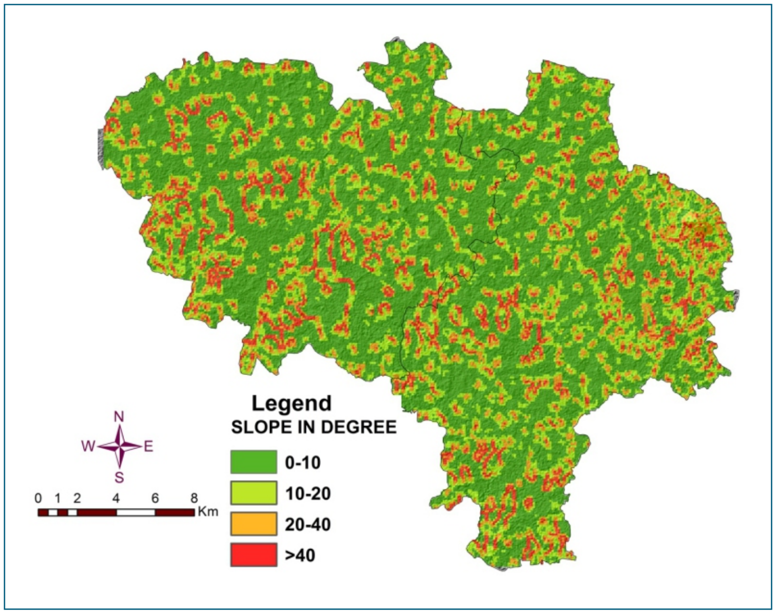
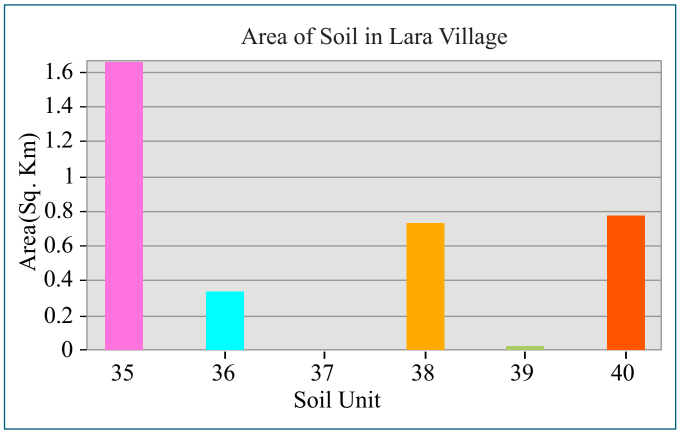


Fig 3.c Slope Map of Kashipur

- High resolution (1m interval) contour map has been prepared at village level.
- Agricultural land has been classified into four categories (Bahal, Kanali, Baid and Tnar) according to elevation, slope, water holding capacity and suitability for growing crops at village level.
- The general elevation of the area ranges from 80 to 400m above mean sea level (MSL) and the highest peak in the blocks is Shusunia (430m). The master slope is towards the east and south-east.

3.3 Soil

Soil formation involves action of climate, organism, relief, parent material and time. Soil of Kashipur and Chhatna blocks are the resultant product of interactions of different soil formation factors as mentioned above. Amongst the mentioned factors, the parent rock, climate and relief seem to play the dominant role in soil formation. Due to the complex interaction of these factors, different types of soils have formed in the study area. For example, one village in the study area exhibits four types of soil series. The total geographic area of Lara village in Kashipur block is 5.09 Sq.Km. of which 1.6 Sq.Km. is under loamy skeletal soil series lajhna-hariharpur, 0.35 Sq.Km. is under loamy skeletal soil series baraban-lajhna, 0.75 Sq.Km. is under sindurpur-lajhna-baraban series and 0.79 Sq.Km. is under nadiha mukundapur soil series (source: NBSS). Village level soil maps of Kashipur and Chhatna blocks have been prepared for associated water management and conservation, and for agricultural planning.



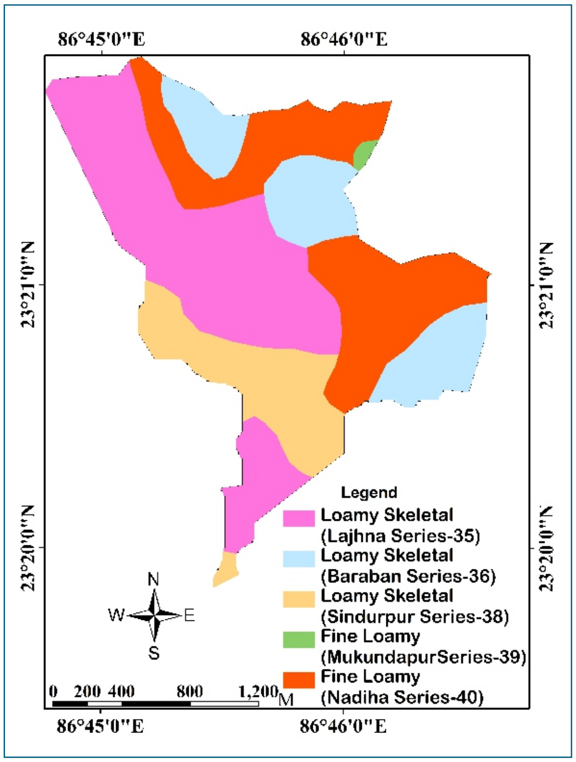


Fig 3.d Soil Map of Lara Village

3.4 Drainage

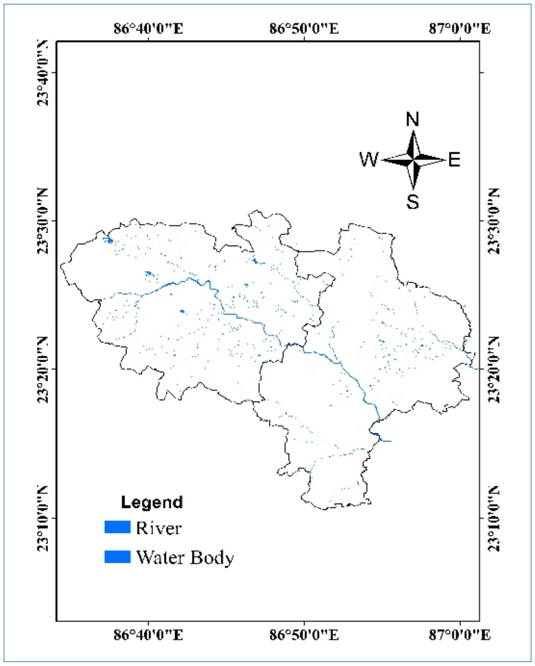


Fig 3.e Drainage Map of Kashipur and Chhatna

Drainage density and type of drainage gives information related to runoff, infiltration relief and permeability. Drainage pattern reflects surface characteristics as well as subsurface formation (Horton, 1945). Dendritic drainage indicates homogenous rocks, the trellis, rectangular and parallel drainage patterns indicate structural and lithological controls. A coarse drainage texture indicates highly porous and permeable rock formations; whereas fine drainage texture is more common in less pervious formations. Major faults or lineaments sometime connect two or more drainage basins and act as conduits (Interconnecting channel ways). Flow of groundwater along these weak zones is an established fact. In the study area, the drainage pattern is generally dendritic and following the natural slope of the land, all the rivers, flowing through the two blocks have easterly or south-easterly course. The Dwarakeswar is the master-stream while the other important rivers are the Ghandheswari River, Arkusha River, Beko River, Dangra River, Darubhanga River. The Beko Irrigation Scheme is comprised of a small earthen dam on river Beko. The reservoir provides water requirement of Kharif crops when there is erratic rainfall. There is also a reservoir on River Andrabi. However, major emphasis has been given to locate and identify small streams, Jor or *Nallahs* to plan small check dams and other water harvesting methods using monsoon run off.

3.5 Micro Watershed Delineation

A watershed provides a natural geo-hydrological unit for planning any developmental initiative. A watershed perspective can be used scientifically to study the effect of land use on water and downstream ecosystems. A watershed is defined as a topographically delineated area drained by a stream system; that is, the total land area above some point on a stream or river that drains past that point. A watershed acts as a receiver, collector, and conveyer of precipitation on a landscape. Land uses affect these pathways by altering surface runoff and groundwater infiltration, thereby changing the quantity and quality of water resources. Micro watershed management needs to be achieved for adequate management of the land and water resources which provide life support for rural communities.

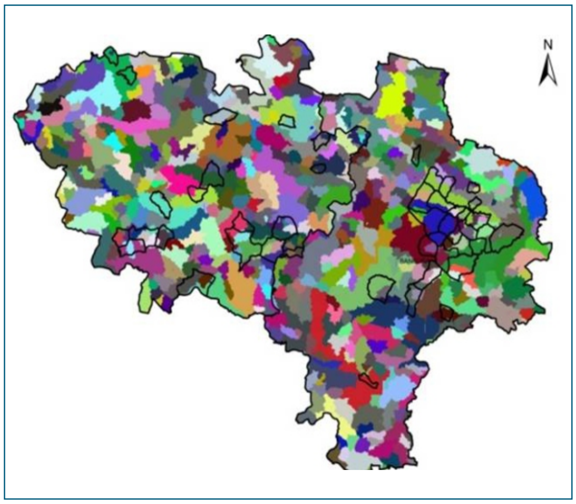


Fig 3.f Micro Watershed of Kashipur and Chhatna

3.6 Hydrogeomorphology

The hydrogeomorphology in the hard rock terrain is highly influenced by the lithology and structure of the underlying formations. The area is characterized by a dominant rocky terrain and a number of erosional and depositional hydrogeomorphic features, which are manifested by hills, uplands and undulating surfaces. Geomorphology of an area is one of the most important features in evaluating the groundwater potential and prospect (Kumar et al. 2008). Remote-sensing studies provide an opportunity for better

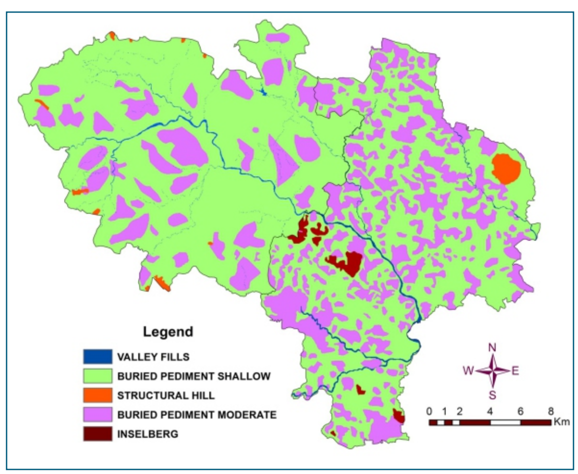


Fig 3.g Hydrogeomorphological Map of Chhatna

observation and more systematic analysis of various hydrogeomorphic units/land forms/lineaments features following the synoptic, multispectral repetitive coverage of the terrain (Horton 1945; Kumar and Srivastava 1991; Sharma and Jugran 1992; Chatterjee and Bhattacharya 1995; Tiwari and Rai 1996).

Structural Hills (SH)

These are broad uplands of considerable elevation, steeply sloping on all directions. Very shallow, coarse loamy soil on moderately steep to very steep hill slopes and open to dense forest and plantation, not suitable for agriculture/pasture/orchards occur here. From the groundwater point of view, the structural hills serve as high run-off zones. The recharge is poor and restricted mainly along the joints, fractures, and faults.

Valley Fills (VF)

The valley fills are accumulation zone of colluvium materials derived from surrounding uplands. The colluvium is shallow to deep and is made up of fine loamy to clayey soil. The soil is fine-textured and moderately well-drained soils with moderate limitation of wetness. The soil has very good porosity and permeability but sometimes the presence of clay may make it impermeable Mono-cropping and terrace cultivation is a noticeable agricultural classes of this zone.

Buried Pediment Moderate (BPM)

BPM exhibits gently sloping topography with very deep, clayey to fine loamy soils that is moderately deep to deep. The soil is fine-textured loamy skeletal to coarse loamy soil. BPM is a single crop area with marginal "Rabi" crops being cultivated. Groundwater prospects are also moderate.

Buried Pediment Shallow (BPS)

BPS has nearly flat to gently sloping topography with shallow to moderately deep, loamy soils followed by regolith zone. The soil is very shallow to shallow, coarse-textured with

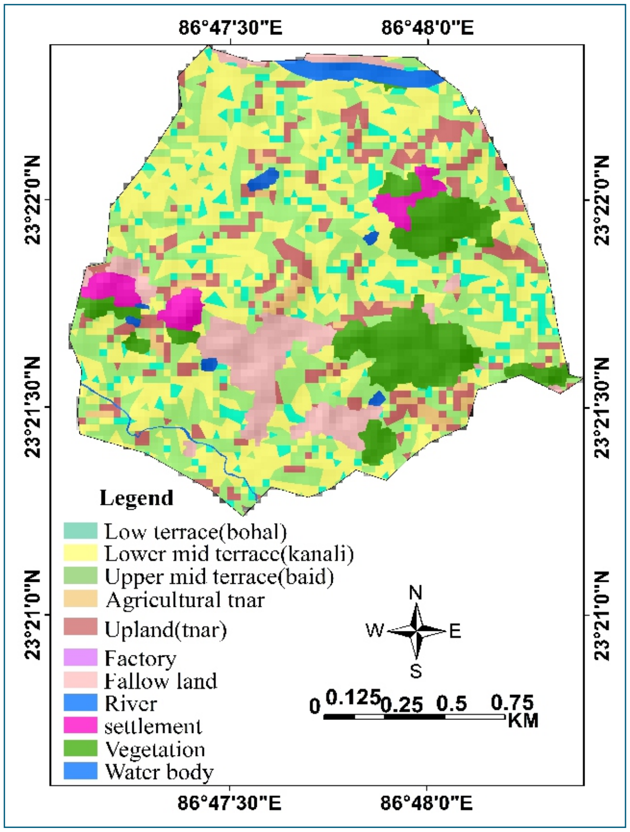


Fig 3.h Agricultural Land Classification of Jagannathdih

occasional weathered outcrops of country rocks. This is also a single crop area. Ground-water prospects are moderate to poor, but open wells yield a good amount of potable water after monsoon rains.

3.7 Agricultural Land Classification

Kashipur and Chhatna blocks have mainly agricultural land as agricultural is the chief source of livelihood in these blocks. Around 75% of working population in the region are employed in agricultural either as cultivators or as agricultural labourers. The Agricultural Land Classification system is a part of the planning system. Agricultural land classification maps at the village level were prepared according to elevation, slope, water holding capacity and suitability for growing crops. Four types of agricultural land identified were:

Tnar These are the uplands consisting of a mixture of non-arable waste land and some cultivable wastes.

Baid These are the mid uplands where good rainfall or assured irrigation is required to harvest paddy.

Kanali These are the mid lowlands, lower than Baid but higher than Bahal land. After Bahal land, the Kanali is best suited for paddy cultivation.

Bahal These are the low lying arable land most suited for paddy cultivation as water from uplands collect in these types of plots making them suitable for cultivation of paddy.

The Kanali and Bahal are best suited for agricultural activities and thus need significant protection from encroachment of development activities.

Table 3: Agricultural Land Area of Villages in Kashipur

Kashipur				
Village Name	Agricultural Land (km^2)	Baid(%)	Kanali (%)	Bahal(%)
Balarampur	0.55	45	30	15
Benagora	0.89	35	40	25
Bodma	1.42	35	50	15
Chakadi	0.41	48	50	2
Ichamara	0.84	40	30	30

(Contd.) Table 3: Agricultural Land Area of Villages in Kashipur

Kashipur				
Village Name	**Agricultural Land (km^2)**	**Baid(%)**	**Kanali (%)**	**Bahal(%)**
Jagannathdi	1.60	25	45	30
Jamkiri	1.74	35	40	25
Jibonpur	1.01	45	50	5
Jorethol	1.28	45	30	25
Kashidi	0.52	80	17	3
Lajhna	0.68	70	25	5
Lara	2.45	55	40	5
Pabra Pahari	1.04	55	35	10
Ranjandih	1.10	40	35	25
Seja	0.63	50	40	10
Sura	0.39	30	45	25
Tilaboni	0.32	30	65	5

Table 4: Agricultural Land Area of Villages in Chhatna

Chhatna				
Village Name	**Agricultural Land (km^2)**	**Baid (%)**	**Kanali (%)**	**Bahal (%)**
Banjura	7.00	35	30	30
Benagaria	0.58	35	30	30
Besara	0.28	30	35	30
Dumur Kundi	0.16	50	32	28
Enari	0.45	35	40	25
Ethani	1.03	65	20	15
Ghoshergan	1.36	35	40	25
Gopalpur	0.41	10	40	50
Hanspahari	0.97	40	35	25
Hasuibad	0.51	30	40	30
Jhunjka	1.29	35	35	30
Jirrakelai	0.68	50	40	10
Joynagar	0.20	35	40	25
Kalipur	0.42	35	45	20
Kendua	0.30	25	35	40

(Contd.) Table 4: Agricultural Land Area of Villages in Chhatna

Chhatna				
Village Name	**Agricultural Land (km^2)**	**Baid (%)**	**Kanali (%)**	**Bahal (%)**
Kharbana	1.08	55	40	5
Lohagar	3.11	35	30	35
Majhidi	0.65	45	35	20
Penchasimul	0.14	25	50	25
Saluni	0.59	55	30	15
Shirpura	0.53	30	50	20
Shuara Bakra	0.67	45	40	15

- According to the textural types, soils of the blocks can be classified under the following types: (1) Sandy (2) Sandy Loam (3) Loam (4) Sandy Clay Loam (5) Clay Loam, Clay Loam and Loamy soils are mostly confident the Dwarkeswar rivers through sporadic occurrences, and is also seen in other small river valleys. The blocks as a whole are covered generally by sandy loam.
- ESE–WNW/E–W, NE–SW and NW–SE, N–S/NNE–SSW trending lineaments are commonly present in the Kashipur and Chhatna blocks.
- The main river through the block is Dwarakeswar. Due to undulated topography, nearly 50% of the rainfall flows away as run off.

  Hydro-geomorphologically, the entire area is classified into flowing categories such as – (i) Structural Hills (ii) Valley Fills (iii) Buried Pediment Moderate and (iv) Buried Pediment Shallow.

Geomorphological analysis looks to assimilate information from various sources to provide a broad-scale and long-term perspective on past and potential future change. In the present study, the geomorphological analysis of slope, soil, drainage, micro watershed, hydro-geomorphology showed that the slope of the study area ranged between 0–40^0, the soil ranged from sandy to clay loam and loamy, the drainage pattern was dendritic with rivers following an easterly or south-easterly course and four main denudational/ depositional landforms, which were mapped and analysed to understand the agricultural potential, and to better plan watershed management, natural resource management and disaster monitoring and mitigation.

4. Climate and Climate Change

The location of the blocks induce relatively dry and extreme weather conditions when compared to other parts of West Bengal.

4.1 Analysis of Climatic Data for a Period of 100 Years

The annual rainfall and temperature data for a period of 100 years was analysed to understand the pattern of climate change in the Kashipur and Chhatna blocks. Kashipur and Chhatna are characterized by hot and dry summers, pleasant and cool winters and adequate monsoon rains. The following section gives an overview of the climate and weather conditions of Kashipur and Chhatna.

Summer

The summer season in Kashipur and Chhatna is extremely hot and dry. The mercury rises to a maximum of about 42°C, with the minimum being around 27°C. The level of humidity in the region is between 55% and 65%. Summers usually start from March and last till June. The days are scorching hot and the nights are warm bringing little relief to the masses.

Monsoon

The coming of June marks the arrival of monsoon in Kashipur and Chhatna. The rainy season in the study area is characterized by heavy rainfall, making most wet and moist period of the year. The average annual rainfall in the blocks is around 1200 mm. Monsoon rains continue till about mid-September. Rainfall lowers the temperature and provides relief from the blazing heat. Also, the level of humidity in the region increases during the wet monsoon period, being somewhere at 75% to 85%.

Winter

The winter season in Kashipur and Chhatna vary from being pleasant to cold. From the middle of November onwards, the mercury starts dipping in the region. While the maximum temperature lies somewhere around 27°C, the mercury drops to about 10°C at night, making the place chilly and cold. The winter season lasts till the middle of February.

4.2 Observed Changes in Climate

Precipitation

A recent report of the IMD (Status of Climate in India, 2010, IMD) indicates that in the southern regions of West Bengal, the winter and pre-monsoon rainfall has decreased by-14.5mm and -6.7mm respectively between 1901 and 2003. In the monsoon season, an increase in the rainfall of about 57 mm is observed. From the analysis of 114 years (1901-2014) of rainfall data in Kashipur and Chhatna blocks, it has been observed that in Kashipur block, rainfall has decreased during the pre-monsoon and post-monsoon season. There is no observed change in annual precipitation in Chhatna, but in the monsoon season rainfall has increased and in the pre-monsoon and post-monsoon season the rainfall has decreased.

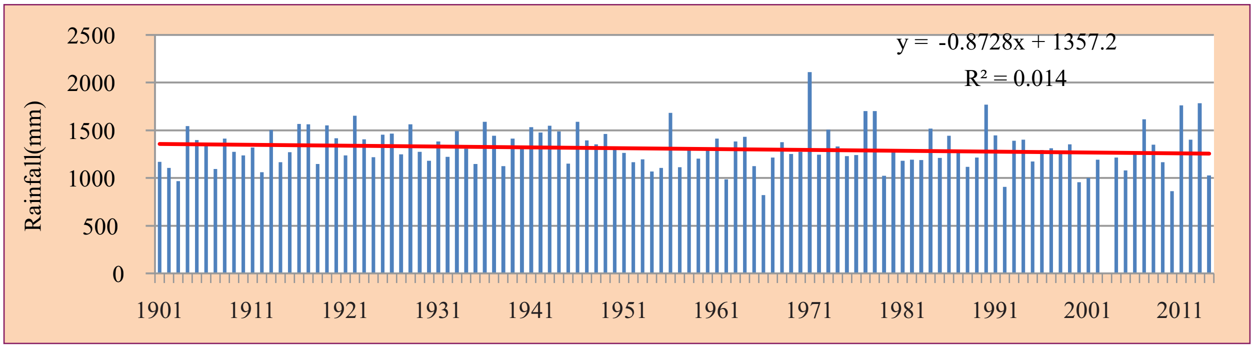


Fig 4.a Annual Rainfall of Kashipur (1901-2014)

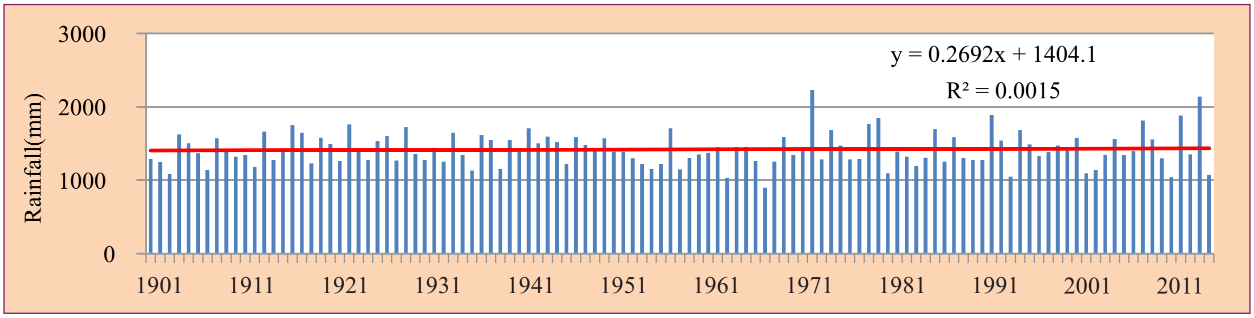


Fig 4.b Annual Rainfall of Chhatna (1901-2014)

Temperature

The MODIES gridded maximum and minimum temperature data of 1 degree spatial resolution for the time period 2000-2015 (16 years) have been used to analyse temporal variation of temperature in the study area. According to the observations during this period, the maximum and minimum temperatures have been rising.

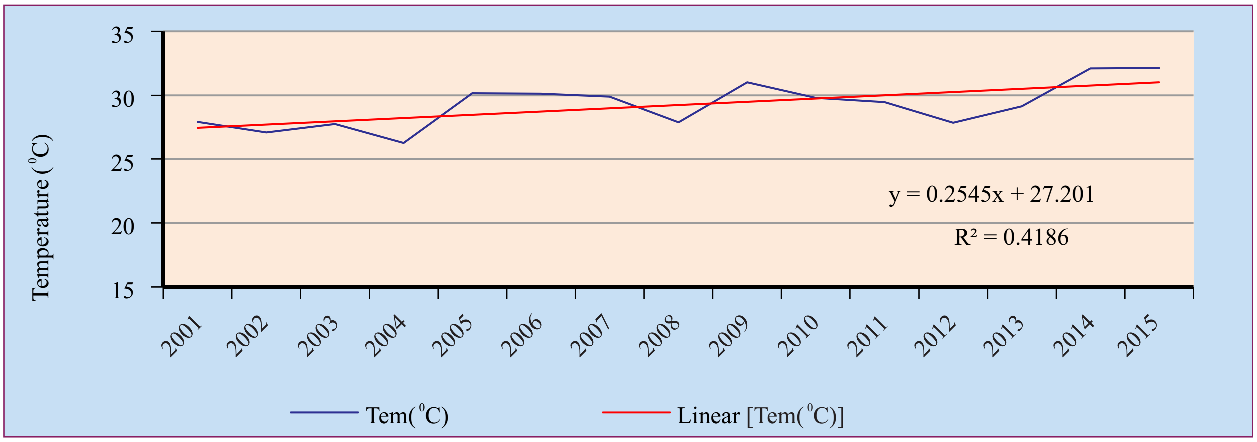


Fig 4.c Annual Mean Temperature of Kashipur and Chhatna (2001-2015)

- There is inadequate and erratic rainfall in the two blocks through the years.
- More than 80% of annual precipitation occurs during monsoon and that too erratically in respect of time and space causing drought. The onset of monsoon is being delayed.
- There is an overall warming with maximum temperatures increasing faster than the minimum temperatures.

4.3 Automatic Weather Station Data Analysis

Block level climatic data was collected (August, 2015 to December, 2016) from 6 automatic weather station at Kashipur (Kroshjuri, Nutandi, Ranjandih) and Chhatna (Beriathol, Chachanpur, Jhunjhka). Hot summers and cool winters are a characteristic feature of the climate in these blocks. Analysis of the Kroshjuri and Nutandi automatic weather station data indicated that, April was generally the hottest month with a mean daily maximum temperature of 38°C and January the coldest with a mean daily maximum temperature of 20°C. In the year 2016, the highest rainfall of around 478 mm occurred in August while in July and September it was around 200 mm. In Ranjandih, the monsoon (July to September) rainfall was observed to be low with 200 mm rainfall in 2016. From the analysis of Beriathol, Chachanpur and Jhunjhka weather station data it was observed that April was the hottest month with a mean daily maximum temperature of 34°C and 45°C respectively and January was the coldest with mean daily maximum temperature of 17.5°C and 21.5°C respectively. Maximum rainfall of Beriathol, Chachanpur and Jhunjhka was at 375 mm in July, 400 mm in August and 300 mm in September respectively.

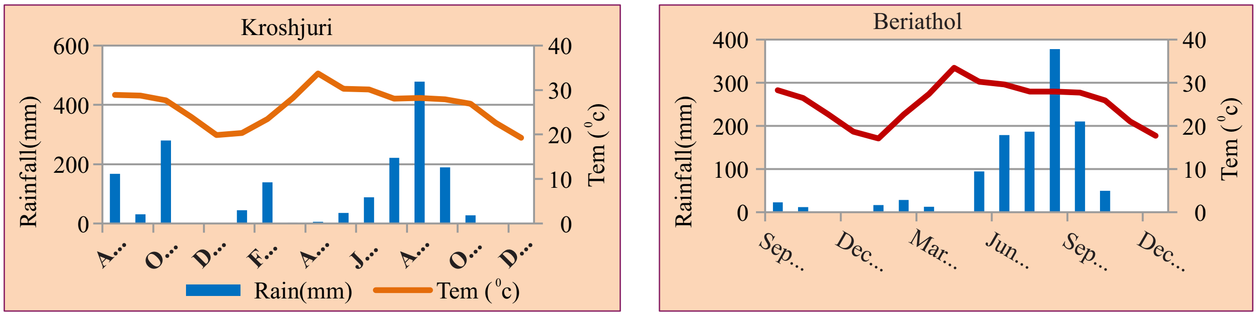


Fig 4.d Automatic Weather Station Data Analysis of Kroshjuri (Kashipur) and Beriathol (Chhatna)

4.4 Comparison Between Weather Station Data and Satellite Data

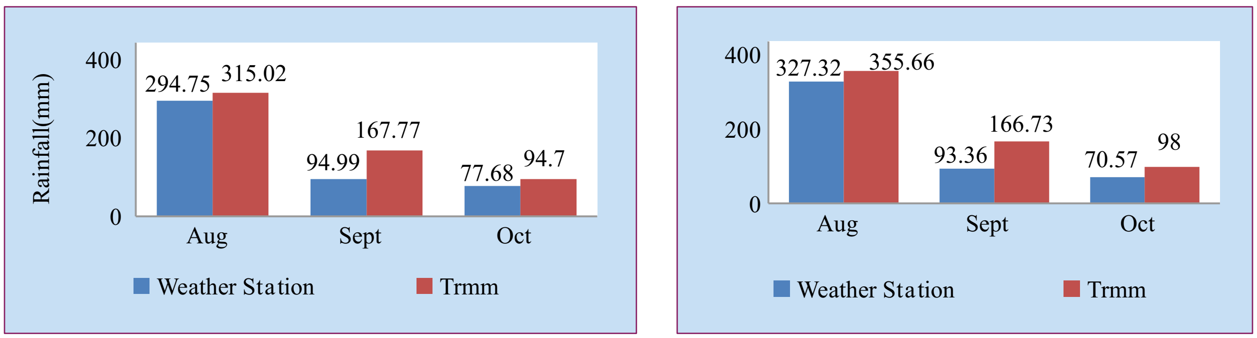


Fig 4.e Comparison Between Weather Station Data (Nutandi and Kroshjuri) and Satellite Data (TRMM)

Monthly satellite based rainfall data from TRMM 3B42 has been validated against the daily gridded data collected from the Automatic Weather Station from August, 2015 to January, 2017. The TRMM product delivers a broader spatial coverage of total rainfall over Kashipur and Chhatna blocks. An observation of the trend line of high and low rainfall in the region reveals that the TRMM is inadequate for accurate representations. However, the patterns of TRMM monthly rainfall are reasonably close to the observed pattern from AWS data as a result of their spatial resolution. TRMM data has a spatial resolution of 0.25 x 0.25 degree grid covering latitudes 50°S to 50°N latitude and the AWS has spatial resolution of 10 meter radius.

4.5 Weather Forecast

Weather is certainly the most important factor determining the success or the failure of agricultural enterprises. It manifests itself through its effects on soil, plant growth as well as on every phase of animal growth and development. A greater proportion of the total annual crop loss is a result of aberrant weather. Also crop and animal disease are greatly influenced by weather. In all, weather accounts for approximately three fourth of the annual loss in farm production both directly and indirectly. However, the crop losses can be reduced substantially by affecting adjustments through timely and accurate weather forecasts. Such weather forecast supports and also provides guidelines for long range or seasonal planning and selection of crops best suited to the anticipated climatic conditions. (www.fao.org).

The weather forecast and agro-meteorological advisory service rendered by DRCSC is a mechanism to arm the farmers with adequate meteorological information to help them efficiently use the natural resources with the aim of improving both quality and quantity of agricultural production. DRCSC has started block level quantitative weather Forecast for Kashipur and Chatna Blocks upto 5 days from 1st January, 2016.

Table 5: Weather Forecast for Kashipur Block (Period: 27-31 December, 2016)

Weather Forecast for Kashipur Block (Periods 27-31 December, 2016)	
	Weather
27.12.16	Shallow Fog/ Mist/Haze in the morning hours with Fine weather
28.12.16	Fog/Mist in the morning hours with Fine weather
29.12.16	Fog/Mist in the morning hour with Fine to Fair weather
30.12.16	Fog/Mist/becoming haze with Fine weather
31.12.16	Fog/Mist with Fine weather

The products comprises quantitative forecast for cloudiness, fog and mist besides weather condition (See table 5). DRCSC communicate this data to the farmers by sending SMS to their mobile phones and also display the information on the notice boards of DRCSC office of the area.

Communication of the Weather Forecast Data to Farmers

4.6 Agro Advisory (27-31 December 2016)

Based on the above forecast by DRSCS the crop information shared with the farmers was

1. **For Wheat :** Land preparation,
2. **For Potato :** First top dressing. Maintain optimum moisture, content in the soil.
3. Aphids may attack the Mustard crop in this cold weather.
4. **Remedy :** Spray wheat flour solution in the initial stage on affected crops.

Other Remedies

1. Mix 1 litre of water with 5 ml. Neem Seed Kernel Extract and spray on the crops.
2. Marigold and Holy Basil can be planted along side the Brinjal crop to act as pest repellent and protect the crops
3. Crush together 200gms. each of leaves from Custard Apple (Atta), Swamp Cabbage (Danga Kalmi) and Guava (Peyara) trees to make a pest repellent.
4. Soak this mixture of crushed leaves overnight in 2-3 litres of water.
5. Mix a 2gm. Bar soap to this mixture in the morning and spray on affected plants.

4.7 Climate Change Prediction

The climate change scenarios are driven by the GHG emission scenarios and the A1B scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A1B scenario portrays a balanced use of different energy sources. We have predicted future climatic condition according to A1B scenario in Kashipur and Chhatna blocks using MPI ECHAM5 model. Comparison between the past (1961-1990) and future (1991- 2020) climate of Kashipur and Chhatna reveal that monthly temperature would increase for all 12 months with the maximum increase noticed in July of around 0.75 degrees centigrade. In the months of March, April and May the increase will be around 0.6, 0.55 and 0.48 degrees centigrade respectively. Rainfall would increase in August, September and October by around 91, 35 and 12 mm respectively but would decrease in June July, December, January, and February by around 27, 26, 5, 7 and 13 mm respectively. This predicts that drought events would increase during the onset of monsoon and post monsoon.

Farmers have to adjust their cropping system and crop management practices to the limitations imposed by the variability of rainfall and hence they have developed their farming system through trial and error based on past experience. However, for modern agriculture this is not enough. Without proper knowledge of variability of rainfall and other agro meteorological conditions, effective crop management cannot be undertaken. The variability experienced at the onset and end of the rainy seasons affects the farmer's cropping strategies as cropping patterns are planned depending on the frequency and amount of rainfall available. Since one of the objectives of this study is to build resilience of the farmers to the vagaries of weather and climate, the **annual rainfall and temperature data for a period of 100 years was analysed to understand the pattern of climate change in the Kashipur and Chhatna blocks. According to the observations during this period**, in the monsoon season, an increase in the rainfall of about 57 mm is observed. From the analysis of 114 years (1901-2014) of rainfall data in Kashipur and Chhatna blocks, it has been seen that in both the blocks, rainfall has decreased during the pre-monsoon and post-monsoon season. Temperature change too has been observed and the data used for this analysis included the MODIES gridded maximum and minimum temperature data of 1 degree spatial resolution for the time period 2000-2015 (16 years). According to the observations during this period, the maximum and minimum temperatures have been rising. From the analysis of the climatic data it can thus be interpreted that the study area is facing erratic and inadequate rainfall and there is an overall warming with rise in both the minimum temperatures and maximum temperatures.

5. Drought Analysis

The micro-level Spatio-temporal drought analysis using various drought indices is useful to mitigate the drought effects in specific location at a specific time

5.1 Drought Analysis (SPI)

Drought index has been developed for the study area as a means to measure drought. There are several indices that measure how precipitation for given period of time has deviated from long term average. Some of the widely used drought indices include Palmer Drought Severity Index (PDSI), Standardized Precipitation Index (SPI), Standardized Water Level Index (SWI), Standardized Precipitation Evapo-transpiration Index (SPEI) etc.

Limitations of the drought indicators are that the indicators assimilate information on rainfall, soil moisture or water supply but do not show much local spatial detail. Also, drought indices calculated at one location is only valid for that single location. Thus a major drawback of climate based drought indicators is their lack of spatial detail as well as their dependency on data collected at weather stations which sometimes are sparsely distributed affecting the reliability of the drought indices (Brown et al,. 2008). Satellite derived drought indicators calculated from satellite derived surface parameters have been widely used to study drought. Normalized Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) are some of the extensively used vegetation indices.

SPI

As in the rest of the state, even in Kashipur and Chhatna blocks, rainfall mostly depends on the vagaries of the south-west monsoon. The Standardized Precipitation Index (SPI) expresses the actual rainfall as standardized departure from rainfall probability distribution function. In this study, severity and spatial pattern of meteorological drought was analysed in the blocks of Kashipur and Chhatna. The Standardized Precipitation Index (SPI) is a tool which was developed primarily for defining and monitoring drought. It is a widely used index to characterize meteorological drought on a range of time scales. On short time scales, the SPI is closely related to soil moisture, while at longer time scales, the SPI can be related to groundwater and reservoir storage.

Standardized precipitation index was mainly computed to derive meteorological drought. SPI has been used to quantify the amount of precipitation deficiency. 1-month SPI reflects short term condition and its application can be related closely to soil moisture (Lei et al., 2003). It was used for 1901 to 2015 time span. From the TRMM rainfall data, SPI has been calculated. The classification of SPI been carried out according to the method proposed by McKee (1993), to represent various meteorological drought intensities. The SPI value varies between -2 and 2. They have been classified into five classes.

Figure 5.a shows the evolution of the monthly SPI calculated over the entire Kashipur and Chhatna blocks. The longest and most intensive droughts were recorded in 2005, 2009, and 2010. Conversely, 2007 and 2011 were predominantly humid. In Kashipur and Chhatna blocks between 2000 and 2010, eight drought events have occurred, with four of them lasting over three months.

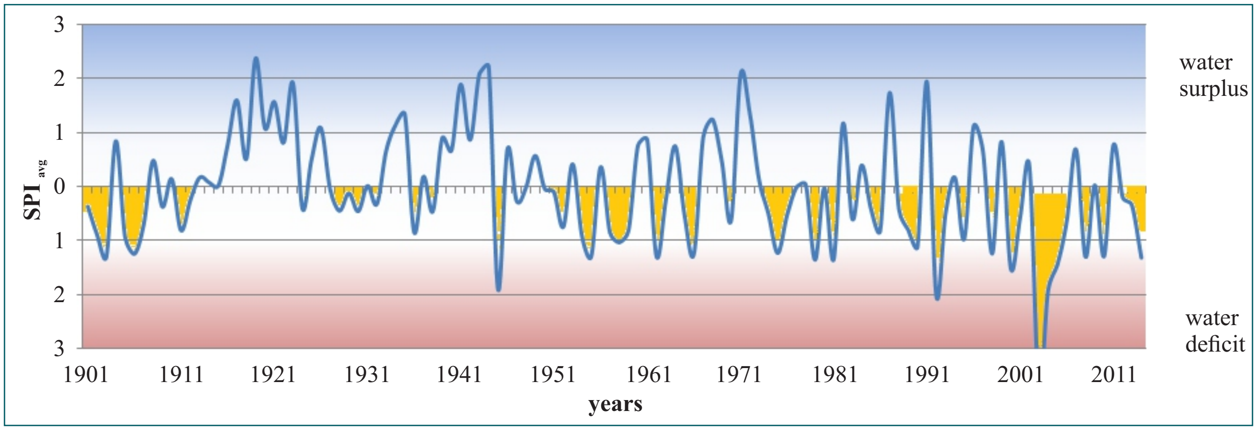


Fig. 5.a Temporal Evolution of 1-Month SPI for the Entire Kashipur and Chhatna Blocks

Normalized Difference Vegetation Index

NDVI is an index of vegetation health and density, computed from satellite imagery using spectral radiance of red and near infrared reflectance using the formula:

$$NDVI = (NIR - R) / (NIR + R)$$

Where, NIR= near infrared band, R= Red band;

NDVI is a powerful indicator used worldwide, to monitor vegetation cover over wide areas, and to detect frequent occurrence and persistence of droughts (Thavorntam and Mongkolsawat, 2006). It provides a measure of the amount and vigour of vegetation on land surface. The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation. In general, higher values of NDVI indicate greater vigour and amounts of vegetation. Tucker first suggested NDVI in 1979 as an index of vegetation health and density (Thenkabail et al., 2004) and it has been considered as the most important index for mapping of agricultural drought (Vogt, 2000; Mokhtari, 2005). NDVI is a non-linear function that varies between -1 and +1 and values of NDVI for vegetated land generally range from about 0.1 to 0.7, with values greater than 0.5 indicating dense vegetation (FEWS N 2006). NDVI is a good indicator of green biomass, leaf area index and patterns of production (Thenkabail et al., 2004). Furthermore, NDVI can be used not only for accurate description of vegetation, vegetation classification and continental land cover but is also effective for monitoring rainfall and drought, estimating net primary production of vegetation, crop growth conditions and crop yields, detecting weather impacts and other events important for agriculture, ecology and economics (Singh et al., 2003).

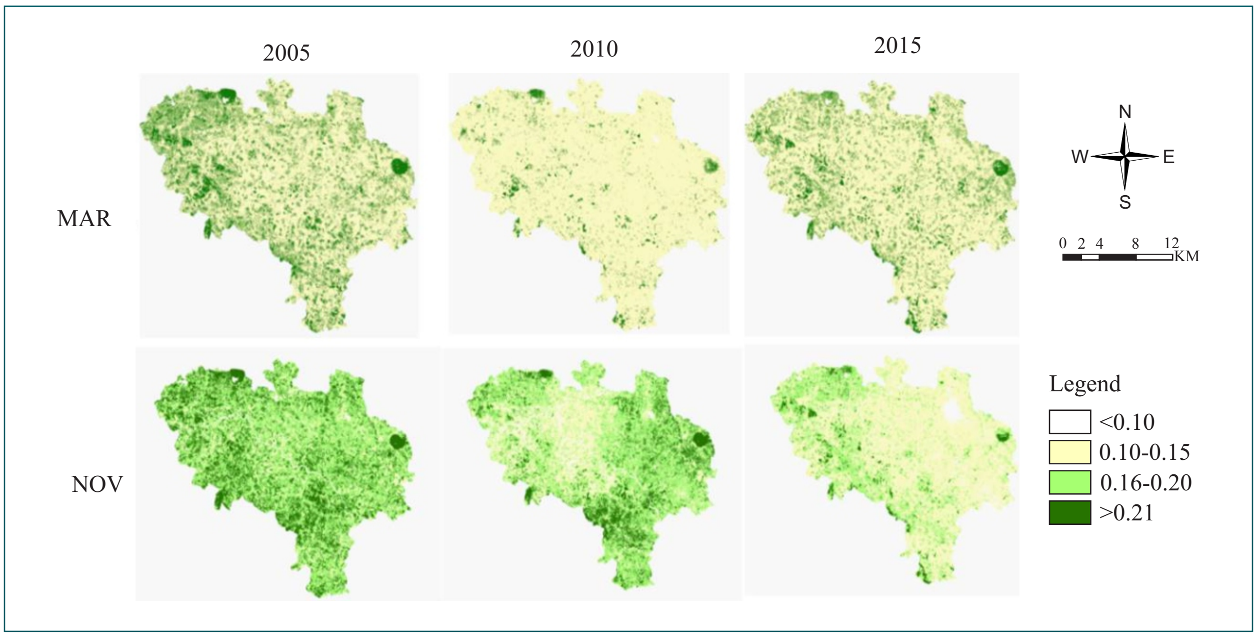


Fig.5.b NDVI of Kashipur and Chhatna in 2005, 2010 and 2015

It has been observed that in the month of March, 2005 the minimum NDVI value was -1 and the maximum value was 0.457, with total precipitation of 54.7 mm from November, 2004 to February, 2005. Similarly, in March 2010, the minimum NDVI value was -1 and the maximum was 0.392457, with total precipitation of 35.35 mm. In March 2015, the minimum NDVI value was -1 and the maximum value was 0.442 with total precipitation of 43.36 mm from November to February 2015. The depth of precipitation was recorded as

606 mm in 2005 (from August to October 2005), 440 mm in 2010 (from August to October 2010) and 301 mm in 2015(from August to October 2015). With the decreasing precipitation, the NDVI value for the month November decreased gradually from 2005 to 2015.

From this NDVI value, it has been possible to assess vegetation healthiness and relationship between NDVI and rainfall. From this NDVI study, it is clearly observed that, NDVI of 2010 indicates the most unhealthy condition of vegetation rather than 2005 and 2015. On the other hand, NDVI of 2005 exhibits the maximum healthy condition of the three years.

The spatial distribution of NDVI was similar to the pattern of seasonal rainfall and it indicates that precipitation is a key factor for vegetation growth.

Vegetation Condition Index (VCI)

Kogan (1990) developed the Vegetation Condition Index (VCI) using the range of NDVI which is a good indicator for assessing the severity of agricultural drought. It is defined as :

$$VCI = (NDVI-NDVI\ Min) / (NDVI\ Max-NDVI\ Min)*100$$

The VCI values between 50 to 100 % indicate optimal or above-normal conditions. At the VCI value of 100%, the NDVI value for the month is equal to NDVI max. Different degrees of a drought severity is indicated by VCI values below 50%.

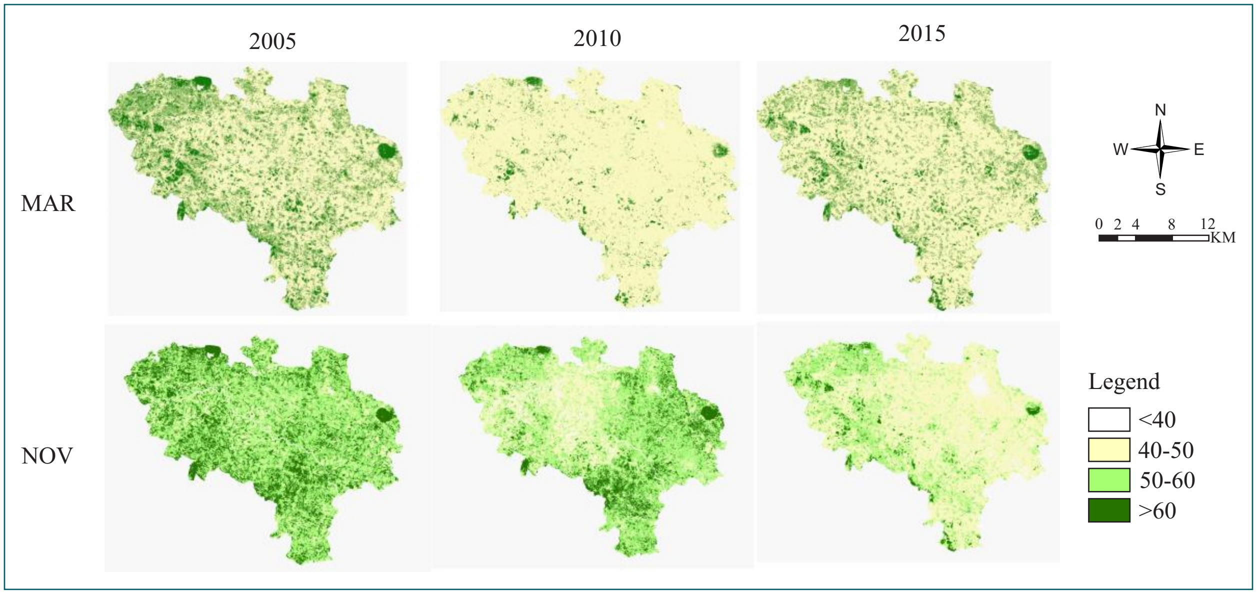


Fig.5.c Vegetation Condition Index of Kashipur and Chhatna Blocks in 2005, 2010 and 2015

The VCI value showed that the maximum area within the entire study area was covered by severe and moderate drought in the year of 2010. In 2005, moderate drought prone area was less visible, maximum area was covered by no-drought and low drought zone and moderate drought covered the maximum area in 2015 year.

When the vegetative drought pattern has been analysed using the Vegetation Condition Index (VCI), like NDVI, it showed an irregular pattern of vegetative drought in Kashipur and Chhatna blocks. Major parts of the blocks showed favourable vegetation condition for pre-monsoon and post-monsoon for the year 2005 with favourable pre-monsoon (54.7 mm) and monsoon (606 mm) precipitation. Extremely unhealthy vegetation (very low VHI) generally associated with low precipitation was seen during pre-monsoon rainfall in 2010 (35.35 mm). The vegetation suffered mild stress due to moderate precipitation during the monsoon of 2010 (440 mm). Good vegetation health was present in pre monsoon of 2015 but moderate vegetation stress was observed in post monsoon of 2015 due to very low and late monsoon rainfall (301 mm).

Moisture Stress Index (MSI)

Moisture Stress Index is used to determine the soil moisture condition during a drought. It is a good indicator of agricultural drought. It has been calculated by using MIR band and NIR band of Landsat data. MSI value range is from 0 to 4.

MSI= Band 7/ Band 4 {for Landsat TM}

MSI= Band 8/ Band 4 {for Landsat ETM+}

Where, [band 4 is NIR and band 7 is MIR for Landsat TM] and [band 4 is NIR and band 9 is MIR for Landsat ETM+].

MSI indicates the soil moisture condition and it is very useful parameter for assessing agricultural drought. In Figure 5. d it has been observed that, the MSI value ranged from 0 to 2.96, 0 to 2.97 and 0 to 3.93 for the year of 2005, 2010 and 2015 respectively. The western, south-western and to some extent the central part of the total study area is under maximum soil moisture stress condition due to presence of barren lands, hard rock terrain and some industrial/commercial area. So, the year 2010 has been identified to be in maximum stress condition of all the three years.

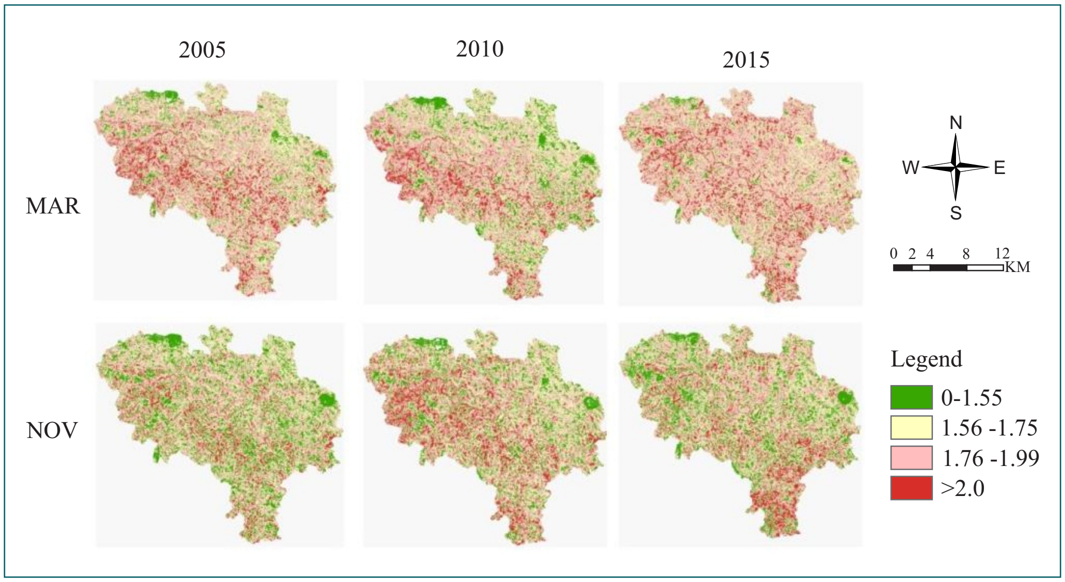


Fig. 5.d Moisture Stress Index of Kashipur and Chhatna Blocks in 2005, 2010 and 2015

5.2 Seasonal Drought Assessment

Month of July and August were chosen for calculating SPI, since this period normally signifies the wet season for the study area. It is worth mentioning that negative SPI values in the wet season indicate monsoon drought throughout the year. The month of April was chosen since it gives the best signature of the pre-monsoon season and the month of November was chosen to study the drought scenario during post-monsoon Kharif crop season. A drought with maximum severity of −2.07 was observed in August 2010, and the next most severe drought occurred in April 2009 and 2014, with a severity of −1.89.

- The maximum drought severity of −1.21 occurred for a continuous duration of five months, between August and December 2015, indicating a failure of monsoon and post-monsoon rainfall.

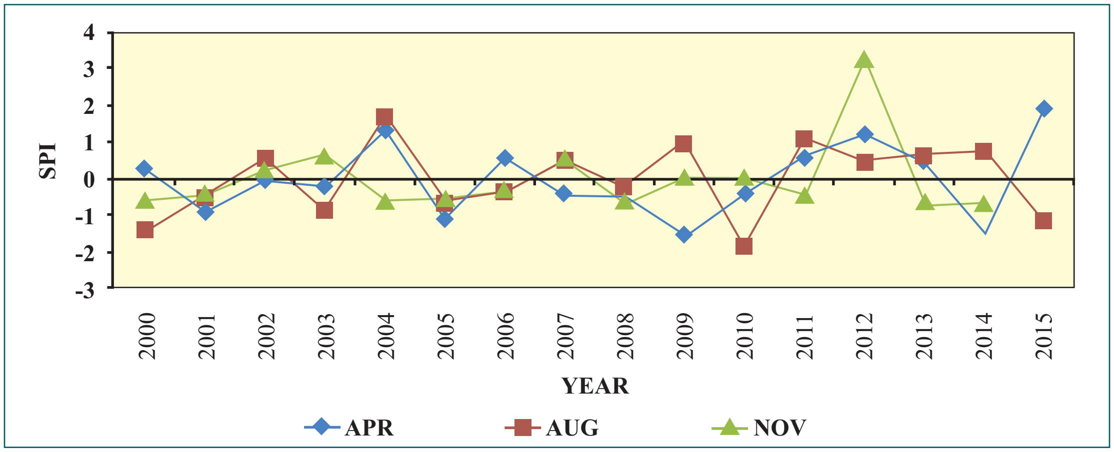


Fig. 5.e Temporal Variation of 1-Month SPI for the Month of April, August and November During the Years 2000 to 2015

Fig 5.f shows the dynamic drought characteristics for two recent years of 2014 and 2015. Based on the 1-month SPI, the Kashipur and Chhatna blocks showed that July 2014 experienced mild drought but July 2015 experienced a wet condition, while August 2015 experienced moderated drought but August 2014 experience a wet condition. September 2015 experienced more drought than September 2014. Maximum drought severity of −1.21 occurred for a continuous duration of five months, between August to December 2015, indicating a complete lack of monsoon and near lack of post-monsoon rainfall. The next most severe drought occurred in April 2014, with a severity of −1.42.

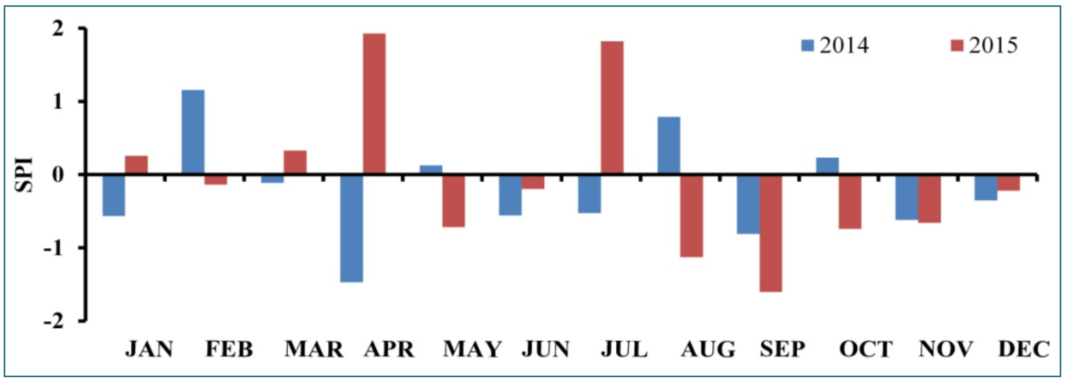


Fig. 5.f 1-Month SPI for the Years 2014 and 2015 in the Kashipur and Chhatna Blocks

5.3 Spatial Scenario of Drought

The spatial variability in the drought scenario revealed that mild and moderate droughts occurred in the north, east and northwest portion of the study area (which included villages like Rangamati, Lapara, Patpur, Kashipur, Suaria, Malanch etc.). The southern part (comprising villages like Gopal Chak, Balarampur, Kustor, Jamkiri, Lari etc.) of the study area was prone to severe drought, however, less prone to extreme droughts. Extreme drought occurred in south-western part (Sunra, Seja, Kashidi, Shampur, Gopalpur, Saharbera villages) of the study area. Hence the entire study area may be labelled as drought prone area (Fig. 5.g) in the month of April (pre-monsoon).

Even in the month of August (i.e. monsoon season) severe droughts were noticed in northern, southern and central portions followed by extreme drought in north eastern portion. Mild and moderate droughts occurred in the western portion of the study area (Fig. 5.g).

Figure 5.g specifically reveals the progression and subsequent withdrawal of the drought phenomena in the region during the drought years of 2005 and 2010 and wet years of 2007 and 2011 in the pre-monsoon, monsoon and post-monsoon seasons. In April 2005, about 25% of Kashipur and Chhatna experienced moderate conditions, with 72.5% under severe drought conditions. With the slow progression of monsoon, the scenario changed considerably in July and August 2005, with 95% of the area experiencing mild drought

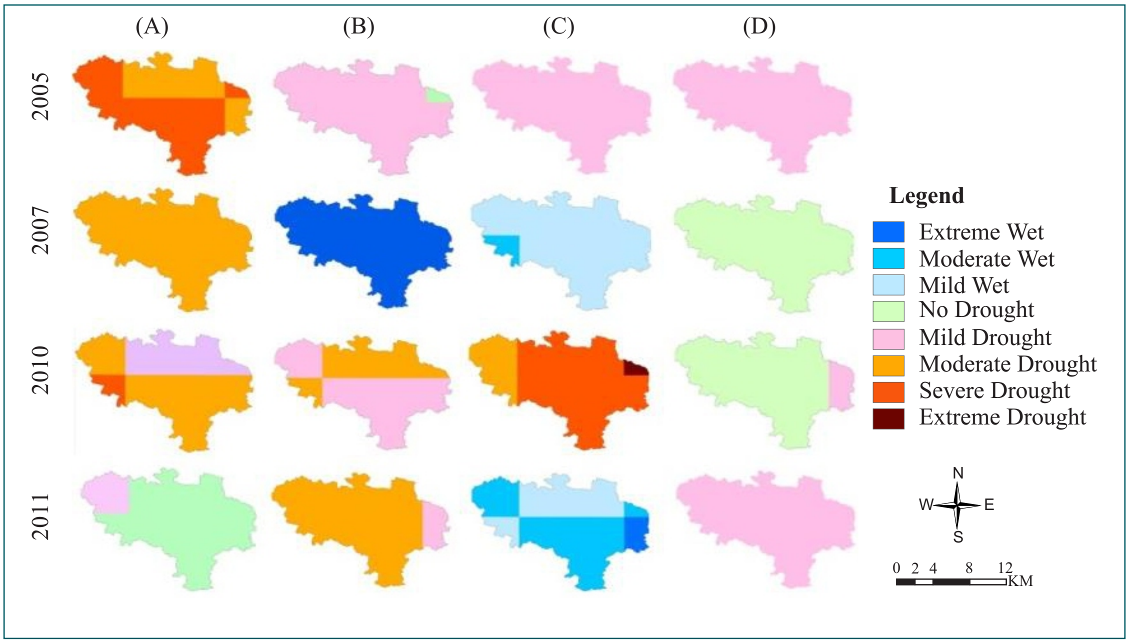


Fig. 5.g Spatial Variation of 1-Month SPI for the Months of April, August and November During the Years 2000 to 2015

conditions. In April 2010, about 55% of Kashipur and Chhatna experienced moderate conditions, with 25% area under severe drought conditions. However, with the slow progression of monsoon in July, the scenario changed in August 2010, with 68.45% of the area experienced severe drought and 23.56 % moderate drought conditions. With continuing deficit in rainfall in August 2010, the situation further deteriorated, with almost the entire Kashipur and Chhatna region coming under drought, with 2.25% of the area under extreme drought.

Table 6: Spatial Drought Scenario (2000-2015) of Kashipur

Kashipur (2000-2015)				
Drought Category	**Colour**	**Pre-Monsoon (Apr)**	**Monsoon (Aug)**	**September**
		Villages		
Extreme Drought				
Severe Drought		Seja, Sunra, Kashidi, Chaka, Lajhna		
Moderate Drought		Bhatin, Balarampur, Jagannathdi, Jamkiri, Jibonpur, Lara, Ranjandi	Bhatin, Balarampur, Jagannathdi, Jamkiri, Jibonpur, Lara, Ranjandi, Bodma, Jorthol, Tilaboni	
Mild Drought		Bodma, Jorthol, Tilaboni	Seja, Sunra, Kashidi, Chaka, Lajhna	Bhatin, Balarampur, Jagannathdi, Jamkiri, Jibonpur, Lara, Ranjandi, Bodma, Jorthol, Tilaboni, Seja, Sunra, Kashidi, Chaka, Lajhna

Table 7: Spatial Drought Scenario (2000-2015) of Chhatna

Chhatna (2000 - 2015)			
Drought Category	**Colour**	**Pre-Monsoon (Apr)**	**Monsoon (Aug)**
		Villages	
Extreme Drought		Dumur Kundi	
Severe Drought		Benagoria, Shuara, Bakra, Lohagar, Kharbana, Kalipur, Ghoshergan, Hanspahari, Enari, Gopalpur, Hausibad, Jhunka, Majhidi, Besara, Kendua, Saluni, Banjurya, Shirpura, Ethani, Jainagar, Hatiashora, Jirrakelai	Benagoria, Shuara, Bakra, Lohagar, Kharbana, Hanspahari, Enari, Gopalpur, Besara, Saluni, Banjurya
Moderate Drought			Kalipur, Hausibad, Jhunka, Majhidi, Kendua, Penchasimul, Shirrpura, Ethani, Dumurkundi
Mild Drought			Jainagar, Hatia, Shora, Jirrakelai

5.4 Drought Frequency and Severity

Drought frequency and severity has been assessed using 115 years data (1901 – 2015). The analysis of 114 years of meteorological data and various drought indices have been designed to date to allow drought extremity to be examined. Drought Index (DI), used in this study has been calculated as follows;

DI = (P-X) / SD

Where P=annual precipitation, X = long term mean and SD= standard deviation. The DI values (and corresponding drought intensity) may be classified into four categories: very severe, severe, moderate and light (DI =< -0.9 light drought, DI = < - 1.49 moderate drought, DI = < - 2.0 severe drought, DI = > -2.0 very severe drought). All drought years in the blocks have been categorized as above. Table 8, shows that a number of severe and very severe drought years across regions were 18 out of 114 years. Over the entire block, 65 out of 114 years were drought years, which means that the chance of occurrence of a meteorological drought in the blocks is 57%. Between 1901 and 1990 one or two moderate and severe drought years occurred at approximately ten year intervals but between 1991 and 2010 there has been 5 severe drought years and 1 extreme drought year, indicating increase both in drought frequency and severity between 2001 and 2010.

❂ Between 1901 and 1990 one or two moderate and severe drought years occurred at approximately ten year intervals but between 1991 and 2010 there has been 5 severe drought years and 1 extreme drought year, indicating increase both in drought frequency and severity between 2001 and 2010.

Table 8: Drought Frequency and Severity of Kashipur and Chhatna (1901-2015)

Years	Drought Frequency	Severity
1901-1910	1903	Moderate
	1907	Severe
1911-1920	1911	Severe
	1912	Moderate
1931-1940	1938	Moderate
1941-1950	1945	Moderate
1951-1960	1954	Moderate
1951-1960	1955	Moderate
1961-1970	1966	Extreme
1981-1990	1983	Moderate
1991-2000	1992	Severe
1991-2000	1998	Moderate
2001-2015	2000	Severe
	2001	Severe
	2003	Extreme
	2004	Moderate
	2005	Severe
	2010	Severe
	2015	Extreme

5.5 Vulnerability to Drought

Vulnerability to drought is another important factor to consider for the agriculture dependent population. It is closely related to food insecurity and can be defined as the probability of an acute decline in food excess or consumption levels below minimum survival needs. In drought years, food insecurity increases due to severe decline in food production or availability, both from individual farms and in the market, due to increased uncertainty of income, which is related to lack of employment opportunities and livelihood. Vulnerability may be assessed in terms of multiple factors/indicators, which expose people to food insecurity through reduced food availability, access and utilization. Vulnerability indicators include forced migration,

- The longest and most intensive droughts have been recorded between 2000 to 2015, in the years 2005, 2009 and 2010. Conversely, 2007 and 2011 were predominantly humid. In Kashipur and Chhatna blocks between 2000 and 2010,8 drought events occurred, with 4 of them lasting over 3 months.
- It was observed that more than 50% of the study area in the month of August was under the influence of severe drought (SPI<-1.49) in the years 2000 and 2010 and under moderate drought (SPI<-1) in the year 2015 and mild drought (SPI<0) in the years 2001, 2003, 2005, 2006, and 2008.

barrowings, skipping meals or food shortage, change of occupation, forced unemployment, failing health conditions etc. Vulnerability assessment may be done for different socio-economic groups based on caste, land ownership, primary occupation, income group and gender. In the context of farm sizes, it is marginal and small farmers who are mostly vulnerable, whereas in the blocks, even the large land holders are vulnerable due to the inferior quality of land with no irrigation facilities and fall prey to erratic rainfall.

5.6 Soil Moisture Survey

Soil moisture plays an important role in the hydrological cycle. Soil moisture at the surface layer (0–5 cm) is an important hydrological variable influencing the feedback between land surface and atmospheric processes that leads to climate irregularity. Soil moisture is the major source of water for crops and hence plays a key role in crop production. Likewise, soil moisture is important for hydrologic applications such as flood and drought monitoring, weather forecasting, weather management and so on, (Sahoo et al., 2008).

Table 9: Soil Moisture Measurement

Mouja	Tola	Sm(%)
	Kalipur	11.4
	Ranga Gora	2
Haushibad	Chingri	3.8
	Kala Jharia	15.7
Majhidihi	Alijhara	12.8
Kendua	Kendua	17.2
	Shirpura	8.8
	Poragola	16.8
	Kelhi	17.1
Pencha Simul	Pencha Simul	15.9

(Contd.) Table 9: Soil Moisture Measurement

Mouja	Tola	Sm(%)
Shaluni	Shaluni	7.3
Joynagar	Kasi Para	19.3
Jhunjhka	Rangagora	10.4
	Mushdhi	13.8

Soil Moisture Measurement

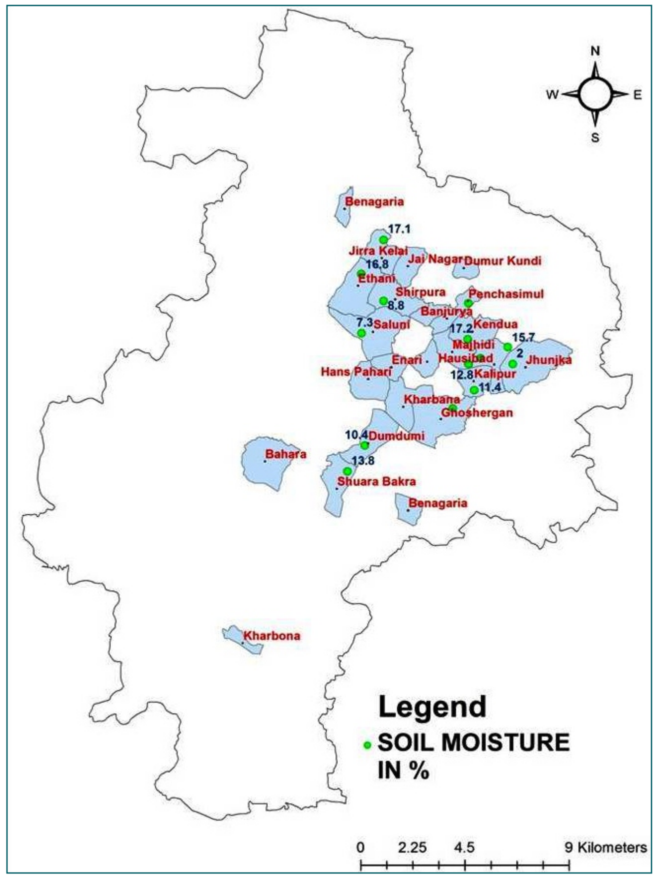


Fig. 5.h Soil Moisture in Chatna

5.7 Comparison Between Average Rainfall (1901-2014) Drought Years and Wet Years

Comparison Between Average Rainfall (1901-2014), drought years of 2005, 2010 and wet years of 2007 and 2011 show that the average rainfall of Kashipur and Chhatna (1901-2014) is at around 1320 mm. The nine years (from 200 to 2015) witnessed a large deficit in rainfall and with largest deficit in 2010. While the observed deficit in rainfall for 2005 was 18% of the long-term mean rainfall, the seasons of 2010, 2014 and 2015 turned out to be droughts (deficit > one standard deviation, which for ISMR is about 10% of the long term average) with deficits of 34%, 22% and 7% respectively.

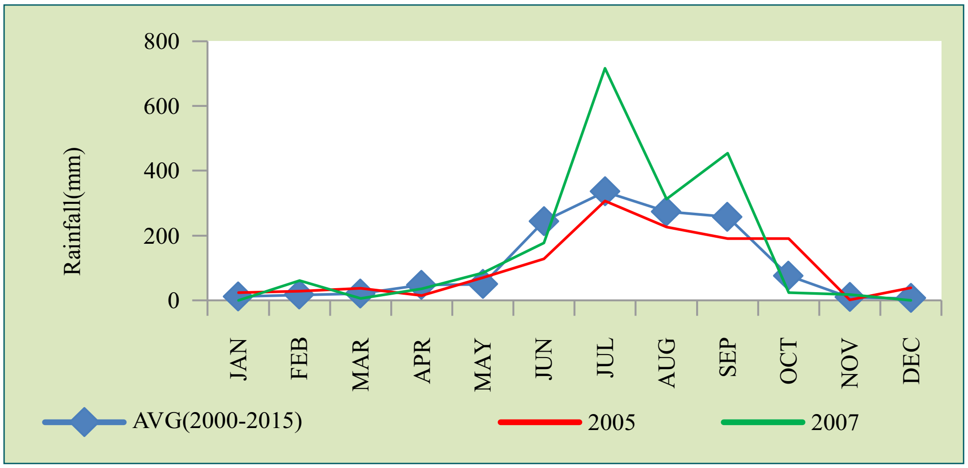


Fig 5.i Comparison Between Average Rainfall (1901-2014), Drought (2005) and Wet (2007) Years

5.8 Relation Between '*El-Nino*' and Drought Index (SPI)

Generally, '*El-Nino*' and the Indian Monsoon rains are inversely related. Trade winds coming from South America normally blow westward towards Asia during Southwest Monsoon. Warming of the Pacific Ocean results in weakening of these winds. Therefore, moisture and heat content gets limited and results in reduction and uneven distribution of rainfall across the Indian sub-continent. However, this is also affected additionally by the prevalence of Indian Ocean Dipole (IOD).

The most prominent droughts in India, six of them, since 1871 have been '*El-Nino*' triggered droughts, including the recent ones that occurred in 2002 and 2009. Nevertheless, it is important to note that all '*El-Nino*' years do not lead to drought in India. The year 1997-98 is a stark reminder as it was a strong '*El-Nino*' year but that did not cause drought in India, in fact, rainfall was in excess. On the other hand, a moderate '*El-Nino*' in 2002 resulted in one of the worst droughts. The role of IOD becomes important in these cases.

Going by historical data of 135 years from 1880 to 2014, about 90% of all evolving '*El-Nino*' years have led to below normal rainfall and 65% of evolving '*El-Nino*' years has brought droughts. (Skymetweather.com 23 May 2015 11.51 AM)

'*El-Nino*' is also correlated with the deficiency of monsoon rainfall in Kashipur and Chhatna blocks. The most severe droughts have all been in '*El-Nino*' years. Since 2000, the four most severe drought years 2002, 2005 2010 and 2015 were the ones that witnessed '*El-Nino*' events. The '*El-Nino*' year 2007 however did not impact the monsoon rains. Therefore, it may be concluded that '*El-Nino*' years adversely affect the weather in India in terms of monsoon rains, with very few exceptions. During an '*El-Nino*' year, the rainfall is generally below the normal average, which has its negative bearing on crop production. This pattern was also observed in the study area. Therefore, study of evolving '*El-Nino*' Phenomena can be useful for advanced drought warning and preparedness planning in the study area.

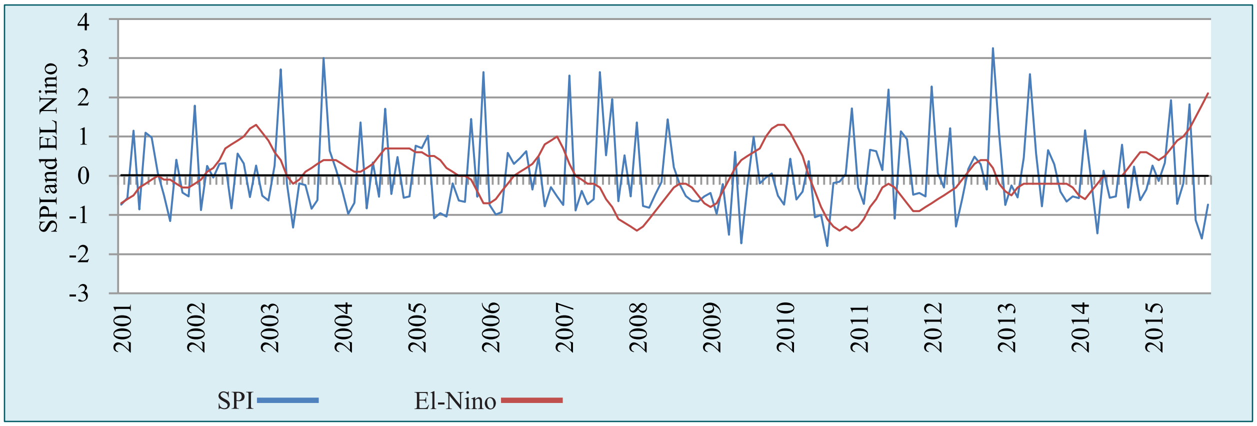


Fig 5.j Relation Between '*El-Nino*' and Drought Index

5.9 Crop Production

Bankura and Purulia are drought prone districts in West Bengal and are characterized by very high variability of rainfall and extreme temperature conditions. From these two districts, two blocks are selected namely Kashipur from Purulia and Chhatna from Bankura. These two blocks comprise of poor tribal population who are vulnerable to the impacts of drought. The Kharif crop (mainly Rice) production in the two blocks of these districts is shown in the graph below:

A comparison of the types of crop grown in the two districts show that the two districts are continuously trying to adapt to the climatic variations by introducing water intensive agricultural practices. It has led to a rise in the production of certain crops making the agriculture less dependent on rainfall and more dependent on irrigation. A shift in temperature and rainfall pattern has also led to the damage of certain crops during their harvest.

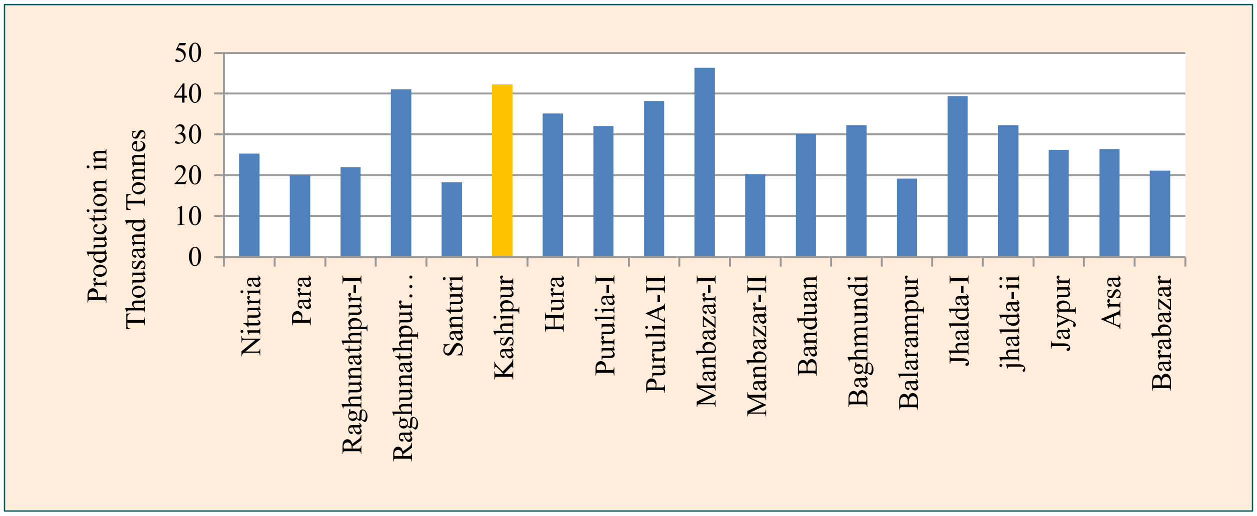


Fig 5.k.a Rice Production in Purulia Districts in Drought Year 2002

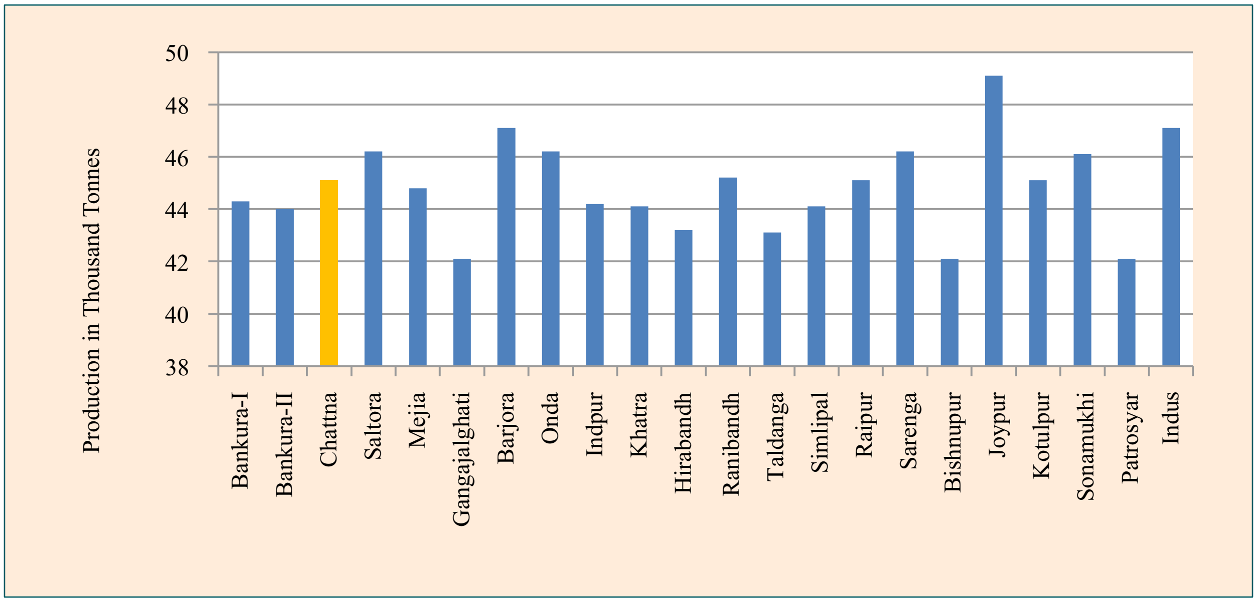


Fig 5.k.b Rice Production of Bankura Districts in Drought Year 2002

Crop Yield

The overall crop yield is higher in Bankura as compared to Purulia. The crop yield is higher for summer crops when compared to the other seasonal crops in both the districts. The Kharif crop yield is higher in Bankura than Purulia. Rabi crop yield was lagging in Bankura and Purulia till 2008 and had a higher yield of Rabi crop in 2009. The crop yield in Bankura increased in 2009 due to cultivation of potatoes. The annual rainfall in Purulia was also lower than in Bankura and the crop yield was more stable in Purulia when compared to Bankura due to cultivation of less water intensive crops.

Table 10: Crop Yield and Rainfall in Bankura and Purulia District

Bankura				
Year	**Summer**	**Kharif**	**Rabi**	**Rainfall**
Crop Yield (tonnes/ha)				
1999	2.7	1.9	1.1	1745.2
2000	3.3	3.3	0.9	1235.0
2001	2.5	1.8	1.4	1323.0
2002	3.0	1.3	0.8	1437.0
2003	3.0	1.2	1.4	1317.0
2004	2.6	4.6	1.0	1559.8
2005	2.3	1.5	0.7	1343.6
2006	2.8	2.2	1.1	1394.4
2007	2.2	2.1	0.9	1814.6
2008	1.8	2.0	0.7	1557.9
2009	1.8	1.8	28.7	1300.1

(Contd.) Table 10: Crop Yield and Rainfall in Bankura and Purulia District

Purulia				
Year	**Summer**	**Kharif**	**Rabi**	**Rainfall**
Crop Yield (tonnes/ha)				
1999	2.4	0.9	1.3	1416.0
2000	2.4	1.0	1.6	1033.0
2001	1.7	1.1	1.5	1434.0
2002	2.0	0.8	1.0	1383.0
2003	2.2	1.1	1.4	1260.0
2004	2.1	1.0	1.0	1220
2005	2.3	0.9	1.1	1079
2006	2.4	1.0	0.8	1276
2007	1.5	0.8	1.0	1783.8
2008	1.7	0.6	0.9	1383.4
2009	2.0	0.5	3.5	1165.8

From both the districts, two drought-prone blocks were selected as study area. Kashipur block was selected from Purulia district and Chhatna block was selected from Bankura district. In both these blocks, comparison was made to understand the impact of deficient rainfall on Aman crop which is harvested post monsoon.

Impact of Deficient Rainfall on Monsoon Crop

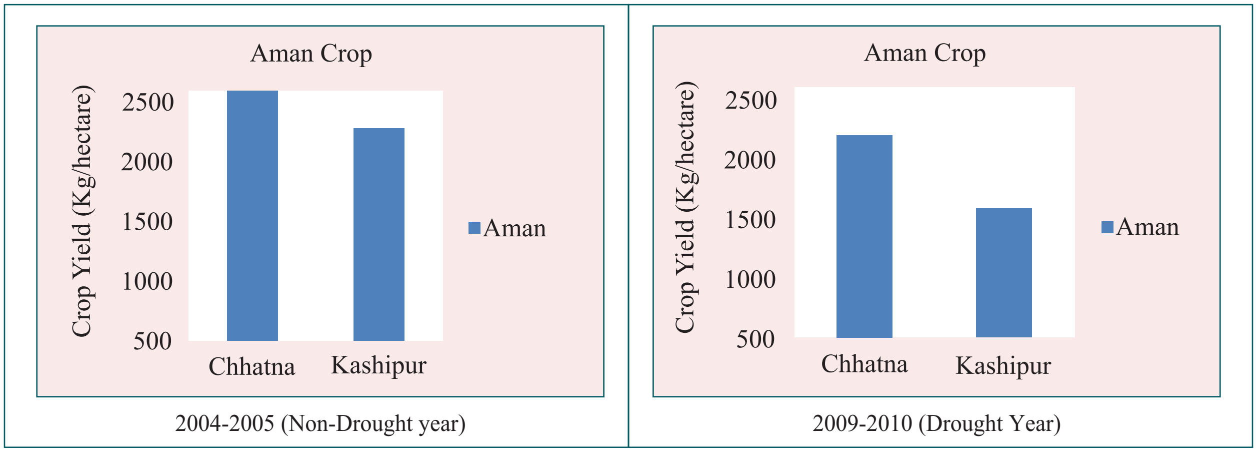


Fig 5.1 Impact of Rainfall on Aman Crop in Kashipur and Chhatna

Comparison of Crop Production in Drought and Non-Drought Year

It could be seen from the graph, that rainfall is directly correlated to production. As rainfall decreases, production also falls. This is true for both the districts but the fall in production was more in case of Kashipur block of Purulia making Purulia more vulnerable to deficiency in rainfall. Kashipur of Purulia was affected more than Chhatna of Bankura and in both drought year and non-drought year, the yield per hectare was low, but during a drought, a sharp decline can be seen in the case of both Kashipur and Chhatna blocks.

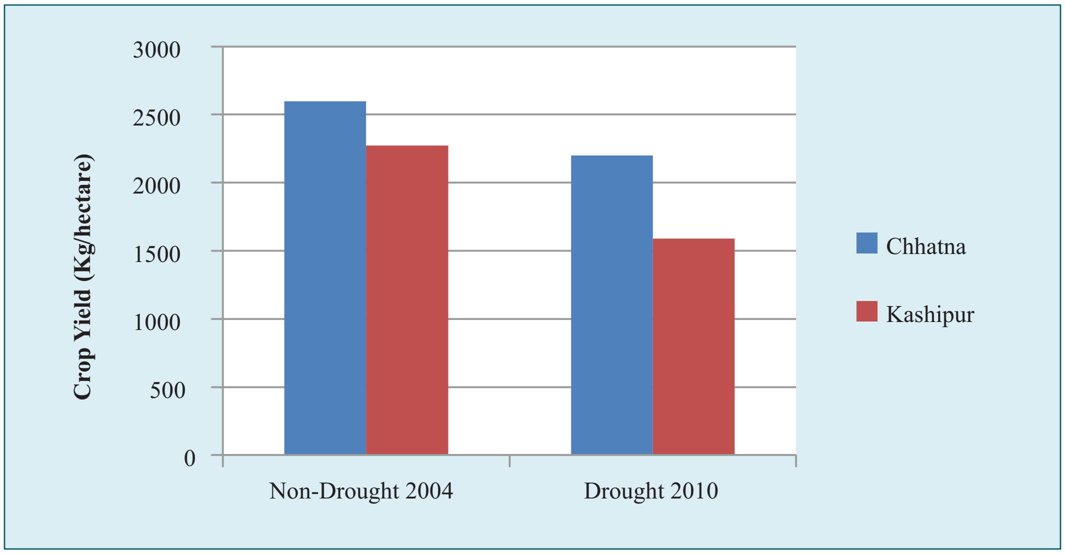


Fig 5.m Comparison of Crop Production in Drought and Non-Drought Years

Crop-Production in Kashipur Block of Purulia

Impact of Rainfall Since Kashipur was worse affected in comparison to Chhatna and seemed to be more vulnerable, the relation between rainfall and rice production in Kashipur has been explored in the graph below:

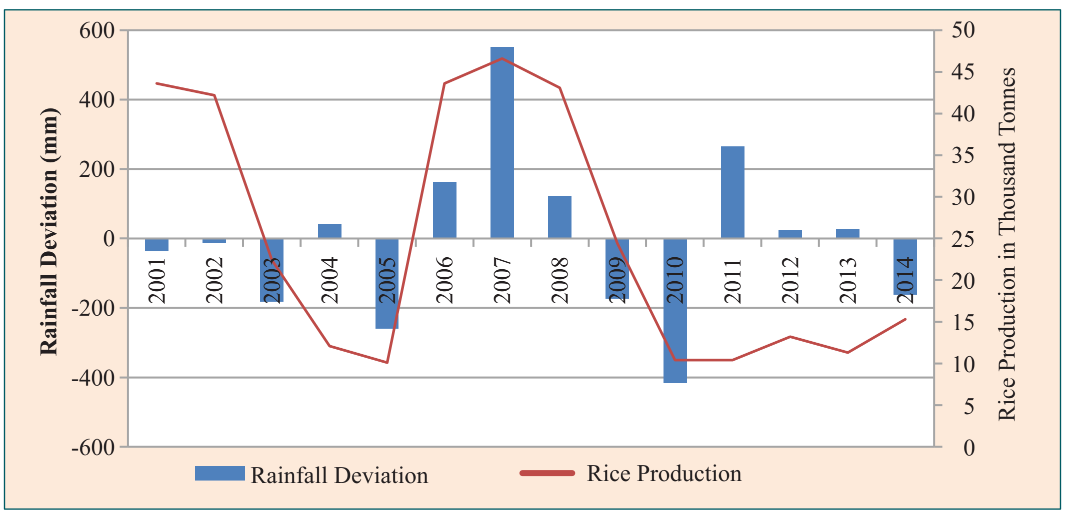


Fig 5.n Relation Between Rainfall and Rice Production in Kashipur

Correlation of Major Kharif Crop-Rice with Monsoonal Rainfall

The correlation of major kharif crop, Rice, was seen to be more affected by the rainfall during the combined months of June and July month than the whole of monsoonal rainfall taken into consideration. June and July rainfall is thus crucial for crop-growth and yield.

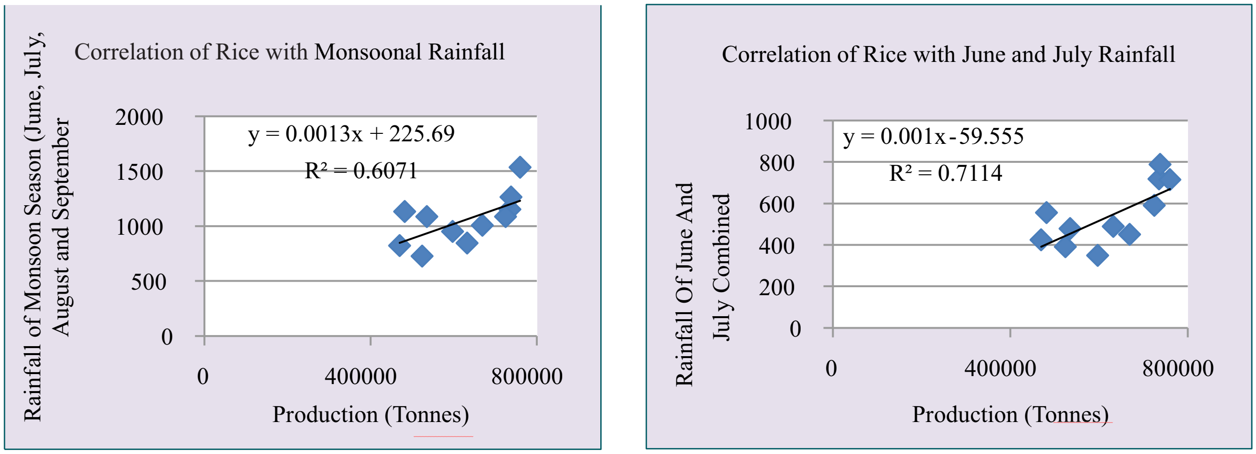


Fig 5.o Correlation of Major Kharif Crop-Rice with Monsoonal Rainfall

Comparison of Impact of Rainfall on Kharif Crop Production of Kashipur and Chhatna Blocks in Purulia and Bankura

It can be seen from the graph that with deviation in rainfall, the rice production of Kashipur block in Purulia was more affected and is responsive to even a small amount of rainfall change, whereas, the rice production in Chhatna block of Bankura did not fall during the years 2003, 2005, 2009, 2012 and 2014, when there was a negative change in rainfall. Impact of rainfall on rice cultivation is more prominent in Kashipur block of Purulia than Chhatna block of Bankura.

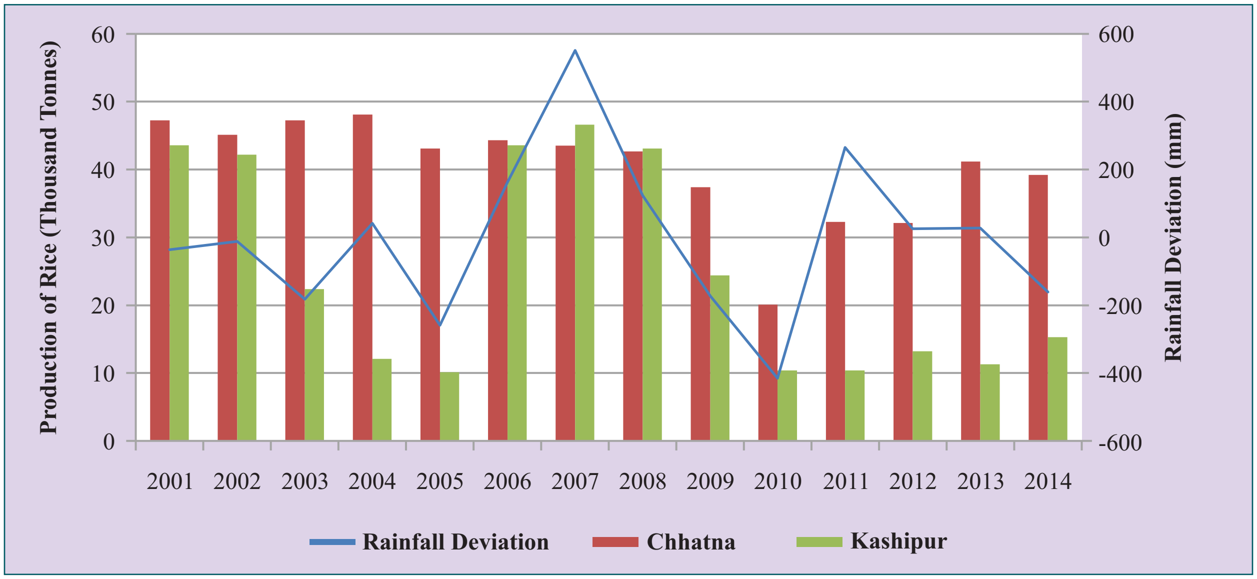


Fig 5.p Comparison of Impact of Rainfall on Rice Production of Kashipur and Chhatna

It can be thus being concluded that the relationship between rainfall and crop production is interlinked and any deviation in rainfall can lead to negative impact on crop-production. Differences in crop responses could be seen in the two drought-prone districts of Bankura and Purulia and thus it is important to study the impacts separately on a regional scale. Block level study in these two blocks identified that the block of Purulia to be more affected. The response to rainfall also varied and kharif crop could be seen to be most responsive to rainfall variation. A positive correlation was found, indicating the impact of rainfall to be very important for Kharif crop production mainly during the months of July and August. This study also points to the fact that the impact of one drought can have a negative impact on successive years and it withdraws very slowly as the capacity of the vegetation to recover from drought is different for different crops. In spite of good rainfall, there can still be negative impact on production if it is preceded by a drought year and that can be explained by the recovery effect. This effect can be countered by cultivating very less water intensive crops like Bajra, Ragi and Maize for food crops and Groundnut, Castor seeds and fodder as cash crops, thus adding value for the farmers to sustain a drought year or deficiency in rainfall. As rainfall is highly variable and the impact on crop production is evident it has also been suggested have alternative sustainable livelihood like rearing of livestock and dairy farming to supplement the loss from droughts.

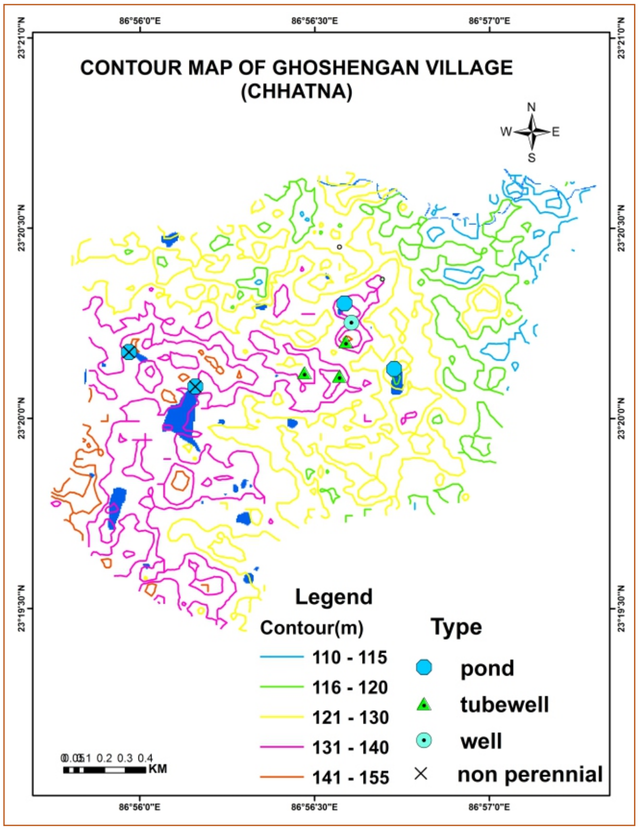
This region already suffers from recurrent droughts, and the ground water potential is not very high with respect to other regions of the state. Thus, policies that augment the storage of surface run off need to be boosted here so that crop yield is not adversely affected even when there is paucity of rainfall.

6. Water Resource

The linkage between rainfall and crop yield led to an important analysis of perennial and non perennial wells and ponds which is a key factor for adaptation to climate variability

6.1 Village Level Water Resource Assessment

Village level water resource assessment according to elevation, depth of water table, soil and watershed has been accomplished in the study area. Table. 11 shows the summarized result. The depth of water table in the village Hanspahari is 5 to 6 m in pre-monsoon season. Two wells located in this village are at 170 m and 160 m elevation, with the depth ranging around 10m.While the well at 170 m elevation is non-perennial, the one at 160 m elevation is perennial.



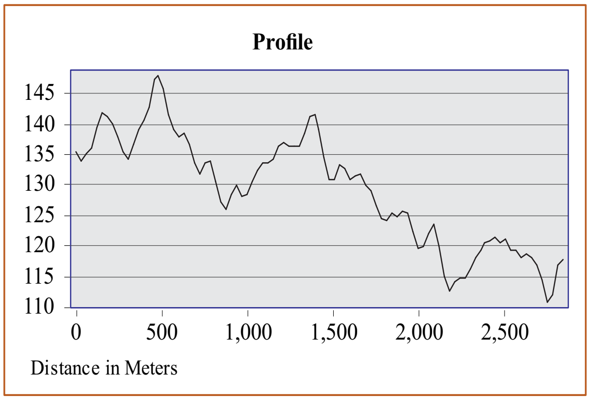


Fig 6.a Contour and Water Bodies of Ghoshengan

Table 11: Village Level Water Resource Assessment

Village	Depth of Water Table (M)	Elevation (M)	Depth (M)	Type of Water Source
Hanshpahari	5-6	170	10 Well	Non Perennial
		160	6 Pond	Perennial
			3 Pond	Non Perennial
			10 Well	Perennial
Ghoshergan	4-5	140	5 Pond	Perennial
			3 Pond	
				Non Perennial
		130	3.5 Pond	Perennial
Benagaria	3-4	110	3.65 Pond	Perennial
		125	3.65 Pond	Non Perennial
Jainagar	4-5	130	2.5 Pond	Non Perennial
		120	4 Pond	Perennial

6.2 Ground Water Level Measurement

A basic measurement in ground-water level is that of water levels in the wells. So water levels in the different wells were measured during both pre-monsoon and monsoon seasons.

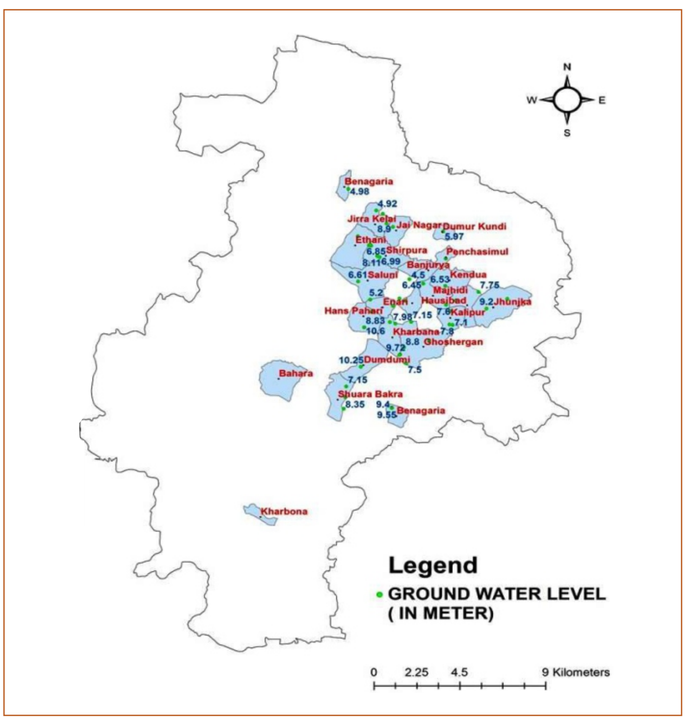



Fig 6.b Ground Water Level Measurement

Table 12: Ground Water Level in Villages

	Pre-Monsoon (m) BGL	Monsoon (m) BGL
Jibanpur	10.76	0
Jibanpur	9	2.4
Dhum Di	9.2	1.69
Tamli Di	10	0.2
Jaganath Di	9.6	4.2
Namogora	6.7	2.96
Namogora	7	0
Jamkiri	9.3	2.4
Jamkiri	9.5	8
Balarampur	10	3.15
Belda	10.4	0.1
Belda	8.5	1.36

6.3 Fluoride Test in Tube Well

Potable water is a necessity for good health. The groundwater quality of Kashipur and Chhatna blocks were undertaken as part of the present study and is based on primary survey carried out in December, 2015.

Fluoride in minute quantities is essential for mineralisation of bones, formation of teeth enamel and helps to prevent dental caries. In excessive doses, however it leads to a chronic fluoride poisoning called fluorosis. According to BIS standard, the highest desirable limit of fluoride is 8.0 mg/l. The fluoride concentration in Kashipur and Chhatna blocks varied between 0.1 to1.31 mg/l and the highest fluoride concentration in groundwater was found at Jhunjka village i.e. 1.31 mg/l, whereas the average fluoride concentration in groundwater of Kashipur and Chhatna blocks is 0.41 smg/l (table.13).

Table 13: Fluoride Level in Tube Wells

Mouja	Tola	Fluoride (mg/lit)
Loha Garah	Lohagarah	0.35
Majhidihi	Alijhara	0.26
Kendua	Kendua	0.25
Annari	Kush Bona	0.32
Hansha Pahari	Shirpura	0.32
Hetasura	**Joynagar**	**0.84**
Pencha Simul	Pencha Simul	0.67
Besara	Beriathol	0.19

(Contd.) Table 13: Fluoride Level in Tube Wells

Mouja	Tola	Fluoride (mg/lit)
Gopalpur	Gopalpur	0.49
Ghosher Gram	Majh Para	0.52
Joynagar	Kasi Para	0.32
Ghosher Gram	Gara Dihi	0.53
Jhunjhka	Rangagora	1.31
	Chanchan Pur	0.23
Bena Goria	Bena Goria	0.13

In Kashipur and Chhatna blocks, fluoride contamination is mainly due to the natural process of leaching of fluorine minerals. In semi-arid climate, high temperature, low rainfall, ground water fluctuations, rocks of pre-cambium metamorphic age, high physical and chemical weathering process etc. lead to the fluoride enrichment process in groundwater.

6.4 Domestic Water Demand

In the drought prone districts of Bankura and Purulia, water for drinking and other purposes is a major problem especially in the dry seasons. Majority of the shallow ponds and wells go dry or retain scanty water during the winter and summer seasons. The present study evaluates the fresh water demands for two blocks of Chhatna (in Bankura) and Kashipur (in Purulia) to understand the fresh water need for domestic and agricultural uses vis-a-vis the water availability. The water level varied from 3 to 7 metres in Chhatna block (Source CGWB) and from 5 to 8 meters in Kashipur block. The sectorial water demand, domestic and crop water demand have been calculated from standard procedures. The domestic water demand has been calculated at the PHED approved rate of 70 litres per head per day (5 litters for drinking water and 65 litters for other domestic works) for Chhatna and Kashipur block in 2001 and 2011. Domestic water demand was 4.32 mcm and 4.78 mcm for Chhatna and Kashipur in 2011. Domestic Water demand has been observed to be growing at the same rate of population increase over the last decade.

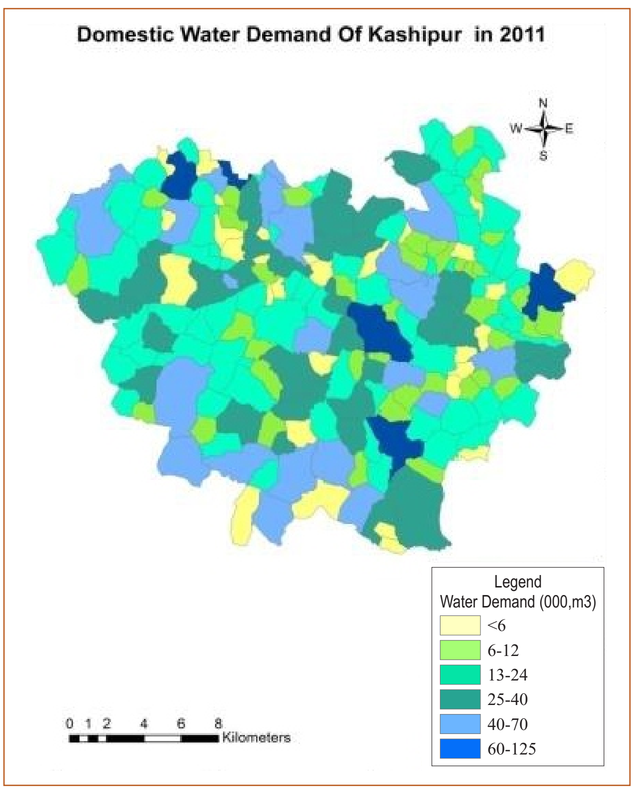
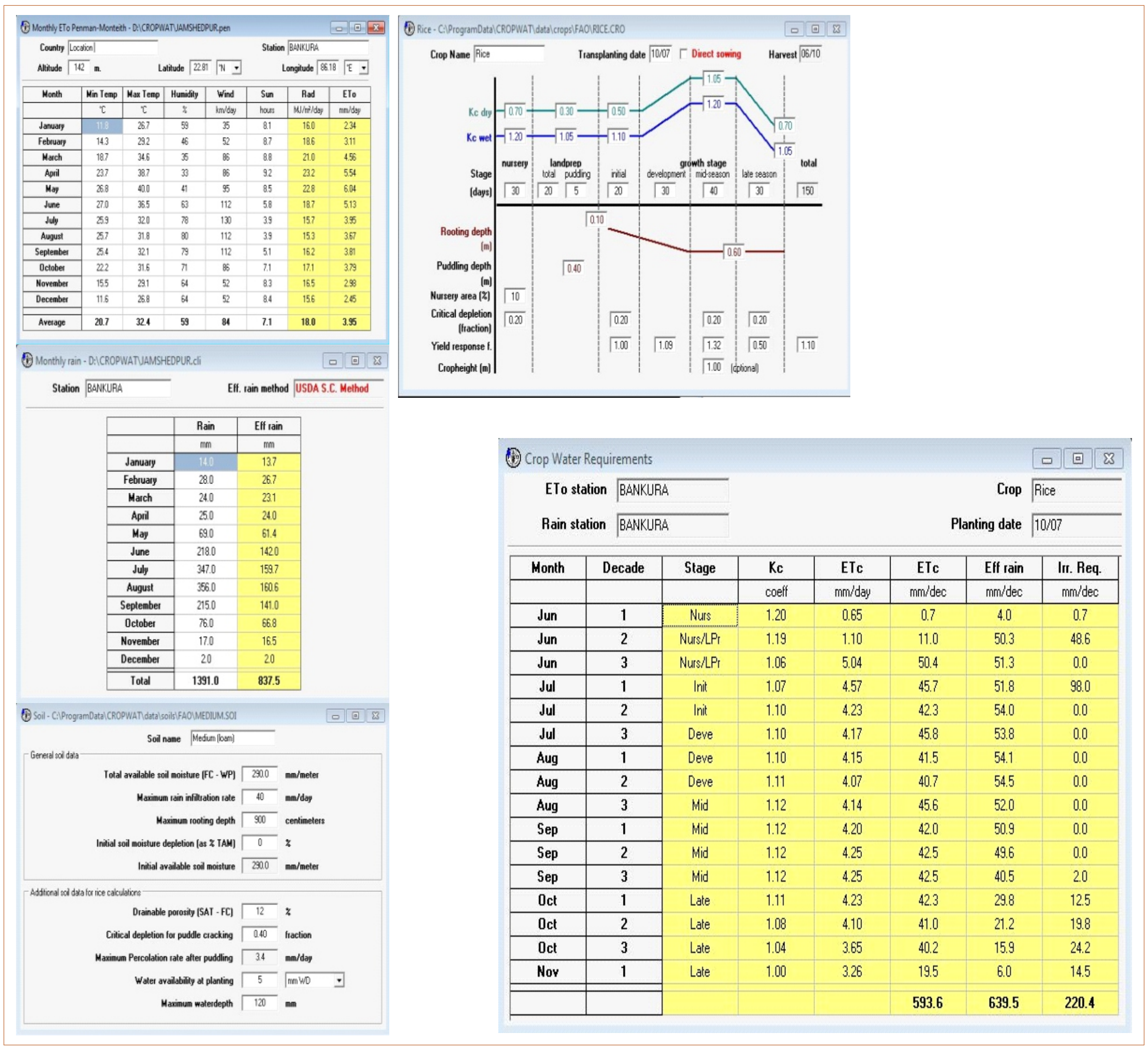


Fig. 6.c Domestic Water Demand of Kashipur in 2011

- Domestic Water demand has been observed to be growing with population over the last decade.
- Aman being the major crop of Kashipur and Chhatna, rain water requirement (1349.25 mcm) and irrigation water requirement (53.347 mcm) are maximum for the Aman paddy cultivation. The monthly crop water demand is maximum during July to September.
- In Chhatna and Kashipur the main sources of irrigation are tanks and dug wells.

6.5 Crop Water Demand

The monthy crop water demand has been estimated (Effective rain and Irrigation water requirement) for different crops (Aus, Aman, Boro, Potato, Wheat, Mustard etc) in Kashipur and Chhatna blocks. The crop water demand has been calculated by CROP WAT 8.0 software. Aman being the major crop of Kashipur and



Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	11.8	26.7	59	35	8.1	16.0	2.34
February	14.3	29.2	46	52	8.7	18.6	3.11
March	18.7	34.6	35	86	8.8	21.0	4.56
April	23.7	38.7	33	86	9.2	23.2	5.54
May	26.8	40.0	41	95	8.5	22.8	6.04
June	27.0	36.5	63	112	5.8	18.7	5.13
July	25.9	32.0	78	130	3.9	15.7	3.95
August	25.7	31.8	80	112	3.9	15.3	3.67
September	25.4	32.1	79	112	5.1	16.2	3.81
October	22.2	31.6	71	86	7.1	17.1	3.79
November	15.5	29.1	64	52	8.3	16.5	2.98
December	11.6	26.8	64	52	8.4	15.6	2.45
Average	20.7	32.4	59	84	7.1	18.0	3.95

	Rain	Eff rain
	mm	mm
January	14.0	13.7
February	28.0	26.7
March	24.0	23.1
April	25.0	24.0
May	69.0	61.4
June	218.0	142.0
July	347.0	159.7
August	356.0	160.6
September	215.0	141.0
October	76.0	66.8
November	17.0	16.5
December	2.0	2.0
Total	1391.0	837.5

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jun	1	Nurs	1.20	0.65	0.7	4.0	0.7
Jun	2	Nurs/LPr	1.19	1.10	11.0	50.3	48.6
Jun	3	Nurs/LPr	1.06	5.04	50.4	51.3	0.0
Jul	1	Init	1.07	4.57	45.7	51.8	98.0
Jul	2	Init	1.10	4.23	42.3	54.0	0.0
Jul	3	Deve	1.10	4.17	45.8	53.8	0.0
Aug	1	Deve	1.10	4.15	41.5	54.1	0.0
Aug	2	Deve	1.11	4.07	40.7	54.5	0.0
Aug	3	Mid	1.12	4.14	45.6	52.0	0.0
Sep	1	Mid	1.12	4.20	42.0	50.9	0.0
Sep	2	Mid	1.12	4.25	42.5	49.6	0.0
Sep	3	Mid	1.12	4.25	42.5	40.5	2.0
Oct	1	Late	1.11	4.23	42.3	29.8	12.5
Oct	2	Late	1.08	4.10	41.0	21.2	19.8
Oct	3	Late	1.04	3.65	40.2	15.9	24.2
Nov	1	Late	1.00	3.26	19.5	6.0	14.5
					593.6	639.5	220.4

Fig 6.d CROP WAT Output for Crop Water Requirement

Chhatna. The monthly crop water demand is maximum during peak monsoon months (from July to September). The water requirement from Aman cultivation in Kashipur block is around 268 mcm, out of which 53 mcm is irrigation requirement. About 342 mcm water is required for Aman Cultivation in Chhatna. The irrigation requirement of the block is about 68 mcm. Crop wise water requirement of 0.07 mcm, 0.32 mcm, 0.10 mcm, 0.05 mcm and 0.5 mcm have been estimated for Boro, Wheat, Maize, Mustard, Potato and Maskalai crops respectively under the existing scenario of cultivation for Kashipur.

Total water requirement (Domestic and Crop) of Kashipur and Chhatna stood at 274.47 mcm and 346.27 mcm respectively in 2013.

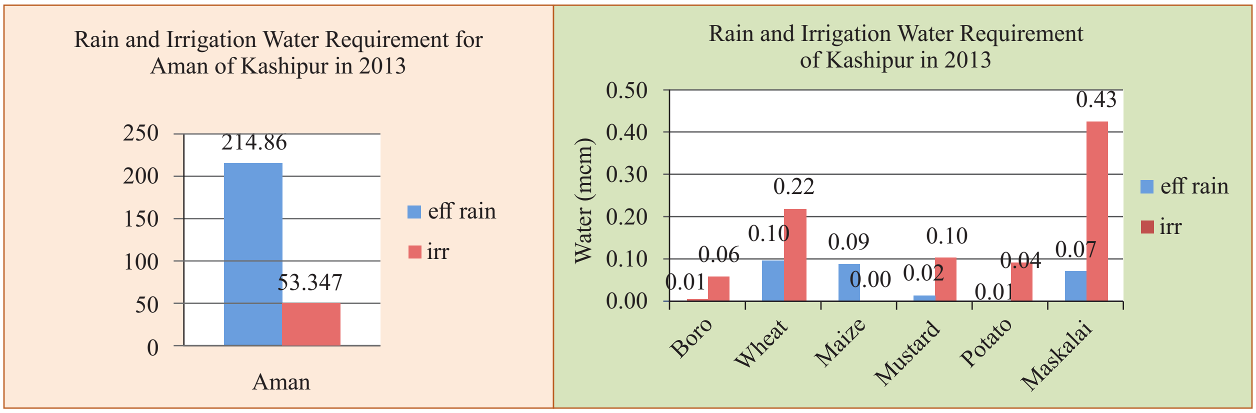


Fig 6.e (a) Water Requirement for Different Crops

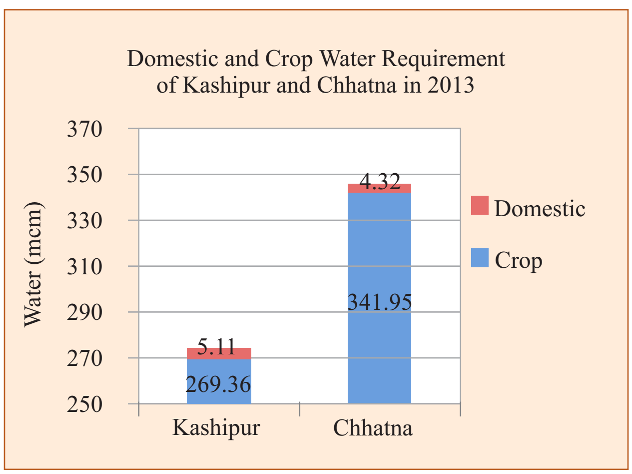


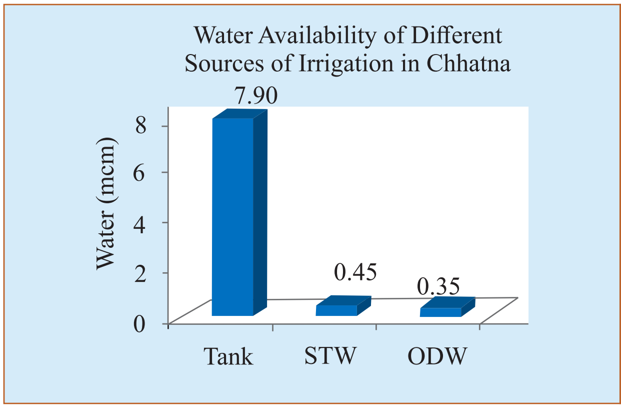
Fig 6.e (b) Domestic and Crop Water Requirement of Kashipur and Chhatna

6.6 Water Availability

Tanks, open dug wells and shallow tube wells are the major sources of freshwater in Chhatna. Canals, tanks, open dug wells and river lift irrigation are different sources of freshwater in Kashipur. In both Chhatna and Kashipur, the main sources of irrigation are tanks and dug wells. In Kashipur, the water availability from shallow ground water sources (tube well) is only 0.45 mcm, from tanks it is 7.90 mcm and 0.35 mcm is from open dug well. In Chhatna, water availability from tanks stood at 0.62 mcm, 14.3 mcm was from open dug wells and 5.37 mcm was from canals.

- Warming temperatures, changes in precipitation and runoff, and river flow have affected and will likely continue to affect water supply and quality.
- Changes to water sources affect many sectors, including human health, agriculture, and ecosystems, and especially fall in agricultural production.

The water sources are mainly tanks, river lift irrigation, open dug wells and shallow tube wells. But these sources depend on good rainfall. Thus the present irrigation scenario in the blocks is not very bright.



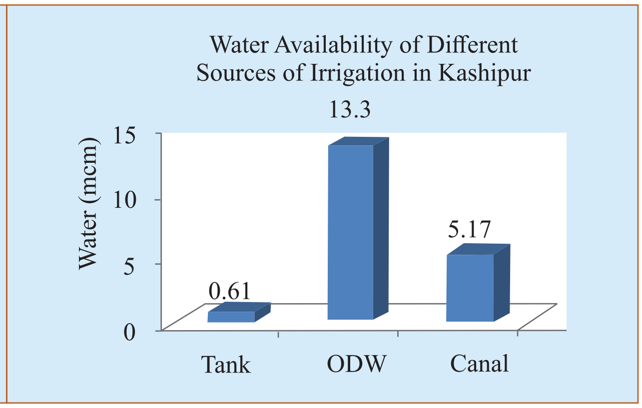


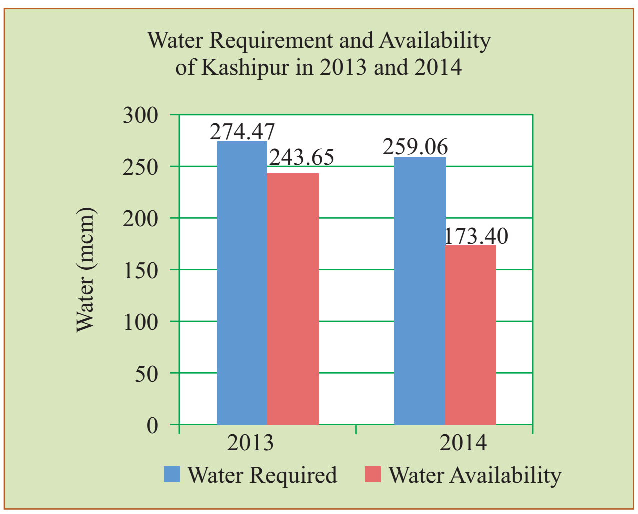
Fig 6.f Different Sources of Water Availability in Chhatna and Kashipur

6.7 Gap Between Water Demand and Availability

Comparing the total ground water availability with the total water demand (domestic and crop) as estimated in the study, it is seen that against the water demand of 341.94 mcm in Chhatna, and 274.5 mcm in Kashipur the water availability from shallow ground water sources (tube well) is only 90.43 mcm in Chhatna and 73.48 mcm in Kashipur. Thus, both Chhatna and Kashipur have water deficit from ground water sources.

With increasing household, number of livestock and crop and irrigated area, the water demand in the domestic and agricultural sectors would increase substantially. The total water requirement was estimated to be more than the total water availability in 2013 and 2014. Total water availability has been declining from the year 2013 when it was 243.65 mm to 173.40 mm in 2014, as annual precipitation (related runoff and river-flow) decreased from 1570 mm in 2013 to 1247 mm in 2014.

It is observed that people in the Chhatna and Kashipur blocks have larger dependency on tank water, than ground water sources while the canals are either not sufficient or not in use. Surface water (tanks, dug wells) thus play a very important role in sustainable agricultural development for the region and construction of water harvesting structure of different sizes for different land situations can be considered for making these areas drought resistant in future.



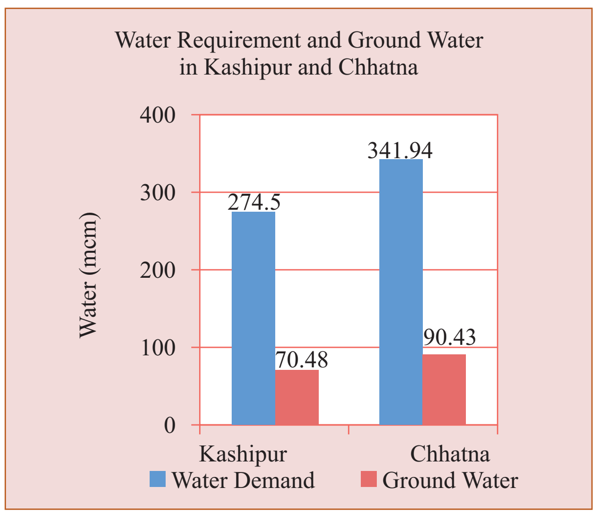


Fig 6.g Comparison Between Water Requirement and Availability in Kashipur and Chhatna

Water outweighs all other natural resources in terms of importance to mankind. All vital processes of value to mankind need water. Looking at the essential role of water in all human activities, the impact of water scarcity would be distressing. Shortage of drinking water would affect health through limited hydration and would also place constraints on hygiene. It would also lead to economic distress because of inadequate crop yield.

The study area of Chhatna and Kashipur are places with chronic water shortages. An attempt has made to understand the demand for water vis-à-visthe availability of water. It has been observed that with burgeoning population the demand for water is on the rise, both for domestic consumption and agricultural production.

The total water requirement (Domestic and Crop) of Kashipur and Chhatna stood at 274.47 mcm and 346.27 mcm respectively in 2013. In the Kashipur Block the water requirement stood at 274.47 mcm in 2013 against availability of 243.65 mcm from rain water tank.

Ground water is a primary resource when surface water is scarce, which is often the case in drought prone areas. Also, the groundwater aquifers are replenished slowly, and human demands often exceed the natural recharge as is observed both in Kashipur and Chhatna blocks. In Kashipur block, while the demand of water stood at 274.5 mcm, the groundwater availability to meet the requirements was only a meagre 70.48 mcm. In Chhatna, the demand stood at 341.94 mcm while the groundwater availability was only 90.43 mcm.

As is evident from above, the study area is drought prone with low groundwater potential. Thus it is necessary to look at ways that can boost the storage of surface water run off to meet the steadily rising water demands of the region.

7. Socio-Economic Condition

Socio-economic condition is an important indicator to measure the development level of any community. Indicators such as population, sex ratio, literacy, educational attainment, work participation rate are discussed.

7.1 Population Growth

According to the 2011 Census, Kashipur, the eastern most block of Purulia had a density of 405 persons per square kilometre, whereas the district had a density of 468 persons per square kilometre. The total population of Kashipur was 2,00,083, out of which 51.1 % were males and 48.75% were females. Kashipur had a sex ratio of 955 females for every 1000 males against the district sex ratio of 958 females for every 1000 males. It has also been observed that 28.47% of the population belonged to scheduled castes and 24.58% of the population belonged to scheduled tribes. Decadal growth for the period 2001-2011 was 6% in Kashipur against 13.79% in the district and 17.84% in West Bengal. The rate of population growth in Kashipur was very low when compared to the district, due to lack of income opportunities, and lack of adequate healthcare.

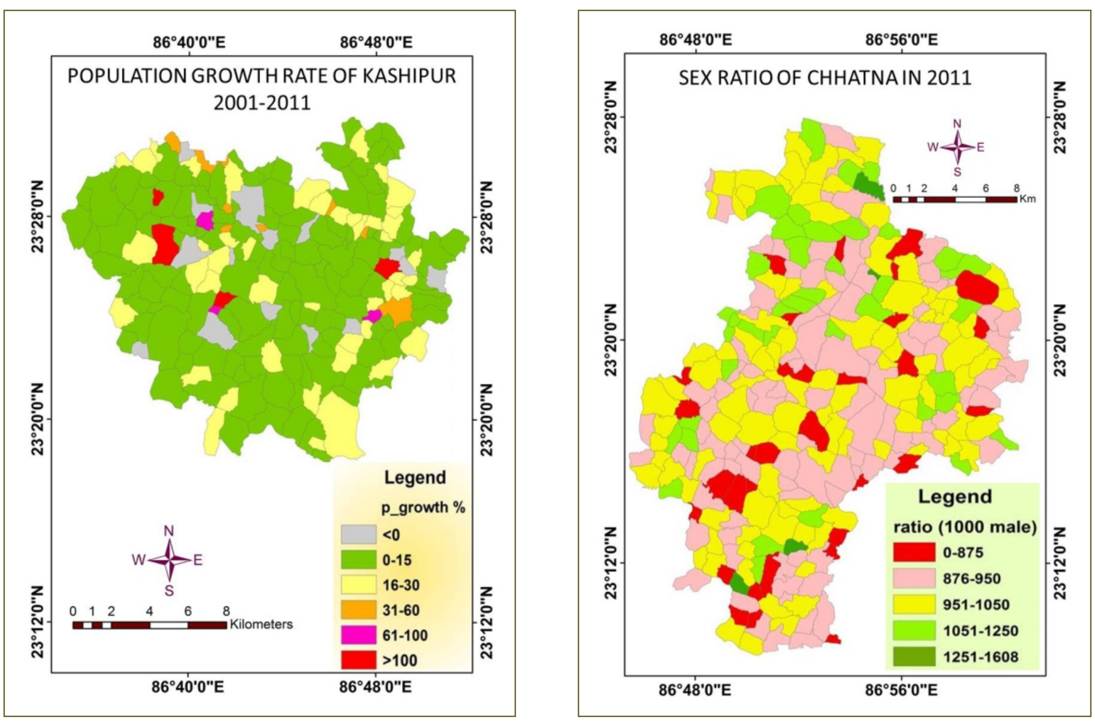


Fig 7.a Population Growth Rate of Kashipur and Sex Ration of Chhatna

According to the Census 2011, Chhatna block had a total population of 1,95,038 of which 51.02% were males and 48.97% were females with a sex ratio 955 female per 1000 males which was at par with the district sex ratio (954 female for every 1000 male in Bankura). The Chhatna block had a population density of 395 inhabitants per square kilometre against 523 persons per square kilometre in the district. It has also been observed that 29.99% of the population belonged to the scheduled castes where as 20.49% people belonged to the scheduled tribes. The decadal population growth rate (2001-2011) in Chhatna was 15% which was equal to the district growth rate (15.43% in Bankura).

7.2 Population Projection

Population projection is an estimate of a future population. A projection may be defined as the numerical outcome of a particular set of assumptions regarding the future population. Population projections can be used for a number of purposes. They provide a tool for analysing the components of growth and the sensitivity of underlying assumptions. Projections can raise our understanding of the determinants of population change. The most important use of population projections is in the role they can play in decision-making. Changes in population size and composition have many social, economic, environmental, and political implications. Population projections help decision makers in both the public and private sectors to make informed choices (Lee and Tuljapurkar, 1997; Miller, 2001). State projections can be used to determine future water demands

Table 14: Projected Population of Kashipur and Chhatna in 2021 and 2031

Admin Units		Census Years				Projected Population
District	Blocks	1991	2001	2011	2021	2031
Purulia	Kashipur	167313	187038	200083	216468	232853
Bankura	Chhatna	156147	169215	195038	214484	233929

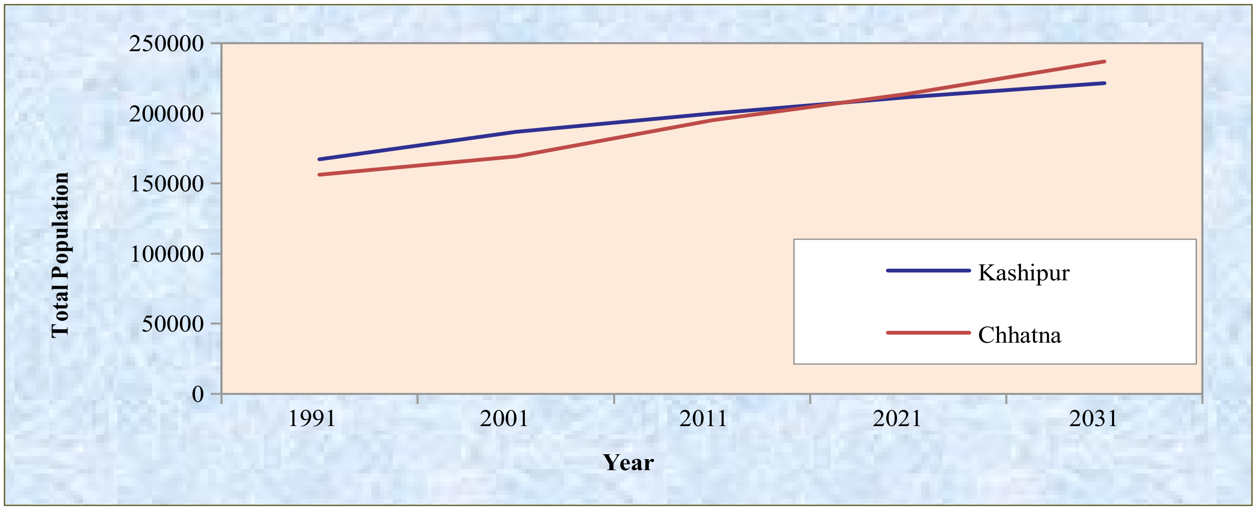


Fig 7.b Projected Population of Kashipur and Chhatna in 2021 and 2031

(Texas Water Development Board, 1997). Projections of population growth estimates for Kashipur and Chhatna for the years 2021 and 2031 is that population will keep growing, reaching an estimated 2,16,468 people in 2021 and 2,32,853 in 2031. The population of Kashipur is currently growing by approximately 20,000 people each year, with a declining growth rate.

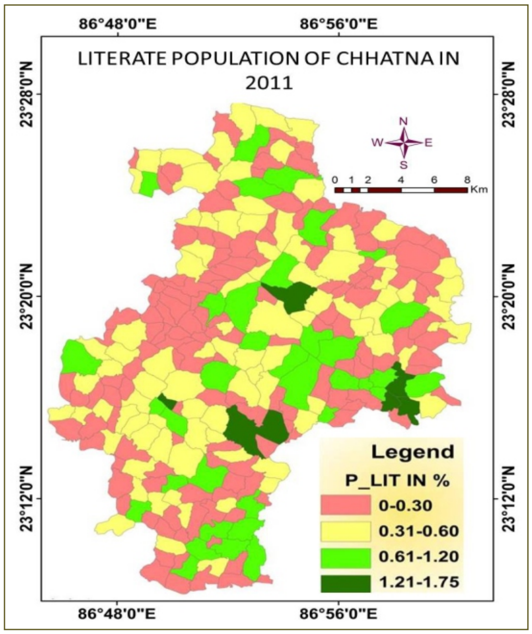


Fig 7.c Literacy Rate of Chhatna in 2011

7.3 Literacy Rate

During pre-independence era, education scenario was very poor in Kashipur and Chhatna. However, literacy rate has risen remarkably after independence. As of 2011, in Kashipur 62.45% of the total population were literate out of which 59.19% were males and 49.80% were females. In the same year Chhatna, had a total literate population of 57.65% out of which 60.25% were males and 39.75% were females.

7.4 Child Population (0-6years)

In Kashipur block, out of the total population, child (0-6 years) population stood at 11.86% in 2011. Of the total child population, 51.58% were males and 48.41% were females. Growth rate of population in children from 0-6 years declined by about 3.54% from 2001 to 2011. In Chhatna block, out of the total population child (0-6 years) population stood at 12.42% in 2011 of which 51.02% were males and 48.97% were females. Growth rate of population (0-6 years) declined by about 2.32% from 2001 to 2011.

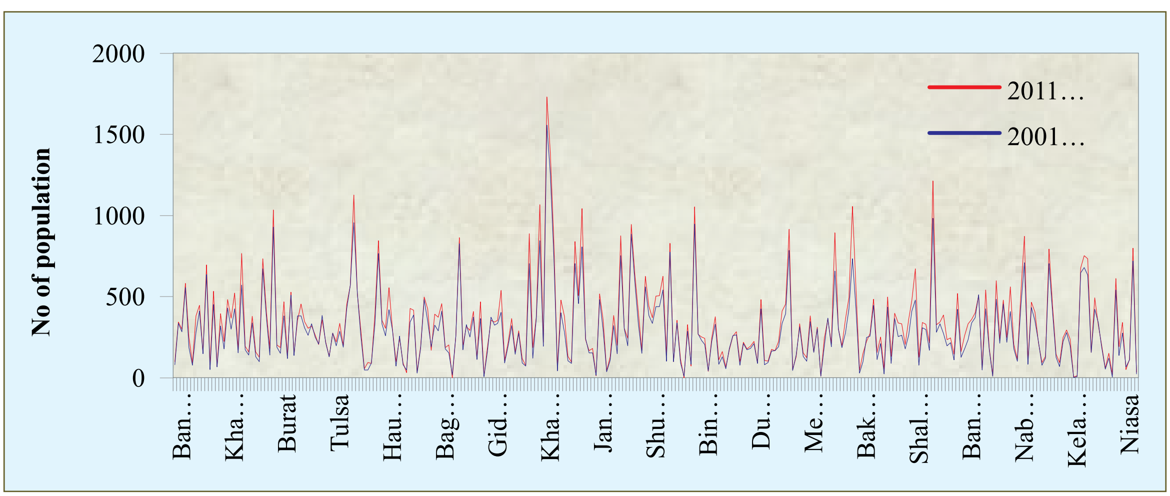
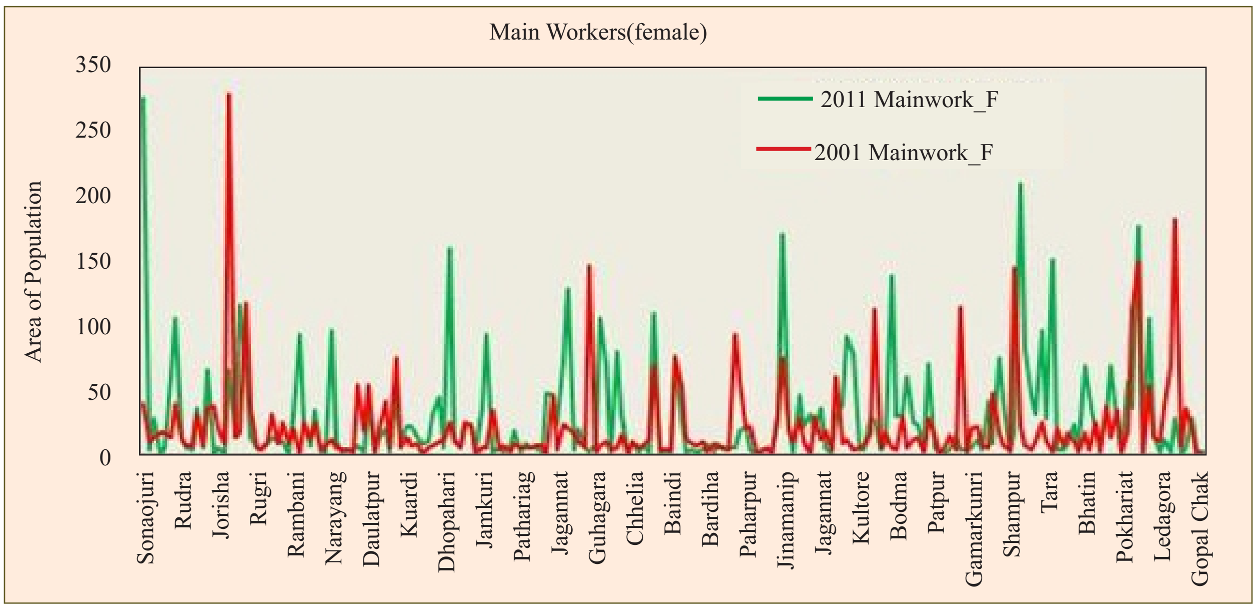


Fig. 7.d Female Child Population (0-6 years) of Chhatna in 2011

- Population growth rate of Kashipur and Chhatna between 2001 and 2011 were 6% and 15% respectively.
- Between 2001 and 2011child population (0-6years) decreased. The rate of decrease was higher in females than males.

7.5 Working Population

In the Kashipur block, working population was very low and constituted of 82,995 persons (2011 Census) which was 41%, of the total population of the block. 18.75% were main workers, 22.45% were marginal workers and remaining 34.62% were non-workers. In the Chhatna block,77,212 persons made up the working population (2011 Census) which was 39.58%, out of the total population. 20.61% were main workers,



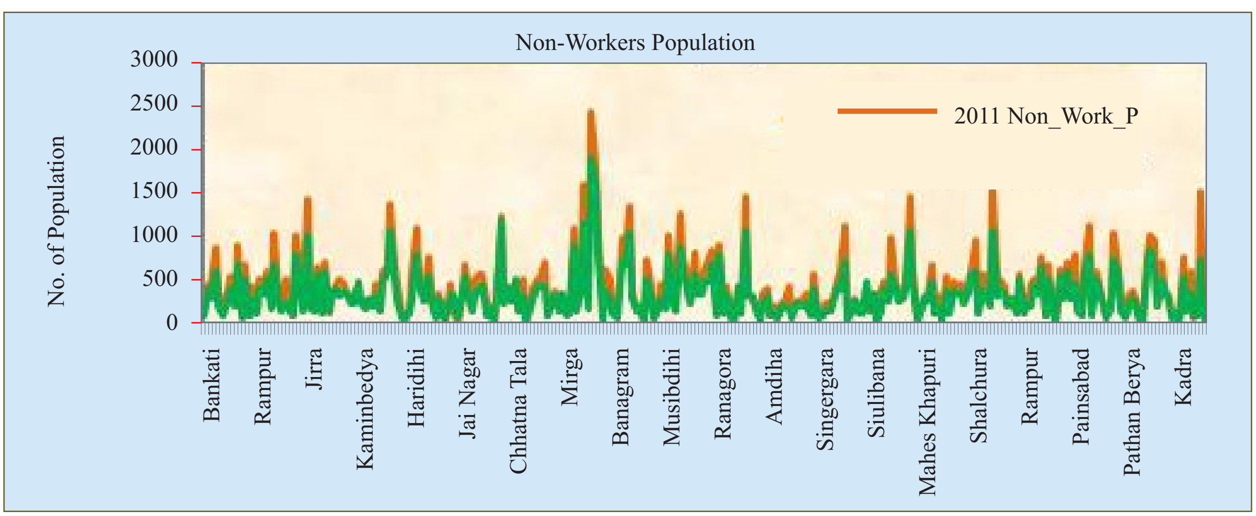


Fig 7.e Main and Non-Workers of Kashipur

18.97% were marginal workers and 37.23% were non-workers. The main workers includes cultivators, agricultural labourers, household, industrial and other workers including social workers, government job holders, factory workers, teachers etc. Main Workers are those workers who work for the major part of the reference period i.e. 6 months or more. Marginal Workers are those workers who do not work for the major part of the reference period i.e. less than 6 months and the non-workers made up of those who do not work at all in a year like students, infants, unemployed youth etc.

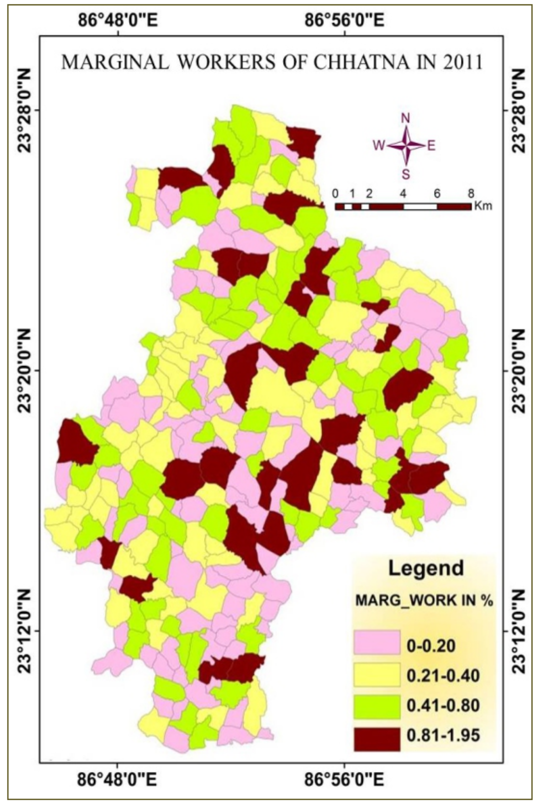


Fig 7.f Marginal Workers of Chhatna in 2011

7.6 Animal Husbandry

Animal husbandry sector is considered to be one of the major activities for providing subsidiary income to small and marginal farming families. Development of this sector is considered very important as a source of supply of essential nutrient. The Kashipur block has 57,584 number of cattle, 4,608 buffaloes, 14,576 sheep, 37,652 goat, 3,274 pig and 1,15,890 poultries. (Table No 15.)

Table 15: Live-Stock of Kashipur

YEAR	Name of Block	No. of Live Stock					Poultry Birds
		Cattles	Buffaloes	Goats	Sheeps	Others	
2012	Kashipur	57584	4608	37652	14576	3274	115890
2013	Kashipur	76401	7761	53308	20447	3732	201798
2014	Kashipur	80221	8149	55973	21469	3919	211888

It is observed from the above table that the livestock is on the rise in this block. The increase was more between 2012 and 2013 than between 2013 and 2014.

7.7 Marginal Workers

The concept of worker was introduced for the first time in India in 1961. According to the Census of India, any person whose main activity is to participate in any economically productive work either by his physical or by his mental activity is classified as worker (Census of India, 1971). Census report defines main worker as a person who works for 183 days or more in the year and those who works any time of the year but do not worked for major part of the year are known as marginal workers.

Changing Pattern of Workforce

The percentage of main workers was 21.12% in 2001 and it declined to 18.75% in 2011 but the percentage of marginal workers was 19.25% in 2001 and it increased to 22.75% in 2011.

Table 16: Main and Marginal Workers 2001 and 2011

	MAINWORK_P	MAINW_M	MAINW_F	MARGW_P	MARGW_F	MARGW_M
2011	37495	31573	5922	45500	23099	22401
2001	39300	31870	7430	36009	16675	19334

P = Population • **M** = Male • **F** = Female (**Source:** census 2001 and 2011)

Agricultural Labourers

Agricultural labourers refer to those who work in another person's land and gets wages. Wages may be in cash or in kind. The agricultural labourers do not take the land in lease or in contract from the landowners. In Kashipur, it was observed that between 2001 and 2011 there was a 5% decrease in main agricultural labourers but a 26% increase in marginal agricultural labourers. Main male and female agricultural labourers decreased by around 2.95% and 23.10% whereas the marginal male and female agricultural labourers increased by around 29.98% and 16.28%.

In Chhatna, main agricultural workers decreased by 12.73%, whereas marginal workers increased by 24.82%. Main female agricultural workers increased by 42.23% and marginal female workers decreased by 5.10%.

Table 17: Main and Marginal Agricultural Labourers 2001 and 2011

	MAIN_AL_P	MAIN_AL_M	MAIN_AL_F	MARG_AL_P	MARG_AL_M	MARG_AL_F
2011	6993	5141	1852	29256	12770	16486
2001	7705	5297	2408	24002	9824	14178

AL = Agricultural Labour • **P** = Population • **M** = Male • **F** = Female (**Source:** census 2001 and 2011)

Household Industry Workers

Census report defines household industry workers as those engaged in an industry run by the head or member of the family. It may either be in a rural or an urban area. Generally extended families run this industry. The proportion of household industrial workers is comparatively small in comparison to other categories of

Table 18: Main and Marginal Household Industry Workers 2001 and 2011

	MAIN_HH_P	MAIN_HH_M	MAIN_HH_F	MARG_HH_P	MARG_HH_M	MARG_HH_F
2011	1069	843	226	1394	675	719
2001	1696	1293	403	648	307	341

HH = Household Worker • **P** = Population • **M** = Male • **F** = Female (**Source:** census 2001 and 2011) occupational structure. The main household industry workers decreased to 36.97% but marginal agricultural labourers increased by around 99% in Kashipur. Total main and marginal household industry workers decreased to 45.80% and 25.41% but marginal male household industry workers increased by around 37.80% in Chhatna.

Other Services

The Census considers all other economic activities such as construction, non-household industry, trade and commerce, hotels and restaurants, gas, water supply, plantation, livestock and fishing, electricity, public services, defence, education, health, transport, communication, storage etc. under this category. The main and marginal other services increased in the two blocks, but the rate of increase of main other services were only 15.57 % but the marginal other services increased by almost 100%.

Table 19: Main and Marginal Other Workers in 2001 and 2011

	MAIN_OT_P	MAIN_OT_M	MAIN_OT_F	MARG_OT_P	MARG_OT_M	MARG_OT_F
2011	20223	17194	3029	8852	5936	2916
2001	17499	15411	2088	2710	1888	822
	15.57	11.57	45.07	226.64	214.41	254.74

OT = Other Workers • **P** = Population • **M** = Male • **F** = Female (**Source:** census 2001 and 2011)

- Literacy rate of Kashipur and Chhatna have grown by 13.91% and 14.91% between 2001 and 2011. The Census indicated a faster growth rate in female literacy (11.33%) than male literacy (7.01%) in the 2001–2011 decadal period.
- Population ratio in Kashipur in 2011 was 965 females per 1000 males. The Sex Ratio in Kashipur showed slow upward trend when the data of the two Census years of 2001 and 2011 were compared. The comparison revealed that there were 963 females to that of 1000 males. But the Sex Ratio (959 female /1000male) in Chhatna in 2011 had decreased when compared to the 2001 Census data (975 female/1000 male).
- Between 2001 and 2011, the Main workers decreased to 6.5% and the marginal workers increased to 26.54%.

7.8 Migration

More than 75% of the people in Purulia and Bankura districts are dependant on agriculture. Agriculture in this region is facing massive problems like lack of irrigation facilities, decrease in landholding size, failure of agricultural production due to drought, lack of storage facilities etc. During summer months, the ponds dry up and the people face acute water shortage forcing them to migrate to other areas for better opportunities.

Census reports indicate the nature and trends of migration process. According to the census of 1961, 16.4% of population of Purulia migrated to other districts of West Bengal and 33.03% population migrated to other states. Most of the small emigration (47,101) from Purulia occurred to the districts of Bankura and Burdwan (13,984). Migration from one district to another occur temporarily or seasonally from time to time.

The estimated number of net migration of male and female population in Purulia and Bankura Districts of West Bengal to the other districts of the state have been calculates and it has been observed that both Purulia and Bankura show out migration.

Table 20: Net Migration of Male and Female Population in Purulia and Bankura

Sate/District	Male	Female
Bankura	-1522.66	-12302.3
Purulia	-24056.8	-37397.3

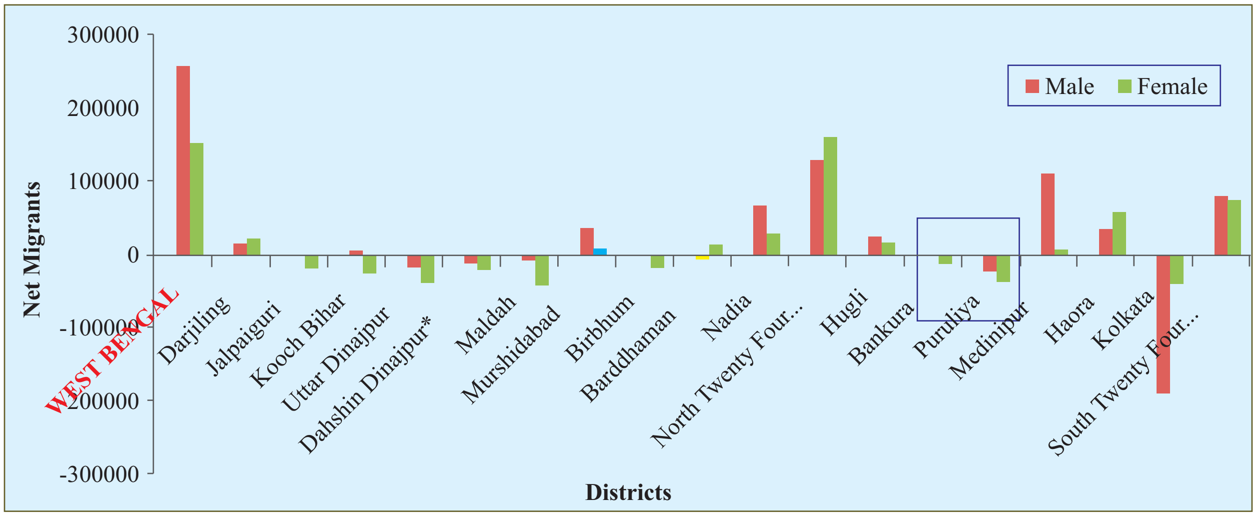


Fig 7.g Net Migration of Male and Female Population in Purulia and Bankura Districts

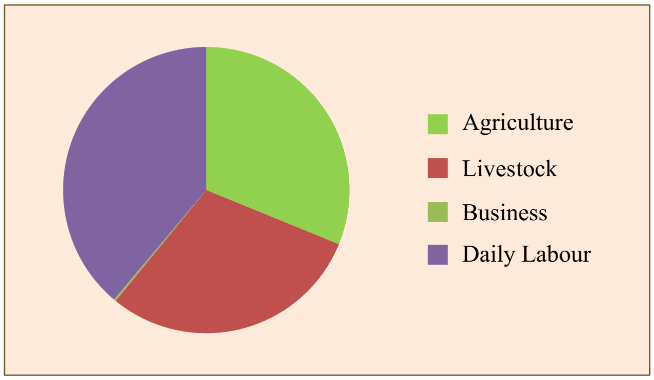


Fig 7.h Migration and Livelihood in Blocks

Migration and Livelihood

On analysing 3000 household (Kashipur 1500 and Chhatna 1500) survey data it has been observed that the maximum number of people (39%) who migrate are daily labourer. The next category of people who migrate are agricultural labourer constituting about 31% of the total population, followed by people who have livestock, which was about 30%.

Landholding and Migration

Analysing the landholding and migration pattern it has been seen that the maximum migrating population belong to the category of people who have land holdings of less than three bighas. While people with land holdings above 15 bighas households was observes to migrate less. Entitlement played a deciding role in migration. The majority of people who migrate are the ones with land holdings ranging from less than three bighas and upto seven bighas. The households with bigger ownership of land are less vulnerable compared to the ones with lesser area of land. Only entitlement of land does not ensure non-migration, the size of the land owned also plays a major part.

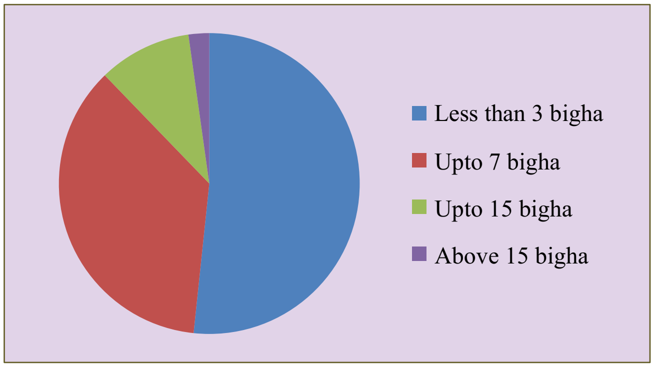


Fig 7.i Landholding and Migration in Blocks

Gender and Migration

The number of migrants from widowed female headed households was at 81%, while from married female headed households it was only around 15% in Purulia. The age group of maximum male and female family members in married female headed households were between 31 to 50 years, while more members belonged to the younger age group of 19-30 years in the widowed female headed households suggesting it is their sons, daughters in-law/daughters who belonged to the younger age-group in relation to the mother.

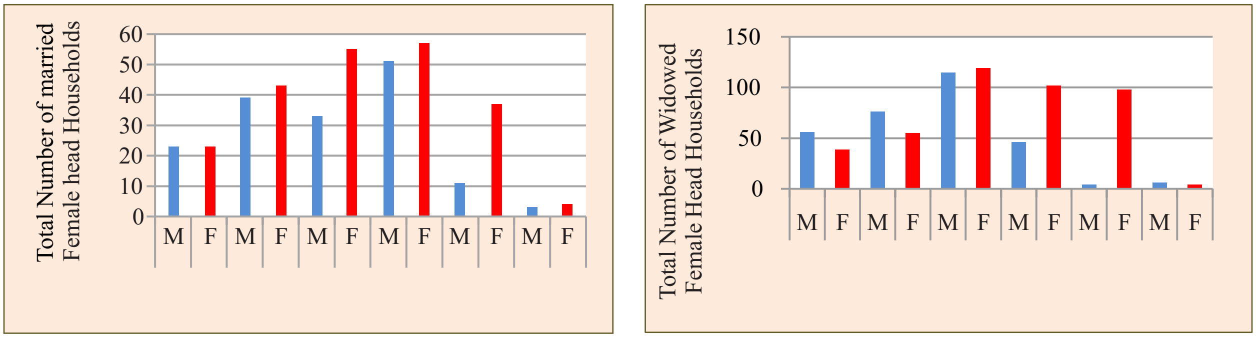
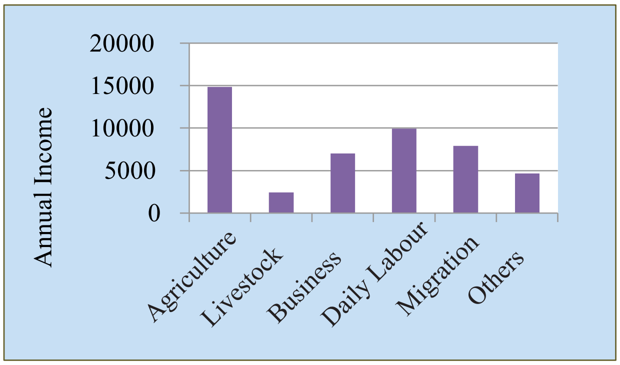


Fig 7.j Gender and Migration in Kahipur and Chhatna

Income in the Female Headed Household

Remittance from migrants has been found to be a major source of income in female headed households contributing between Rs.8000 to Rs.10000 in the annual income. Business and daily labour was not practiced in the widowed female headed households.



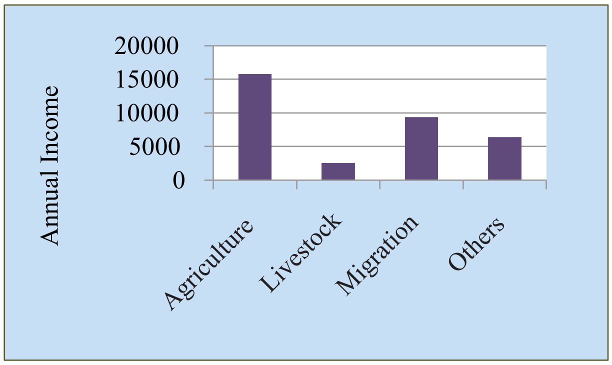


Fig 7.k Income in the Female Headed Household Married and Widowed

Occupation of the Migrant Households (Married Woman)

The graph indicates that in the married female headed households, livestock and daily labour were two major occupations other than agriculture. The number of male population (as can be seen from the graph above) was more in the age-group of 31-50 years suggesting that the remittance from migration was in the form of daily labour.

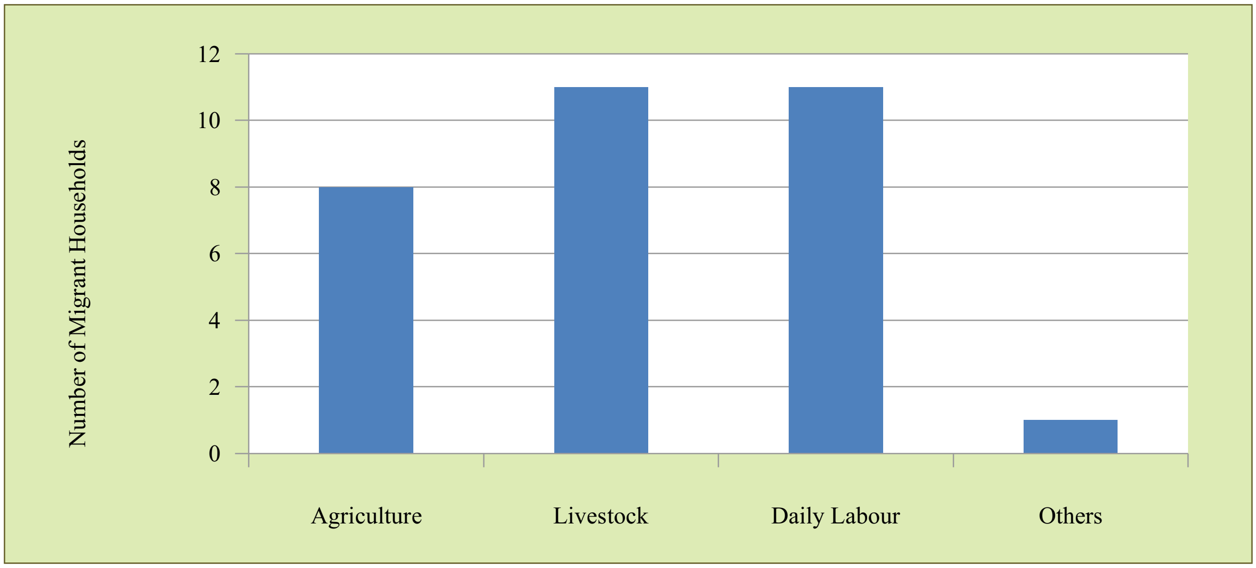


Fig 7.l Occupation of the Migrant Households of Married Woman

Occupation of the Migrant Households (Widowed)

In the widowed households, there was no member engaged in daily labour. Numbers of female members were more and they were involved in agricultural activities. The number of males (as can be seen from the graph above) was high in the age-group of 19-30 years and they, being young, did not migrate out and were more involved in agricultural activities.

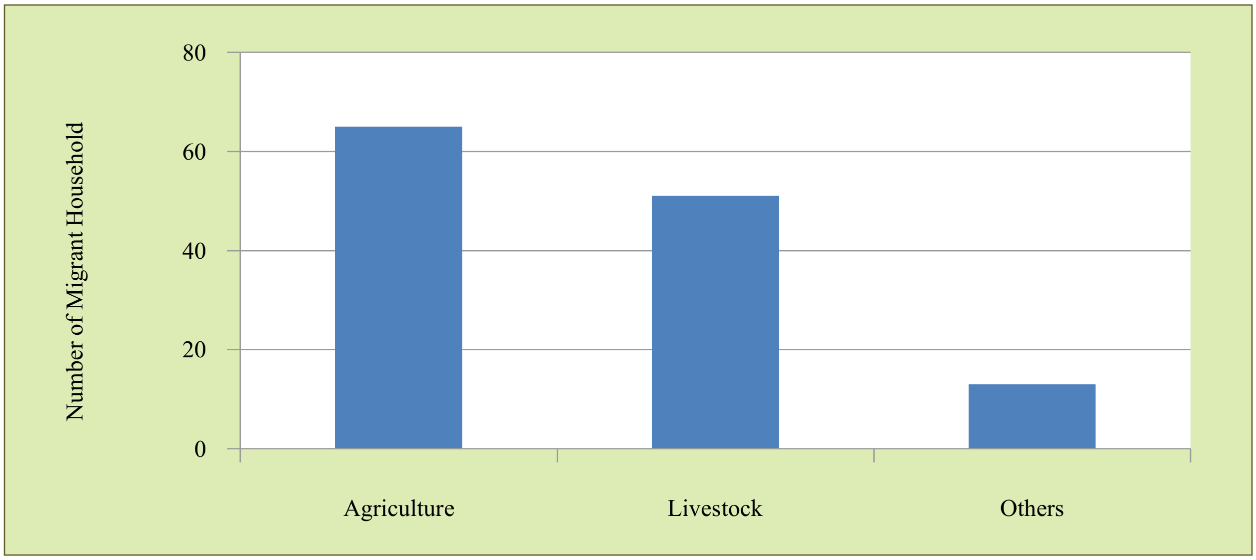


Fig 7.m Occupation of the Migrant Households of Widowed Households

When declining growth rate is largely through decline in the fertility rate this would be taken as a positive indicator of development. But in the case of the area under study the declining growth rate may be attributed to out migration due to lack of livelihood opportunities.

Scarcity of water leading to non-viability of agricultural employment may be conjectured as the driver of the low population growth rate (6% in Kashipur and 15% in Chhatna compared to 17.71% for the state) and pattern of out migration of marginal workers.

In absence of any viable irrigation (surface/sub-surface) facility, the crop production is entirely dependent on rainfall in the area and any deviation in rainfall can lead to reduction in crop-production. This study also points to the fact that the impact of one drought can have a negative impact on successive years and it withdraws very slowly as the capacity of the vegetation to recover from drought is different for different crops. Practice of alternative sustainable livelihood like rearing of livestock and dairy farming to supplement the loss from drought are being encouraged to increase the resilience of the farmers to climatic shocks. It has been observed that the livestock is on the rise in the study area. The increase was more between 2012 and 2013 than between 2013 and 2014.

Out-migration and rural development are interlinked. Rural development seeks to increase the economic and social independence of people, which in the final analysis should encourage people to remain in rural areas; Out-migration happens as a consequence of lack of development or developmental opportunities in rural areas. In the two blocks of Bankura and Purulia districts, magnitude of out migration is of serious concern. In both the districts, female migration is significantly higher than male migration. On analysis of data of 3000 surveyed households (1500 in Kashipur and 1500 in Chhatna) it has been observed that the maximum numbers of people (39%) who migrate are daily labourers. The next category is of agricultural labourers constituting about 31% of the total population. 5% of the workers migrate to other places for extra income. The number of migrants from widowed female headed household is 81%,while from married female headed household is 15% in Kashipur. All these point to the fact that the migration is not by choice but under distress due to lack of opportunities linked to water stress and climate change. Remittances from migration are a major source of income in female headed households. It is therefore not only necessary to reduce the climate risk at micro level by changing the agricultural and water use practices through a gender sensitive community involvement planning but also it is necessary to pro-actively address the issue of migration and remittance by increasing livelihood opportunities to benefit the marginal communities. Rural poverty, manifested in low agricultural income, low productivity and unemployment is an important factor behind out migration of people, which has to be addressed to bring down the rate of out migration.

One positive indicator is regarding literacy growth rate of females, which at 11.33% was substantially more than the male literacy growth rate of 7.01% in the 2001–2011 decadal period.

8. Spatial Decision Support System

A spatial decision support system (SDSS) is an interactive, computer based system designed to assist in decision making while solving a semi structured spatial problem.

8.1 Spatial Decision Support System (SDSS)

This is an interactive, computer-based system designed to assist in decision making while solving a semi-structured spatial problem. It is designed to assist the spatial planner with guidance in making land use decisions. A system which models decisions can be used to help identify the most effective decision path.

An SDSS is sometimes referred to as a policy support system, and comprises of a decision support system (DSS) and a geographic information system (GIS). This entails use of a database management system (DMS), which holds and handles the geographical data; a library of potential model that can be used to forecast the possible outcomes of decisions; and an interface to aid the user's interaction with the computer system and to assist in analysis of outcomes.

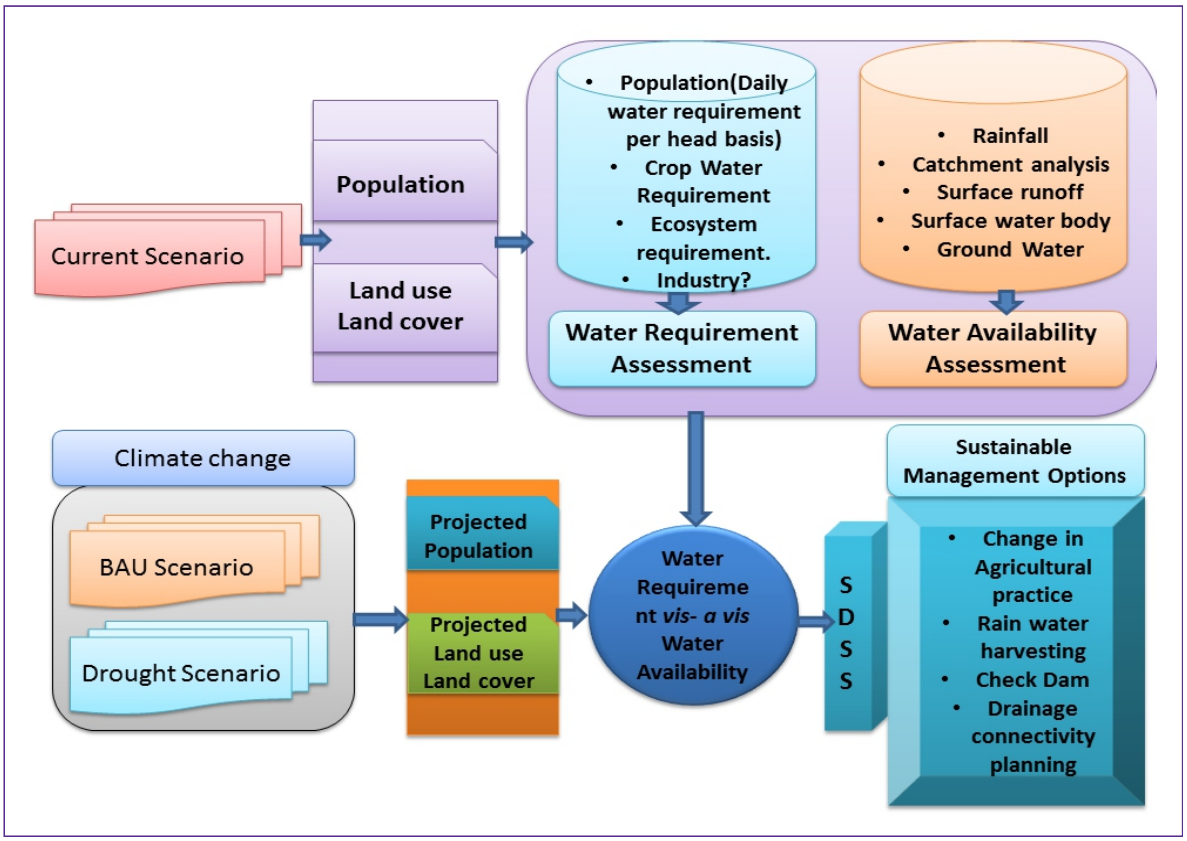


Fig 8.a Spatial Decision Support System (SDSS)

8.2 Proposed Pond, Well and Ditch Locations and Depth Analysis

Taking advantage of undulating terrain, it has been suggested that small and medium sized reservoirs are to be created to arrest the surface runoff and simultaneously the old and existing reservoirs are also to be re-excavated to increase the water resources. It is also suggested to undertake soil water conservation measures like infiltration ditch, semi-circular bunds, stone bonding etc. A model has been prepared for village level surface water management using the Spatial Decision Support System.

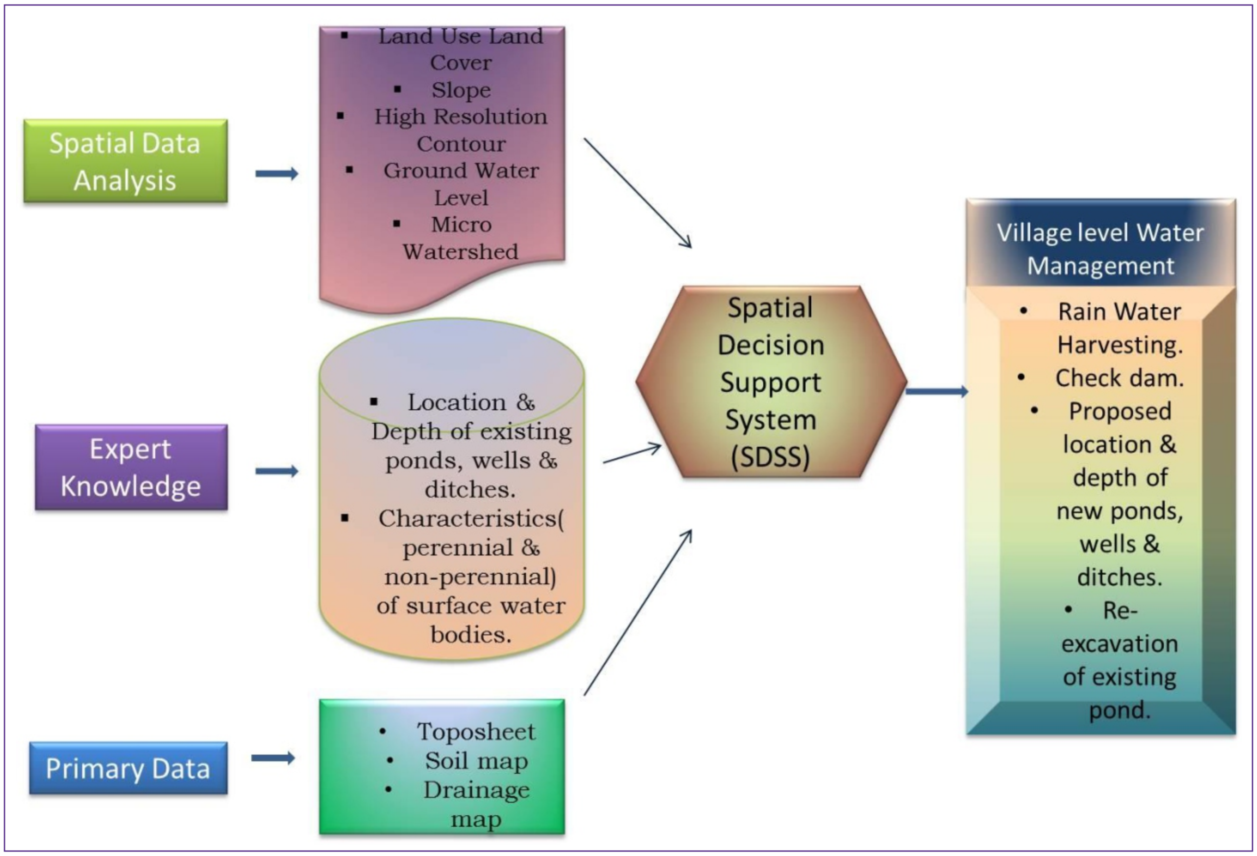


Fig 8.b Model of Village Level Water Management

Table 21: GIS Location of Proposed Ponds, Wells and Ditches in Kashipur

No	Village	Name	Longitude (M)	Latitude (M)	Type	Remark	Proposed Depth
1	Beldi	Biswanath Saren	469594	2578683	Hapa	Shift 10 m towards North beside Kanali	8-10 Feet
2	Beldi	Pashupati Mandi	469904	2578703	Hapa	Suitable	8-10 Feet
3	Beldi	Shambhu Hansda	469384	2578665	Hapa	Suitable	8-10 Feet
4	Ichamrah	Sumitra Murmu	472057	2579744	Hapa	Shift 12 m towards North East beside Kanali	8-10 Feet
5	Ichamrah	Badani Murmu	472034	2579711	Hapa	Suitable	8-10 Feet
6	Ichamrah	Astami Murmu	472269	2580294	Hapa	Suitable	8-10 Feet
7	Ichamrah	Shaktipada Hembram	472163	2579780	Hapa	Suitable	8-10 Feet
8	Khaplari	Subrata Saren	472614	2579700	Hapa	Suitable	8-10 Feet
9	Ichamrah	Samir Mahato	471978	2579397	Hapa	Suitable	8-10 Feet
10	Khaplari	Gitarani Mahato	472363	2579733	Hapa	Suitable	8-10 Feet
11	Khaplari	Parubala Mahato	472465	2579719	Hapa	Suitable	8-10 Feet
12	Sura	Mangal Ch. Hembram	466116	2582999	Hapa	Suitable	8-10 Feet
13	Sura	Masha Murmu	465671	2582545	Hapa	Suitable	8-10 Feet
14	Sura	Abinash Kisku	465176	2583000	Hapa	Suitable Margin of Kanali and Bahal	8-10 Feet
15	Jibanpur	Samudra Hembram	475433	2584539	Hapa	Suitable	8-10 Feet
16	Jibanpur	Pradip Hembram	475474	2584441	Hapa	Suitable	8-10 Feet
17	Jibanpur	Jageswar Hembram	475550	2584424	Hapa	Suitable	8-10 Feet
18	Jibanpur	Sanjit Murmu	476564	2583638	Hapa	Shift 20 m towards West beside Bahal	8-10 Feet
19	Jibanpur	Susanta Hembram	476431	2583704	Hapa	Suitable	8-10 Feet
20	Jibanpur	Swapan Hembram	476186	2583970	Hapa	Suitable	8-10 Feet
21	Jibanpur	Lilacharan Hembram	475776	2583610	Hapa	Suitable	8-10 Feet
22	Lara	Basudeb Hembram	477292	2582767	Hapa	Located outside of the study area	8-10 Feet
23	Lara	Durjadhan Saren	476874	2582942	Hapa	Located outside of the study area	8-10 Feet
24	Lara	Ajit Murmu	476774	2583416	Hapa	Located outside of the study area	8-10 Feet
25	Lara	Ruplal Saren	476609	2583457	Hapa	Located outside of the study area	8-10 Feet

(Contd.) Table 21: GIS Location of Proposed Ponds, Wells and Ditches in Kashipur

No	Village	Name	Longitude (M)	Latitude (M)	Type	Remark	Proposed Depth
26	Lara	Kalabaran Murmu	475978	2583148	Hapa	Shift 7 m toward North Margin of Kanali and Bahal	8-10 Feet
27	Lara	Babunath Besra	476166	2583399	Hapa	Suitable	8-10 Feet
28	Lara	Mangal Saren	475602	2583403	Hapa	Suitable	8-10 Feet
29	Lara	Naran Hembram	475533	2583348	Hapa	Suitable	8-10 Feet
30	Kashidi	Haradhan Majhi	466099	2582130	Hapa	Shift 10 m towards North-West beside Kanali	8-10 Feet
31	Kashidi	Arjun Murmu	466142	2581925	Hapa	Suitable	8-10 Feet
32	Kashidi	Lakhi Mahata	466562	2581674	Hapa	Suitable	8-10 Feet
33	Kashidi	Lakhi Mahata	466681	2581707	Hapa	Suitable	8-10 Feet
34	Kashidi	Sabitri Mahata	466668	2582094	Hapa	Shift 30 m towards North beside Kanali	8-10 Feet
35	Jamkiri	Haradhan Mandi	466667	2581382	Hapa	Suitable	8-10 Feet
36	Jamkiri	Fatik Bouri	466666	2580981	Hapa	Suitable	8-10 Feet
37	Jamkiri	Somai Soren	466669	2582465	Hapa	Suitable	8-10 Feet
38	Jamkiri	Sujit Pouria	466669	2582505	Hapa	Shift 15 m towards North Margin of Kanali and Baid	8-10 Feet
39	Lara	Ahala Dahar Gowta	476618	2583166	Pond	Out of the study area	27-30 Feet
40	Lara	Ahala Dahar Gowta	476043	2583160	Pond	Shift 10 m towards South	27-30 Feet
41	Jamkiri	Radeswam Mandi	479077	2582460	Pond	Suitable	27-30 Feet
42	Jamkiri	Mahadeb Tudu	478870	2582643	Pond	Suitable	27-30 Feet
43	Bodma	Marangburu Mahila Dal	472779	2587823	Pond	Existing. Re Excavation?	27-30 Feet
44	Jalumdih	Mulu Chandu Mahila Dal	469502	2582963	Pond	Suitable	27-30 Feet
45	Jalumdih	Mulu Chandu Mahila Dal	469362	2583048	Pond	Suitable	27-30 Feet
46	Bangora	Rilamala Mahila Dal	470059	2584346	Pond	Suitable	27-30 Feet
47	Bangora	Rilamala Mahila Dal	470291	2584177	Pond	Existing. Re Excavation?	27-30 Feet
48	Beldi	Nirmal Ch. Mahato	470020	2578919	Dugwell	Suitable	30-33 Feet

(Contd.) Table 21: GIS Location of Proposed Ponds, Wells and Ditches in Kashipur

No	Village	Name	Longitude (M)	Latitude (M)	Type	Remark	Proposed Depth
49	Beldi	Dilip Mahato	469758	2578734	Dugwell	Shift 10 m towards West	30-33 Feet
50	Ichamrah	Ashokkumar Mahato	472163	2579868	Dugwell	Shift 10 m towards North East	30-33 Feet
51	Jibanpur	Dharmadas Hembram	475772	2584044	Dugwell	Suitable	30-33 Feet
52	Jibanpur	Jaladhar Hembram	475894	2584496	Dugwell	Shift 20 m towards West	30-33 Feet
53	Jibanpur	Mohanlal Hansda	476677	2583953	Dugwell	Located outside of the study area	
54	Jibanpur	Malinda Hembram	476750	2583839	Dugwell	Located outside of the study area	
55	Jibanpur	Bidhan Hansda	476428	2584154	Dugwell	Located outside of the study area	30-33 Feet
56	Jibanpur	Amardas Kisku	476095	2583880	Dugwell	Suitable	30-33 Feet
57	Jibanpur	Manik Saren	475663	2584120	Dugwell	Suitable	30-33 Feet
58	Tamlidih	Sahebram Saren	479316	2583738	Pond	Existing. Re Excavation?	21-23 Feet
59	Tamlidih	Purna Chandra Hembram	478814	2583889	Dugwell	Suitable	21-23 Feet
60	Namogora	Rameswar Murmu	479748	2583501	Pond	Existing. Re Excavation?	21-23 Feet
61	Jagannathdih	Ananda Murmu	479399	2584354	Hapa	Suitable	21-23 Feet
62	Jagannathdih	Mahadeb Mandi	479298	2584267	Hapa	Shift 12 m towards West beside Baid	21-23 Feet
63	Jagannathdih	Somnath Mandi	478656	2583653	Hapa	Suitable	21-23 Feet
64	Jagannathdih	Babunath Hansda	479194	2583356	Hapa	Suitable	21-23 Feet
65	Jagannathdih	Anil Murmu	479204	2584439	Dugwell	Suitable	21-23 Feet
66	Jagannathdih	Jiten Mandi	479403	2584397	Dugwell	Suitable	21-23 Feet
67	Jagannathdih	Dukhu Mandi	478766	2583995	Dugwell	Suitable	21-23 Feet
68	Dangagora	Chini Roy	471093	2585399	Hapa	Suitable	21-23 Feet
69	Lara	Ranjit Hansda	476095	2583139	Pond	Suitable	21-23 Feet
70	Sura	Rasamani Hembram	465893	2582228	Hapa	Located outside of The Sura Village	21-23 Feet
71	Sura	Keshari Murmu	465473	2583498	Hapa	Suitable	8-10 Feet
72	Sura	Sarala Murmu	465882	2583436	Hapa	Suitable	8-10 Feet
73	Sura	Jamani Kisku	465109	2583007	Hapa	Suitable	8-10 Feet

(Contd.) Table 21: GIS Location of Proposed Ponds, Wells and Ditches in Kashipur

No	Village	Name	Longitude (M)	Latitude (M)	Type	Remark	Proposed Depth
74	Seja	Haripada Hansda	467371	2583359	Hapa	Suitable Near Pond Exist	8-10 Feet
75	Seja	Haradhan Hansda	467391	2583430	Hapa	Suitable Margin of The Kanali and Bahal	8-10 Feet
76	Seja	Babunath Hembram	466647	2583507	Hapa	Suitable	8-10 Feet
77	Seja	Jyotilal Majhi	467949	2583561	Hapa	Suitable	8-10 Feet
78	Ranjandi	Chandana Tudu	470293	2586296	Dugwell	Suitable	Above 25 Feet
79	Ranjandi	Alaka Tudu	470279	2586261	Dugwell	Shift 3m towards North Near Bahal	Above 25 Feet
80	Ranjandi	Mamata Hembram	470274	2586270	Dugwell	Suitable	Above 25 Feet
81	Ranjandi	Fulmani Tudu	470260	2586238	Dugwell	Suitable	Above 25 Feet
82	Ranjandi	Jotsna Tudu	470248	2586246	Dugwell	Shift 10 m towards Northern besider Agricultural land	Above 25 Feet
83	Ranjandi	Panmani Tudu	470107	2586250	Dugwell	Suitable	Above 25 Feet
84	Ranjandi	Sadmani Tudu	470089	2586276	Dugwell	Suitable	Above 25 Feet
85	Ranjandi	Damni Tudu	470097	2586301	Dugwell	Suitable	Above 25 Feet
86	Ranjandi	Kalimani Tudu	470106	2586342	Dugwell	Suitable	Above 25 Feet
87	Ranjandi	Lakhi Tudu	470051	2586279	Dugwell	Suitable	Above 25 Feet
88	Ranjandi	Chandmani Saren	469987	2586342	Dugwell	Suitable	Above 25 Feet
89	Ranjandi	Jaleswari Saren	469970	2586481	Dugwell	Suitable	Above 25 Feet
90	Ranjandi	Dinesh Tudu	470240	2586286	Dugwell	Suitable	Above 25 Feet
91	Ranjandi	Fakir Tudu	470210	2586254	Dugwell	Suitable	Above 25 Feet

(Contd.) Table 21: GIS Location of Proposed Ponds, Wells and Ditches in Kashipur

No	Village	Name	Longitude (M)	Latitude (M)	Type	Remark	Proposed Depth
92	Ranjandi	Chunka Majhi	470181	2586319	Dugwell	Suitable	Above 25 Feet
93	Ranjandi	Hari Tudu	470209	2586272	Dugwell	Suitable	Above 25 Feet
94	Lara	Ranjit Hansda	475722	2583059	Dugwell	Suitable	Above 25 Feet
95	Lara	Abani Besra	475737	2583054	Dugwell	Suitable	Above 25 Feet
96	Lara	Lakhindar Hansda	475758	2583043	Dugwell	Suitable	Above 25 Feet
97	Lara	Durjodhan Saren	475811	2583083	Dugwell	Suitable	Above 25 Feet
98	Lara	Naran Hembram	475622	2581434	Dugwell	Suitable	Above 25 Feet
99	Lara	Babunath Besra	475773	2583245	Dugwell	Shift 10 m towards Northeast Near Kanali	Above 25 Feet
100	Lara	Udaylal Mandi	475766	2583142	Dugwell	Suitable	Above 25 Feet
101	Lara	Basudeb Hembram	475714	2583136	Dugwell	Suitable	Above 25 Feet
102	Lara	Babulal Murmu	475658	2583250	Dugwell	Suitable	Above 25 Feet
103	Lara	Purna Chandra Majhi	475475	2582835	Dugwell	Suitable For Drinking Purpose	Above 25 Feet
104	Lara	Jaydeb Tudu	475834	2582622	Dugwell	Suitable	Above 25 Feet
105	Lara	Parimal Tudu	475873	2582613	Dugwell	Suitable	Above 25 Feet
106	Jibanpur	Amardas Kisku	476176	2583800	Dugwell	Suitable	Above 25 Feet
107	Seja	Panchanan Hansda	467334	2582764	Dugwell	Suitable	Above 25 Feet
108	Seja	Purna Chandra Hansda	467344	2583426	Dugwell	Suitable	Above 25 Feet
109	Seja	Purna Chandra Mandi	467835	2582515	Dugwell	Suitable	Above 25 Feet

Table 22: GIS Location of Proposed Ponds, Wells and Ditches in Chhatna

No	Village	Name	Type	Longitude X	Latitude Y	Remark	Proposed Depth
1	Ghosergram	Bhutunath Baske	Dugwell	494257.6	2581135	Suitable	30-33 Feet
2	Dumdumi	Sanom Murmu	Dugwell	491495.9	2578714	Suitable	30-33 Feet
3	Suarabakra	Binay Mandi	Dugwell	490783.4	2576948	Suitable	30-33 Feet
4	Benagoria	Sukdeb Gorai	Dugwell	493052.2	2576212	Suitable	30-33 Feet
5	Benagoria	Bapi Gorai	Dugwell	492813.6	2576227	Suitable	30-33 Feet
6	Benagoria	Gadadhar Gorai	Dugwell	492584.8	2576428	Shift 20 m towards South West	30-33 Feet
7	Hansapahan	Subhas Saren	Dugwell	491571.5	2581841	Suitable	30-33 Feet
8	Hansapahari	Santosh Hansda	Dugwell	491215.8	2581997	Shift 12 m towards North-East	30-33 Feet
9	Hansapahari	Shibaram Hansda	Dugwell	491692.3	2581508	Shift 10 m towards West	30-33 Feet
10	Hansapahari	Sukdeb Tudu	Dugwell	490716.7	2582032	Shift towards Pond	30-33 Feet
11	Enari	Ajay Bauri	Dugwell	492409.8	2582491	Suitable	30-33 Feet
12	Enari	Bablu Barui	Dugwell	491948.2	2582649	Suitable	30-33 Feet
13	Kharbona	Ramkali Saren	Dugwell	492579.7	2580603	Suitable	30-33 Feet
14	Kharbona	Chandi Barui	Dugwell	492147.4	2581990	Shift 50 m towards East	30-33 Feet
15	Kelai	Ramkrisna Mondal	Dugwell	491798.2	2588556	Suitable	30-33 Feet
16	Kelai	Debdulal Singha Babu	Dugwell	491621.1	2588136	Suitable	30-33 Feet
17	Joynagar	Aditaya Tudu	Dugwell	492672.6	2587534	Shift 30 m towards North	30-33 Feet
18	Jirrakelli	Deepak Tudu	Dugwell	491935.9	2587746	Shift 40 m towards North - West	30-33 Feet
19	Jirrakelli	Dilip Roy	Dugwell	492045.5	2588224	Suitable	30-33 Feet
20	Saluni	Sibami Mandi	Dugwell	490758.9	2584536	Shift 40 m towards South - West	30-33 Feet
21	Hansapahari	Luthu Mandi	Pond	490699.9	2581572	Suitable	18-20 Feet
22	Poradiha	Poradiha Krisak Dol	Pond	492189.5	2588495	Existing. Re Excavation?	Above 20 Feet
23	Ghosergram	Sukdeb Murmu	Ditch	494138.5	2581523	Suitable	8-10 Feet

(Contd.) Table 22: GIS Location of Proposed Ponds, Wells and Ditches in Chhatna

No	Village	Name	Type	Longitude X	Latitude Y	Remark	Proposed Depth
24	Ghosergram	Panchanan Baske	Ditch	494157.2	2562531	Out of the Study Area	8-10 Feet
25	Ghosergram	Shital Murmu	Ditch	493994.3	2581536	Suitable	8-10 Feet
26	Dumdumi	Pratima Mandi	Ditch	491274.4	2578700	Suitable	8-10 Feet
27	Dumdumi	Padabati Mandi	Ditch	491792.5	2578969	Suitable	8-10 Feet
28	Benagoria	Sukdeb Gorai	Ditch	493127.3	2577187	Out of the Study Village (Suitable)	8-10 Feet
29	Hansapahari	Subhas Saren	Ditch	491581	2582012	Suitable	8-10 Feet
30	Hansapahari	Budhu Hansda	Ditch	490828.7	2582246	Suitable	8-10 Feet
31	Hansapahari	Luthu Mandi	Ditch	490745.7	2581575	Suitable	8-10 Feet
32	Hansapahari	Dipali Hansda	Ditch	491541.9	2582112	Suitable	8-10 Feet
33	Hansapahari	Niyoti Hansda	Ditch	491713.7	2582182	Suitable	8-10 Feet
34	Hansapahari	Laxmimoni Hansda	Ditch	491661.5	2582213	Suitable	8-10 Feet
35	Hansapahari	Churamoni Hansda	Ditch	491378.6	2582068	Suitable	8-10 Feet
36	Hansapahari	Sonamoni Hansda	Ditch	491403.4	2582330	Shift 12 m towards West besaid Baid	8-10 Feet
37	Enari	Bablu Bauri	Ditch	491946.2	2582670	Suitable	8-10 Feet
38	Tilasota	Tulsi Saren	Ditch	493611.2	2582217	Suitable	8-10 Feet
39	Tilasota	Tulsi Saren	Ditch	493495.6	2582043	Suitable	8-10 Feet
40	Kelai	Ramkrrisna Mondal	Ditch	491757	2588528	Shift 9 m towards North	8-10 Feet
41	Kelai	Purnachandra Mondal	Ditch	491746.7	2588490	Suitable	8-10 Feet
42	Kelai	Laxmikanta Mondal	Ditch	491825.7	2588518	Shift 10 m towards South East beside Baid	8-10 Feet
43	Kelai	Sankar Mondal	Ditch	491748.8	2588604	Suitable	8-10 Feet
44	Kelai	Biwajit Mondal	Ditch	491621.2	2588351	Suitable	8-10 Feet
45	Kelai	Debdulal Singha Babu	Ditch	491621.1	2588136	Suitable	8-10 Feet
46	Poragala	Dinesh Murmu	Ditch	491146.2	2587548	Suitable	8-10 Feet
47	Joynagar	Ranjit Murmu	Ditch	492286.2	2587742	Exist. Re Excavation?	8-10 Feet
48	Jirrakelli	Suplal Murmu	Ditch	491926.7	2586912	Suitable	8-10 Feet
49	Dumurkundi	Pramila Hembram	Ditch	493933.9	2586756	Located outside of the study village	8-10 Feet

(Contd.) Table 22: GIS Location of Proposed Ponds, Wells and Ditches in Chhatna

No	Village	Name	Type	Longitude X	Latitude Y	Remark	Proposed Depth
50	Dumar Kundi	Niranjan Mondal	Ditch	561426.2	2586629	Located outside of the study village	8-10 Feet
51	Dumar Kundi	Paritosh Mandi	Ditch	492985.9	2586204	Located outside of the study village	8-10 Feet
52	Banjura	Aswani Roy	Ditch	494024.2	2584665	Suitable	8-10 Feet
53	Banjura	Bikash Roy	Ditch	494072.5	2584782	Suitable	8-10 Feet
54	Banjura	Jaladhar Roy	Ditch	493790.2	2583789	Suitable	8-10 Feet
55	Banjura	Sudan Roy	Ditch	493951.2	2584543	Suitable	8-10 Feet
56	Banjura	Sunil Roy	Ditch	494185.9	2584477	Suitable	8-10 Feet
57	Banjura	Deban Roy	Ditch	494037.6	2584696	Suitable	8-10 Feet
58	Penchasimul	Budhan Mandal	Ditch	495844.7	2585449	Located outside of the study village	8-10 Feet
59	Penchasimul	Susanta Mandal	Ditch	495804.7	2585411	Located outside of the study village	8-10 Feet
60	Penchasimul	Bhagirath Mandal	Ditch	495560.2	2586161	Suitable	8-10 Feet
61	Penchasimul	Hamata Mandal	Ditch	495600.7	2585793	Located outside of the study village	8-10 Feet
62	Penchasimul	Maghnath Bauri	Ditch	495392.2	2585370	Located outside of the study village	8-10 Feet
63	Penchasimul	Ajit Mandal	Ditch	495530.5	2585587	Located outside of the study village	8-10 Feet
64	Penchasimul	Debakar Barui	Ditch	494406.8	2585309	Suitable	8-10 Feet
65	Penchasimul	Debakar Barui	Ditch	495026.3	2586417	Located outside of the study village	8-10 Feet
66	Penchasimul	Ananda Mandal	Ditch	495251.7	2585589	Out of the Study Village	8-10 Feet
67	Saluni	Asoke Mandai	Ditch	490577.2	2585002	Shift 5 m towards East	8-10 Feet
68	Saluni	Guamoni Hansda	Ditch	490565.8	2585013	Shift 5 m towards North	8-10 Feet
69	Saluni	Sadhan Hembram	Ditch	490704.1	2585053	Suitable	8-10 Feet
70	Saluni	Alladhi Mandi	Ditch	490556.9	2584746	Suitable	8-10 Feet
71	Saluni	Mayan Mandi	Ditch	491131.8	2584830	Suitable	8-10 Feet
72	Saluni	Latika Mandi	Ditch	490509.1	2585043	Suitable	8-10 Feet

(Contd.) Table 22: GIS Location of Proposed Ponds, Wells and Ditches in Chhatna

No	Village	Name	Type	Longitude X	Latitude Y	Remark	Proposed Depth
73	Sirpura	Budhan Mandal	Ditch	492100	2586235	Suitable	8-10 Feet
74	Sirpura	Aditaya Mandal	Ditch	492034.7	2586235	Suitable	8-10 Feet
75	Sirpura	Gopal Mandal	Ditch	492533.8	2586287	Suitable	8-10 Feet
76	Sirpura	Banshidhar Mandal	Ditch	492705.2	2586179	Suitable	8-10 Feet
77	Sirpura	Tapan Mandal	Ditch	495723.7	2585312	Out of the Study Village	8-10 Feet
78	Dumurkundi	Paritosh Mandi	Dugwell	493770.1	2586598	Out of the Study Village	26-30 Feet
79	Penchasimul	Tapan Mandal	Dugwell	495271.2	2585716	Shift 10 m towards South West beside Baid	26-30 Feet
80		Pradip Mandal	Dugwell	495337.2	2585707	Out of the Study Village	26-30 Feet
81	Penchasimul	Kirtik Mandal	Dugwell	495254.9	2585573	Out of the Study Village	26-30 Feet
82	Penchasimul	Samir Bauri	Dugwell	494689.9	2586054	Suitable	26-30 Feet
83	Penchasimul	Susanta Barui	Dugwell	495392.2	2585370	Suitable	26-30 Feet
84	Jirrakelli	Haripada Soren	Dugwell	493825.1	2587780	Out of the Study Village	26-30 Feet
85	Jirrakelli	Dilip Roy	Dugwell	492045.5	2588224	Suitable	26-30 Feet
86	Dumurkundi	Paritosh Mandi	Dugwell	493770.1	2586598	Suitable Near Settlement	26-30 Feet
87	Penchasimul	Tapan Mandal	Dugwell	495271.4	2585716	Suitable Near Settlement	26-30 Feet
88	Penchasimul	Pradip Mandal	Dugwell	495337.2	2585707	Suitable	26-30 Feet
89	Penchasimul	Kirtik Mandal	Dugwell	495254.9	2585573	Out of the Study Village	26-30 Feet
90	Penchasimul	Samir Barui	Dugwell	494689.9	2586054	Suitable Out of the Study Village	26-30 Feet
91	Penchasimul	Susanta Barui	Dugwell	495392.2	2585370	Suitable Out of the Study Village	26-30 Feet
92	Saluni	Sibani Mandi	Dugwell	490758.9	2584536	Suitable Out of the Study Village	26-30 Feet

(Contd.) Table 22: GIS Location of Proposed Ponds, Wells and Ditches in Chhatna

No	Village	Name	Type	Longitude X	Latitude Y	Remark	Proposed Depth
93	Penchasimul	Ajit Mandal	Pond	495439.4	2585545	Out of the Study Village	24-26 Feet
94	Penchasimul	Goutam Mandal	Pond	494984.6	2585414	Suitable	8-10 Feet
95	Penchasimul	Brajaswar Mandal	Pond	494792.1	2585544	Suitable but Near Existing Pond 44m towards South West	24-26 Feet
96	Penchasimul	Ajit Mandal	Pond	495439.4	2585545	Out of the Penchasimul Village near Existing Pond at 25 m towards North-West	24-26 Feet
97	Poradiha	Poradiha Krisak Dol	Pond	492189.5	2588495	Re excavation?	24-26 Feet
98	Dumdumi		Pond	490845.4	2578560	Suitable	25-33 Feet
99	Hansapahari		Pond	491219.3	2581646	Shift 20 m towards North East	25-33 Feet
100	Hansapahari		Pond	490699.9	2581572	Not Suitable	25-33 Feet
101	Kharbona		Pond	492544.2	2580601	Suitable	25-33 Feet
102	Poragala		Pond	491159.7	2587320	Suitable	25-33 Feet

The interactive Spatial Decision Support System (SDSS) for planning village amenities help decision makers and planners to find the optimum location for placing amenities like ponds and also the excavation depth necessary for existing infrastructures like wells for optimal usage of the water amenities. This has been done through a quantitative spatial evaluation and verification process. The study investigated the options for site selection of the village ponds for the best possible surface water management to counter the problems of water shortage within a framework of given decision rules.

9. Adaptation to Climate Change

Adaptation refers to the ability of a system to adjust to climate change in order to reduce its vulnerability, and enhance the resilience to observed and anticipated impacts of climate change.

Mitigation refers to any strategy or action taken to remove the GHGs released into the atmosphere or to reduce their amount.

Climate change, as some of the studies suggest (NATCOM, 2004; INCCA, 2010), may alter the distribution and quality of India's natural resources, enhance water insecurity, reduce agriculture productivity, enhance exposure to extreme weather events, and pose even unforeseen health risks. This in turn is most likely to adversely affect development of the economy that is closely linked to the natural resource base. Consequently exposing majority of its population thriving on climate sensitive livelihoods such as agriculture and forest products are subjected to great risk (West Bengal State Action Plan for Climate Change).

As those dependant on agriculture and forest products have been deemed to be most vulnerable to climate change, the present study was carried out to increase the resilience of marginal farmers to Climate Change and Climate shocks in two districts of West Bengal that have been prone to recurrent droughts. It is feared that with rising winter temperature and increasing variability of rainfall due to climate change, the vulnerability of agriculture sector will exacerbate in the near future unless mitigative measures are taken up after careful observation and analysis of the study area.

Management

Per capita water availability, whether it be surface water availability or groundwater availability would be adversely affected due to climate change leading to water insecurity and reduced agriculture productivity, amongst others effects. So adaptation strategies are necessary that will augment the storage of surface runoff and also recharge the groundwater

9.1 Rain Water Harvesting (Pond, Well, Ditch)

Rain water harvesting is the method of collecting, storing and distributing rainwater for manifold uses. The collected water can be stored for direct use or diverted for groundwater recharge. Some of the on-going work towards building rain water harvesting structures in the study area has been mentioned below along with the rationale for choosing the same.

Relevance of Step Pond

In step ponds, the evaporation loss becomes less and water can be retained for longer duration. Steps are used for cultivation when water becomes less by utilizing the moisture of the soil of steps and soil erosion can also be checked. Water of this pond can be used for critical irrigation of paddy as well for growing season extension. This structure is also ideal for fishery as most fish do not go beyond 6 feet depth.

Total Target: 40, Total Achievement: 1 completed, work on going: 8

Ditches and Dug Wells

Relevance

Ditches are constructed especially in medium lowlands and low lands to act as a harvesting structure during the monsoons. They also help to recycle sub-surface flow locally in the post-monsoon months. Erratic rainfall has serious impacts on cultivation of paddy which happens to be the main crop of the area. Irrigation with the stored rainwater can save an almost mature crop of paddy. The ditches made can be owned by an individual, but four to five owners of adjacent lands who are also members of the group will have the right to make use of the water stored in the ditch to cultivate low water-demanding crops like mustard, linseed, wheat and vegetables in the winter.

Total Target: 800, Total Achievement: Completed 52, Ongoing: 18

Lift Irrigation

A number of Sub-soil Rivers flow through this region. It is very difficult to access the river water as a source of irrigation for the lands situated at a higher point in the gradient. These lands are often left fallow or cultivated only during the monsoon season. The project proposes to install River Lift Irrigation Systems (RLI) by constructing a well on the riverbed to collect river water which is then pumped up and distributed to the fields through piped channels.

Total Target: 5. **Total Achievement: Ongoing: Site selection is going on**

Check Dam

Relevance

Many uncontrolled streams intersect this region. Four check dams will be constructed on the way of these streams to collect the water which will be pumped to the neighbouring fields through a piped channel. The irrigation facilities will help to reduce the dependence on only rain fed crop and will assure second and in some cases a third crop also. This activity will directly help to increase the adaptive capacity of the households.

Total Target: 4, Achievement: on going 2 (Site selection process is on)

Step Pond

Pond

Dugwell

Ditch

Fig 9.a Rain Water Harvesting (Pond, Well, Ditch)

9.2 Plantation in Tnar Land

Relevance

Plantation increases greenery, checks soil erosion and acts as a carbon sink. Biomass generated in plantation patch, helps to improve soil fertility as well as water retention capacity of the soil. Livelihood options are created and biodiversity is increased. Communities are motivated to select local plant varieties as regular source of food, fodder, firewood and herbs. Accordingly, three types of plantation can be done such as social forestry, orchard plantation and plantation for sericulture. Some seasonal crops can be grown in the inter-space between trees to provide short term return in the early years of the initiative.

Total Target: 250 hectares, Total Achievement: 22.53 hectare, On-going: 6.33 hectares

Fig 9.b Social Forestry and Orchard Plantation

9.3 Mixed Cropping

Practice Introduced for Mixed Cropping

Relevance

Mixed cropping of plants with different root depths and structures, result in optimal utilization of water and nutrient and higher resilience against environmental stress. Multi-storey agro-forestry extend growing season and reduce soil erosion, while enhancing carbon sequestration.

Model 1: 1.5 feet wide boundary of Cassava and Roselle plants. Distance between two Cassava plants to be 4 feet. One Roselle to be planted between two Cassava plants. **One block:** 33 feet x 33 feet and within the block ground nut, black gram, cowpea or any other legume variety according to the choice of the farmers can be planted.

Model 2: Boundary: 1.5 feet wide boundary of Cassava and Roselle. Distance between two Cassava to be 4 feet. One Roselle to be planted between two Cassava plants. **One block:** 33 feet x 33 feet and within the block the distance between two Cassava to be 10 feet. Taro or Khamalu (Greater yam) to be planted between two Cassava plants.

Model 3: Boundary: 1.5 feet wide boundary of Lemon grass/Vertiber or Citronela with Rari. Distance between two Rari to be 10 feet. **Inside:** Mixed cropping according to the choice of the farmers.

Model 4: Three lines: Cereals like Sorghum (jowar), Pearl Millets, Bardhona, Maize. **Two lines: Pulses** like Pigeon pea (Arhar). **Three lines:** Oil seeds like Krishna til or Sarguja. **Two lines:** Vegetables like Yardlong beans (Barbati), Lady's finger/ okra, Ridge Gourd (Jhinga). Next Repetition of vegetables, oil seeds, pulses and cereals follows the earlier pattern. **Inside:** Mixed cropping according to the choice of the farmers.

Fig 9.c Mixed Cropping

9.4 Winter Cropping

Practice Introduced for Winter Cropping

Relevance

Seasonal planning is being done with proper crop rotation so that moisture is properly used and soil health is maintained. Heat-tolerant crops and less water-demanding crop cultivation is the main focus in winter cropping. During the Rabi season, in the water stressed areas, crop combination like wheat + Mustard + Chickpea or Chick pea + Linseed + sesame has been promoted for cultivation. Relay cropping is gradually becoming more popular among targeted beneficiaries with the introduction of crops like grass pea and linseed utilising the residual moisture left in the paddy field.

30.5 Hectares of land has been brought under relay cropping so far

Fig 9.d Relay Cropping

9.5 Organic Farming

Promoted the Organic Farming

Relevance

Irresponsible use of chemicals has over the years increased the compaction of land, reduced permeability and the fertility of soil. With the introduction of sustainable agriculture practices, farmers are motivated and trained to produce organic fertilizers and pest repellents at home by recycling of organic wastes and also to make use of Integrated Pest Management (IPM) techniques. Organic farming is promoted to reduce the cost of agriculture, to increase the adaptive capacity of the farmers and to diminish the loss of soil fertility.

Total Target: 1,000 Hectares of land. **Total Achievement: 342.8 Hectares**

Nutrition Garden

Relevance

Beneficiaries are able to harvest nutritious vegetables (leaves, fruits, roots, tubers, legumes etc.) for more than 9-10 months. There are number of edible weeds, unconventional fruits, unknown leafy vegetables which can be conserved in the gardens. Tuber crops like elephant yam, cassava, *Diaschorea esculanta* etc. which, if not harvested, can be stored live under the soil.

Total: 726 nutrition garden has been developed

Fig 9.e Organic Farming

9.6 Seed and Fodder Bank

Grain Bank

Relevance

In view of the erratic nature of rainfall and the long drought spells over the area, agricultural production is not secure. Most of the villages in the area do not have agricultural work during the months of September through November and March through May. So there is loss of livelihood for agriculture labourers. To combat this situation, community managed grain banks have been introduced at community level to save a portion of the produce for consumption during lean periods of agriculture caused by climate induced changes.

Total Target: 40. **Achievement: Complete: 3, Ongoing: 2**

Seed Bank

Relevance

Farmers have become mostly dependent on markets for high yielding and/or hybrid seeds. These seeds show less tolerance to the effects of climate change. These seeds are usually not available at the right time and in sufficient quantities. Moreover, the farmers cannot save these seeds for future use. Efforts will be made at the grass root level for collection and preservation of indigenous seeds which are more resistant to climatic stress.

Total Target: 5. **Achievement: 0**

Fodder Bank

Relevance

Availability of fodder has become very low in the region. The scope for collection of fodder from the wild has reduced with diminishing of forest cover caused by erratic rainfall, deforestation, longer summers, low soil moisture etc. In view of the above problem, the project encourages plantation of fodder trees, so that in lean season, beneficiaries access to fodder for the livestock. Facilities for storing the agricultural wastes of the village will be made. Crop based fodder cultivation will also be promoted at individual household level. The activity will act as a cushion to withstand climate stress and provide round the year supply of food for both humans and livestock without succumbing to the vicious cycle of poverty, dominated by the money lenders etc.

Total Target: 5. **Achievement: Ongoing 2**

9.7 Multilevel Cropping System and Integrated Farming Practices

Relevance of IFS

The integrated farms are being developed based on the first principle of ecology that states that all the components of nature, biotic and abiotic are interrelated. It is an established principle in ecology now that the stability of a system is enhanced by higher connectivity among different biotic elements of a system. As the system is integrated, output of one subsystem is used as the input in others, thus reducing the cost of production which translates into more cash in the hands of beneficiaries.

Total Target: 100. **Total Achievement: Ongoing: 51**

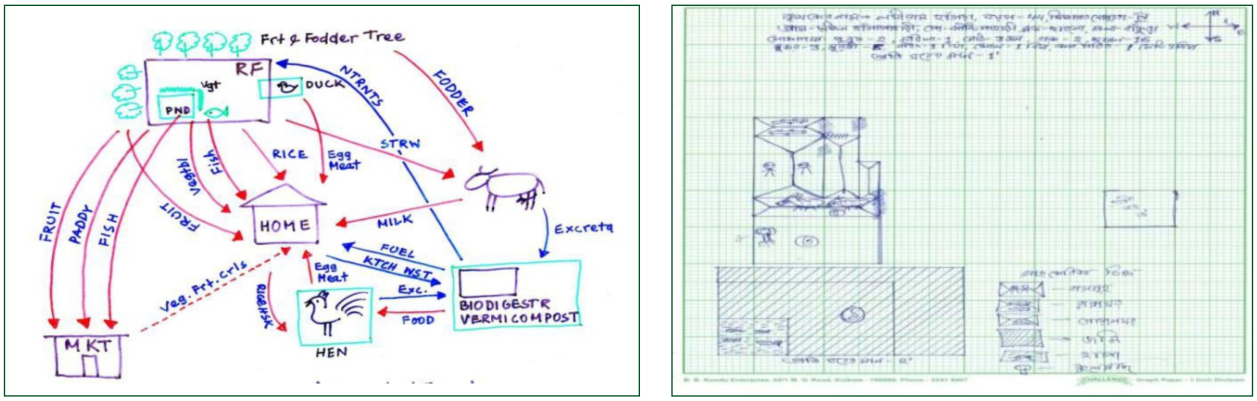


Fig 9.f Relation Between Different Subsystems in IFS Model and Sketch Map of the Farm

9.8 Soil and Water Conservation (Semi Circular Bunds, Check Dams, Gully, Plugs, Infiltration Ditch)

Soil and Water Conservation Facilities

Relevance

Measures like contour bunds, check dams, semi-circular bunds, stone bunding and trenches/pits are planned to resist run-off. Water Absorption Trenches (WAT) is being constructed with dimensions of 3 m X 1 m X 0.67 m (depth). About 90 such WATs are being constructed per hectare with an inter-space of 0.67 m. Stone binding will be made where there are gullies. Some semi-circular bunds will be constructed across the slopes. Uneven lands are being levelled with erection of land bunding to transform unproductive fallows to productive ones. It is envisaged that the barren land over which these structures are being made will help to make it productive in the long run thereby enhancing the capacity of the community to become resilient to climate change.

Total Target: 300 Hectares, Total Achievement: 36.46 Hectares of land has been covered through various soil water conservation measures

Fig 9.g Soil and Water Conservation

9.9 Alternative Livelihood

Animal Husbandry and Fishery

Relevance

Livestock rearing is a normal practice for people living in the project area as this can be done with least investment. Support and capacity building is being offered to the women beneficiaries for rearing small animals e.g. sheep, goat (*Black Bengal*), rabbit, pig and small birds e.g. duck (*Pati Hansh*, *China Hansh*), chicken (*Mayur puccho*) etc. Local breeds are chosen as these have more tolerance. Beneficiaries are being trained in adapting scientific animal rearing practices like vaccination etc. Natural resource based feed production is also being undertaken.

Total Target: 2750 Households. **Achievement: 304 Households**

Fishery

Group based fish cultivation (Indian Carp and Mudfish) are being encouraged in the newly constructed water bodies. These types of diversified activities with different income sources for the programme participants are acting as supplementary income to agriculture; thereby increasing their adaptive capacity.

Total Target: 500 Households. **Achievement: 208 Households**

Fig 9.h Promotion of Rabbit Rearing and Group Based Fishery

9.10 Energy Sufficient Oven, Biogas and Low Cost Water Filters

Energy Efficient Ovens

Relevance

To reduce the consumption of fuel and adverse effects on health, improved *chullahs* are being installed at individual family level. The *energy efficient cooking stoves* having a hot water storage tank with the capacity of producing about 12 litres of hot water besides cooking, using the same firewood. The improved *chullah* helps to save at least 3 kg of firewood (on an average) per day. This also helps in reducing carbon emission (5.4 kg per family per day on an average).

Total Target: 2400 Households. **Achievement: Completed: 475 Households, Ongoing 26 Households**

Biogas

Households with cattle produce dung. This cattle dung is stacked in large pits in the ground and is kept in the open to dry and rot. The rotting mass produces methane gas and invites environmental problems. This sun-dried dung is also less effective as a fertilizer. Bio-gas plants can be a solution for this. The bio-gas slurry is used as fertilizer in agriculture field, fishery etc. The promotion of biogas reduces the firewood consumption leading to reduced pressure and protection of common land as a buffer especially for food/fodder need during stress periods.

Total Target: 250 Households. **Achievement: Completed: 15 Households, Ongoing 13 Households**

Community Based Drinking Water Facility

Relevance

During the longer dry spells, underground water levels are so low that the hand pumps or tube wells are unable to lift any water. The supply of safe drinking water through community based drinking water system will help to check the water borne diseases among the community, especially in the dry season.

Total Target: 5. **Achievement: Site selection is going on**

Low Cost Water Filter

Relevance

Crisis of drinking water reaches the peak during periods of climate stress, and tube wells are unable to lift any water. People do not get quality potable water resulting in a spate of water-borne diseases like *amoebiasis*, cholera, diarrhoea, hepatitis A, and other enteric diseases leading to social stress. Use of Low-cost Water Filters for filtering water collected from tube wells and ponds will help in reducing these diseases during climate stress periods.

Total Target: 2500 Households. **Achievement: 433 Households**

Fig 9.i Energy Efficienct Oven, Biogas and Low Cost Water Filters

9.11 Village/Community Based Organizations

Community Level Organisation

In the different initiatives, group approach has been adopted by the implementing agency to enhance cooperation, mutual understanding, fellow felling and collective initiatives for sustainability of these activities.

Achievement: Total 295 groups (Farmer Group 101, Gardeners Group 194)

Fig 9.j Self Help Group Capacity Building and Sustainable Agriculture Hand Holding Training

This chapter has enumerated the strategies and actions to address the concerns of the beneficiaries due to climate change.

The study area falls within a drought prone zone and so water scarcity is a regular feature, which is compounded by climate stress. This study has looked into an integrated approach to water management to alleviate water scarcity in the region. Undertaking of recharge activities in over exploited ground water areas, rain water harvesting, and maintaining of existing canals and other structures are some of the measures that have been suggested.

Availability of adequate water would also ensure food security as well as associated livelihoods for the people by ensuring adequate crop productivity. Some other strategies that have been suggested and are in the process of implementation include crop diversification, sequential cropping, popularising the concept of Integrated Farming System, developing seed banks and grain storages etc. along with animal husbandry.

Supply of water filters, energy saving chullahs, help in providing sources of alternative livelihoods are all aimed towards building the resilience of the population living in the study area to climate change.

Climate change adaptation needs to happen at all levels be it, national, regional or local. At the local level the beneficiaries of this project have come together to participate in adaptive measures that address their immediate concerns. Thus these communities become more capable of handling threats due to climate change.

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