

Life in the Shadow of Embankments  
– Turning Lost Lands into Assets in  
the Koshi Basin of Bihar, India



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# Executive summary

The central objective of the research project 'Documenting and Assessing Adaptation Strategies to Too Much, Too Little Water' is to document adaptation strategies at local or community level to constraints and hazards related to water and induced by climate change in the Himalayan region, including how people are affected by water stress and hazards, their local short and long-term responses, and the extent to which these strategies reduce vulnerability to water stress and hazards. Five case studies were carried out in four countries. The results of each have been summarised in separate documents on a CD-ROM to accompany a single synthesis document.

The India case study presented here, documents and assesses how people in the Koshi basin, Bihar, India, respond to water stress and hazards in the context of climate variability and change. The Koshi is known for its frequently shifting courses and the devastation that it has caused in the past. Conventional flood-control measures have not only altered the agroecology of the Koshi basin, they have also increased the frequency and intensity of water-related stress and hazards throughout its basin. Flood-prone and waterlogged areas have increased, and erosion and sand casting have temporarily or permanently rendered vast areas of land uncultivable, leading to an increase in landlessness and distress among the local community.

Five villages were selected on the basis of their location in the Koshi basin in order to have a representative sample of sites. The study draws its findings from literature review, group discussions, focus group discussions, and participatory rural appraisal (PRA) techniques, such as social mapping, resource mapping, transect walks, and crop and season calendars.

Landlessness is rampant in all these villages; only 20-30% of the people own land and the rest are labourers. The literacy rate for the districts in the basin is significantly low by national standards and lower than the state average. Bihari rural society remains dominated by rich farmers who usurp all the benefits of state assistance for development and poverty alleviation. The main livelihood options for the people are agriculture, animal husbandry, and migration. Despite these constraints, communities have been coping with and adapting to water stress and hazards. Structural and non-structural strategies have been adopted to deal with floods. These strategies have been mainly in the form of adjustments in the cropping cycle ('garama dhan'), introduction of new (sunflower) and improved varieties (maize and wheat) of crops, alternative use of waterlogged (for 'makhana' cultivation) and sand-cast (vegetable cultivation) lands, use of local and cheap technology for irrigation (bamboo tube wells and movable pump sets), and better cultivation methods. These soft approaches, practised in a decentralised and autonomous manner, have been able to offset many of the losses incurred due to hazards. Additionally, these approaches seem to be based on 'getting away from floods rather than preventing them', which is an ecologically sound way of dealing with rivers in flood plains.

Migration has become an important adaptation; it has increased over the years and its nature has also undergone significant change. The need to diversify income generation strategies underlies the central role of migration and commuting in the actions households take to reduce the impact of extreme climatic events. The existing pattern of vulnerability is a result of the gender, income, and social position of respective individuals or classes. The adaptive capacity of the affected community is not only related to the ability of information, goods, and services to flow into and out of an area impacted; it also depends on the social capital and institutional checks and balances present in rural areas.

The limited reach of state machinery, coupled with corruption and an inefficient bureaucracy, has led to poor delivery of innumerable government programmes and schemes which otherwise have great potential to increase the adaptive capacity of vulnerable communities. At their best, the autonomous 'adaptive' strategies documented in this study have helped community groups to cope with the existing water stresses and hazards. It is worthwhile noting that there is no permanent or fixed adaptation strategy, including the ones documented in this study. A resilient system or community is one which is flexible enough to change its strategy easily. For that to happen, governance will have to be changed or at least reformed.

# Life in the Shadow of Embankments – Turning Lost Lands into Assets in the Koshi Basin of Bihar, India

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## Introduction

This study set out to understand how people in the Koshi basin respond to water stress and hazards in the context of climate variability and change. The objectives were:

- to assess the impacts of water stress and hazards on livelihoods;
- to assess local responses to water stresses and hazards; and
- to provide recommendations for adaptation to climate change in future.

This basin was chosen for the study because of its history of disasters. The Koshi is known for its frequently shifting courses and the devastation it has caused. It also supports a huge population which is affected by hazards and water stresses, while, at the same time, benefiting from the water brought by the river. Another factor that influenced the decision was a relatively long history of human intervention in river management and control in this region, the ramifications of which are significant. It was also felt that the impact of climate change on a river basin like this will be substantial and that measures to deal with this should be identified and encouraged. It was evident that the communities living in this basin must have developed their own strategies to deal with adverse situations. We have made an attempt to identify and document such measures.

The study did not look into climate downscaling to see what might be the future climate scenario. It was strongly felt that, considering the poor maintenance of weather data in the south Asian region, sparsely spread weather stations, and the uncertainties and complexities of weather in the Himalayan region, climate modelling would not be a cost-effective option. Rather we were of the opinion that people's response to climate variability in the past could provide us with a good indication of what possible steps could be taken to deal with the uncertainties of climate change. This study attempted, therefore, to document the community's perception of climate change and variability and its response to it.

The report is organised into six parts. The first discusses the research approaches and methods applied. This is followed by a socioeconomic, political, and geographical account of the Koshi basin; a detailed discussion of the adaptation strategies followed in the region; and a discussion about the factors that influence local adaptation in the region. Finally some conclusions based on the findings are presented together with a short summary of recommendations.

## Research approach and methods

### Field team profile

The field team consisted of four members who are researchers from Winrock International, India (WII), a consultant who has worked extensively in the region for the last two decades, and two local research assistants (RAs). The RAs were mainly involved in collecting secondary sources and data from local government offices and in assisting the team with field work: the rest of the team was involved in a literature review, developing a list of indicators and /or questions for focus group discussions (FGD), and field survey and report writing. All the members have some background in research in and implementation of projects in different areas of natural resource management. The team leader and consultant have a lot of experience in research into issues related to water, in general, and flood-prone areas in particular: the latter especially has a huge body of work on the subject. The other three members from WII have worked on natural resource management (NRM) issues, especially those related to forestry, rural development, and rural energy access. There was only one woman in the team. The chart below gives a brief background of the team members.

S. No	Team member	Academic background	Gender	Role in research team
1	Praveen Singh	PhD in Environmental History from Jawaharlal Nehru University, New Delhi, India	Male	Team Leader
2	Nilanjan Ghose	MSc in Social Policy and Development from London School of Economics, UK	Male	Team Member
3	Regina Hansda	MBA from the Indian Institute of Forest Management (IIFM), Bhopal, India	Female	Team Member
4	Nitin Chaudhary	MPhil in Natural Resource Management from the Indian Institute of Forest Management, Bhopal, India	Male	Team Member
5	Dr D.K. Mishra	Civil Engineering graduate from IIT-Kharagpur	Male	Consultant
6	Premnath Das	MSc Botany, University of Mithila, Bihar	Male	Research Assistant
7	Kameswar Kamti	BSc and LLB	Male	Research Assistant
8	Sanyogita Bhoria	BA from the University of Delhi	Female	Programme Support

### Key concepts used in the project

Whereas the research team developed an understanding and definition of all the important concepts before going to the field, it was necessary to translate and articulate these into the local lexicon so that the communities too understood. Another way of doing this was to list down the factors and indicators that together constitute these concepts and gather information and /or data on these. We followed the second method. **A list of indicators** was prepared by the team and discussed with key informants in the area. At times, additions and deletions to the list were made after interaction with the communities.

**Vulnerability to water stress and hazards** refers to the degree to which households, groups, or communities are susceptible to the impacts of water stress and hazards. Vulnerability is a function of the impacts of stress and hazards and the associated adaptation capacity of an individual, group, or community. Vulnerability to water stresses or hazards and other stresses can sometimes lead to poverty.

**Adaptive capacity** is the potential or capability of a household, group, or community to alter its activities or behaviour in order to adjust to the existing changes. Adaptive capacity is constrained by the existing information, technology, and resources of the household, group, or community under consideration.

A household's vulnerability, or its reverse adaptive capacity, is broadly a function of material, institutional, and attitudinal factors (Mustafa et al. 2008). The team's purpose was to acquire information on each of these indicators so as to arrive at a comprehensive understanding of each concept.

**Adaptation** refers to a process of adjustments in behaviour and/or activities in response to experienced or expected changes or stress. Adaptation includes new strategies and taking advantage of new opportunities. **Autonomous adaptation** refers to automatic responses to changes. **Planned adaptation** refers to the response of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required (IPCC 2007).

**Maladaptation** refers to a response to a stress or hazard which ends up increasing risk by exacerbating a household, group, or community's vulnerability to the hazard or stress at a certain time and in a certain place.

**Coping** refers to temporary or short-term action to 'survive' in times of immediate stress. Information about adaptation and coping activities was recorded by asking the respondents how they deal with water hazards (flood) and stress (drought).

**Stress** refers to continuous or slowly increasing pressure (e.g., soil degradation, water quality, and water quantity) commonly within the range of normal variability (Turner et al. 2003).

**Hazard** refers to any process or condition that constitutes a threat to human safety and property.

Whereas it was clear that floods and droughts are the two major hazards, the researchers tried to assess the possible types of hazards and their causes. For instance, floods could be caused by the river overflowing its banks or changing its course; they could also be caused by breaching of the embankments: waterlogging caused by drainage congestion is a recurrent hazard in this area also.

**Risk** refers to the probability of a hazard occurring based on the degree of vulnerability and magnitude or characteristics of the hazard.  $Risk = f(\text{hazard} \times \text{vulnerability})$ . The project team tried to discover how and to what magnitude the same hazard affects different sections of the community in different locations of the basin.

**Livelihoods** are strategies that allow an individual or a household to make a living (broader than just how an individual and a household earn an income; this term also involves all the non-monetary activities that help people live). How people make a living is based on a combination of assets (natural, human, physical, financial, and social capital) and activities and access to these (mediated by institutions and social relations) (Ellis 2000). All sets of activities or strategies, monetary and non-monetary, which helped households make a living during both normal times and hazardous ones, were listed and information gathered on each to the extent possible.

### General step-by-step approach

The research project started with a regional inception workshop in June 2008 in which the details of the project, its objectives, and concepts were explained to the different teams. This was attended by the team leader from WII. The rest of the WII team was exposed to the outcomes of this workshop later. After selection of the study area, the team began a literature search on the subject in general and on the region. The literature review helped the team to design the research and prepare details of the relevant issues or questions that needed to be examined during the field survey. A list of the methods – transect walks, resource and social mapping, crop and seasonal calendars, focus group discussions (FGD), and semi-structured interviews (which were to be used for soliciting information) – and perspectives was prepared. Study site selection (given in detail below) took place following a short scoping visit to the area. A list of indicators and questions was prepared and later shared and discussed with the consultant and the RAs.

The field work was carried out over a period of two weeks in the month of May. The follow-up visit took place in mid-August to observe the coping strategies of flood-affected communities. The field teams were divided to cover different caste groups located in different areas within the village. Opinion makers within the selected villages and also prominent people in the area were interviewed also during the trip. The team used the services of local non-government organisations (NGOs) wherever they existed; and their functionaries were also interviewed. Extensive photo documentation was made of all the locations.

### Selection of study sites or villages

Five villages were selected on the basis of their location in the Koshi basin in order to cover representative sample sites.

The first village, Chandrain, was chosen because it lies close to the embankment and had to face the direct onslaught of the Koshi after the embankment breached in 1984. Including the breach in 2008, the Koshi embankments have breached eight times since they were built.

The second village, Dhamara, and other villages like it, remains trapped between the river and the embankment and has to deal with the full discharge (silt and water) from the Koshi which otherwise would have been deposited over a larger area.

Dhamara lies between the two main channels of the Koshi, each of these flowing along the eastern and western embankments. In the past it has suffered from sand casting (deposition of large amounts of sand by floodwater) and erosion and is subjected to floods every year during the monsoon.

Tilathi, situated just outside the eastern embankment, has suffered from severe waterlogging ever since the embankments were built. The seepage of water from under the embankments and poor drainage of rain water converts this village into a virtual pool during the monsoon, and most of its very fertile agricultural land remains waterlogged for more than eight months of the year.

Dhamara village is a complete contrast to the other villages. It is unprotected by any embankment. The Koshi flows freely until it reaches the village where it is forced to flow under the railway bridge. Because of this bridge the village has suffered from erosion and several of its 'tolla' have been constantly shifting to new places.<sup>1</sup> Another unique feature of this village is that it is trapped between the Koshi and the Bagmati rivers, the latter a tributary of the former. So it suffers from floods every year.

Rahuamani is the only village in this selection which does not suffer from floods, and it has in fact gained from the Koshi project. It falls in the command area of the Koshi canals and, until few years ago, it was irrigated by water from the Koshi. Now it no longer receives an annual silt deposition on its land. The village also lies on the Saharsa-Supaul highway and is very close to the district headquarters.

A logistics' criterion was used while selecting the sites. For instance, the first four villages were selected based on the accessibility to Saharsa or Mahisi where the field team was stationed. The team was stationed in Khagaria district town to cover the last village. Table 1 summarises the basic characteristics of the study sites. Details of the amenities available are provided in the Annex (Table A1).

Table 1: **Basic characteristics of the study sites**

Name of the village and district	Households	Population (Sex ratio)	Location with reference to the embankment/river	Accessibility before and during the rains	Stresses
Chandrain, District Saharsa	969	4954 (916)	0-2 km from the left embankment	Accessible by all weather roads; condition of roads bad	Waterlogging; still not completely recovered from sand casting caused by 1984 breach; undulations in agri fields; fields inside the embankment suffer from sand deposition; constant fear of embankment breaches
Aina, District Saharsa	1056	5202 (925)	Trapped between the embankment and river; an island between two channels of the Koshi; diara	Accessible only by boats; boat service is bad	River floods and erosion; constant fear of embankment breaches
Tilathi, District Saharsa	435	2188 (943)	0-2 km from the left embankment	Accessible by all weather roads; condition of roads bad	Severe waterlogging;
Dhamara, District Khagaria	506	2492 (874)	Not protected by any embankment and falls between the Koshi River and Bagmati River diara	Accessible only by boats and rail; problem transporting agricultural produce	Erosion and river floods; lack of transportation
Rahuamani, District Saharsa	452	2673 (913)	8-10 km from the embankment and in the command area of the Koshi canal	Accessible by all weather roads	Canal not working for last few years

<sup>1</sup> The name of these 'tolla' makes their past obvious. For instance, Cutting 'tolla' experiences erosion now and did in the past; railway 'tolla' had to relocate to an old and abandoned railway embankment.

## Field work and data collection

### Field work

The first round of field work was carried out in the middle of May 2009 when harvesting of the main crops in the region – wheat and maize – was already over and most of the people, including those who migrate outside, were present in the village. The trip lasted two weeks, including the time spent in travelling to the sites. The second round of field work was undertaken for a week in the month of August, during the peak of the monsoon and flood season, to observe the field sites during floods. In all, five study sites were selected and the team spent at least three days at each site. Apart from these five, the team made brief visits to other villages where interesting experiments were witnessed.

It was a challenge to carry out the field visit because of the relative inaccessibility of most of the villages and the time spent in travelling. The team stationed itself in Saharsa, the nearest place where accommodation was available and which was not more than an hour's drive to most sites: for access to the last site, the team was stationed in Khagaria. To maximise use of the short time available, the team worked from early morning to late in the evening. By taking the help of local NGOs and other contact persons we were able to meet as many people as possible: the research assistants (RAs) had also made contacts at the sites before the team arrived.

All the team members were well versed in Hindi which was spoken and followed by all the respondents. The NGO functionaries were discouraged from sitting in during the focus group discussions (FGD) and interviews to avoid any distortion or bias in the information collected. To avoid misrepresentation of the team's objectives the respondents were only told about the broad objectives of the research; i.e., 'The problems faced by them with respect to water stress and hazards and their responses'. At times the discussions would veer towards marginally important issues like poor infrastructure, politics, and caste conflicts. The team encouraged these discussions, except when conflicts between the FGD participants started to get out of hand. Permitting such discussions gave us their views on a wide range of topics and issues; and important facts and perspectives emerged during these discussions.

In most instances, external observers have a hard time explaining their affiliations and the aims of their visit to the community. If it is not presented properly, the information and accounts from FGDs and interviews can be flawed and biased. To avoid this, one of the team members would inform the respondents that the team was not affiliated to any state agency or political group. It was because of this that the team planned its field visit after the General Elections were over. This fact was re-asserted whenever the team felt that the community was trying to mislead the researchers. The presence of locals (RAs) also helped clear the confusion.

The team members also interviewed women for their perspectives. The field work was planned to allow the only woman member of the team to visit all the villages and sites so that women's and gender dimensions were not omitted. The rule barring local NGO functionaries from discussions was waived for the few women from local NGOs.

### Data collection

There is an immense amount of literature on the Koshi River and it covers diverse issues such as the politics and history of flood control; scientific and technical studies on the Koshi; social, political, and economic development in the region; and agriculture and agrarian relations. The literature gave us a comprehensive background profile and context of the region. This review also helped us to select study sites representative of the basin. Conspicuously missing from this literature, however, was a significant study of people's adaptation strategies to 'too much water- too little water'.

Secondary data, mostly official district, block, and village-level information related to demography and social and economic statistics, were also collected. Wherever possible a time series of the past 40-50 years was collected to examine the changes in the region. These included the data collected by the Census of India 2001, land-use data collected by the Revenue Department 1994, data on agricultural productivity, and data on the socioeconomic status of people in the study sites.

In addition to gathering secondary data, the field team visited the study sites and interacted with community groups and individuals through focus group discussions and semi-structured interviews. Initial discussions with the villagers were followed by more in-depth key informant interviews to arrive at a detailed understanding of the adaptive strategies and also for triangulation of collected data. Resource maps, social maps, and crop and seasonal calendars were drawn up after transect walks with community elders to familiarise ourselves with the village. Community elders and leaders of community institutions were also interviewed.

## Data verification and analysis

Information collected through community interactions was cross-checked with community leaders and elders and with local development workers: it was also cross-checked through the secondary data and existing literature. Scholars who have worked in this region were also consulted. The project team took photographs of the physical and structural adaptation strategies that were undertaken by the community. Discussion sessions took place with different sections of the community in order to understand the non-structural strategies relating to adaptation.

## Challenges and shortcomings

There was enormous curiosity among the local population regarding the visit of the project team. Although the project team clearly explained the purpose and objective of the interactions to the community beforehand, there was, at times, an assumption that the visiting team was part of a government delegation. This is indicative of the fact that the local communities are dependent on government relief operations to ease their hardships. This assumption, at times, led the community to exaggerate their plight, as caused by the floods, during discussions. In doubtful situations, efforts were made by the project team to validate the information collected through multiple sources.

## Impacts of water stress and hazards on livelihoods

### Geographical background

Bihar (Figure 1) is a northern Indian state bordered by West Bengal in the east, Uttar Pradesh in the west, Jharkhand in the south, and the country of Nepal in the north. The state has a population of 82.87 million (it is the third most populous state in India after Uttar Pradesh and Maharashtra) and a geographical area of 94,163 sq.km. Most of the people of Bihar still live in rural areas, as the proportion of urban population is only 10.47%. The population density is 880/km<sup>2</sup> and it has a gender ratio of 921 women to every thousand men. The literacy rate: 60.32 for males and 33.57 for females.

The River Ganges, which is the main drainage system for the state, flows in an easterly direction and stretches 432 km across Bihar, bisecting the state. North Bihar, the plain located north of the Ganges, is interspersed with eight major river basins; i.e., the Ghaghra, the Gandak, the Burhi Gandak, the Bagmati, the Adhwara group of rivers, the Kamala, the Koshi, and the Mahananda. Thus, all the rivers in North Bihar share basins either with another Indian state or with Nepal and Tibet.

The flat terrain and the huge seasonal variations in water volume in the rivers cause extensive flooding in the North Bihar plains. Gradients vary from 22 cm per km near the Indo-Nepal boundary to 7.5 cm per km near the confluence of the rivers with the Ganges. The difference between minimum and maximum flows in Himalayan rivers is high. During normal years, the rivers carry between 10 and 20 times more water during the monsoon than in winter but, during periods of intense rainfall in the catchment areas, they can increase a hundred-fold in size.

Himalayan rivers carry large amounts of sediment during the monsoon. The heavy downpours in the mountains scour the slopes and turn the swift waters into a muddy brew. As they reach the plains and lose momentum, the rivers deposit their loads and begin to meander. Rivers like the Koshi are notorious for changing course. The records available suggest that the river was flowing about 160 km east of its present course some 200 years ago. This river was flowing east of Purnea in the late eighteenth century and is now flowing west of Darbhanga (Mishra 2008c). The lateral movements of rivers cause erosion and loss of land. At the same time new land is continuously formed. These new chaur (low-lying lands), however, remain waterlogged for years before they become productive.

A considerable portion of the land in Bihar is waterlogged, a phenomenon that has been exacerbated by development: natural drainage has been impeded by embankments, canals, roads, and railway tracks. Official records suggest that nearly one million hectares of land in Bihar, 85% of it in North Bihar, is waterlogged. The 835,000 hectares of waterlogged area constitutes about 16% of the total area of North Bihar, which has a population of 52.3 million people and an area of 52,312 sq.km (GoB 2009).





## The Koshi river

The Koshi starts its journey at a height of about 7,000 masl in the Himalayas; its upper catchment is located in Nepal and Tibet. The Everest and Kangchenjunga ranges form part of the Koshi Watershed. The river is also called the Sapta Koshi in Nepal as it is comprised of the waters of the Indravati, the Sun Koshi or Bhote Koshi, the Tama Koshi, the Likhu Koshi, the Dudh Koshi, the Arun Koshi, and the Tamar Koshi. The first five rivers listed form the Sun Koshi that flows from west to east. These rivers descend from the Gauri Shankar and Makalu ranges. The sixth stream is called the Arun Koshi and Sagarmatha (Mount Everest) is located in its catchment. The seventh stream is called the Tamar Koshi and it flows from east to west bringing the Kangchenjunga waters with its flow. Thus, the Sun Koshi, the Arun Koshi, and the Tamar Koshi join at Triveni in the Dhankuta district of Nepal and assume the name of the Sapta Koshi, Maha Koshi, or the Koshi (Figure 1). Triveni is located within the hills and it is about 10 km north of Chatra where the river discharges into the plains.

After reaching the plains, the bed of the Koshi widens drastically and it spreads over six to 10 km. After traversing a distance of about 50 km in Nepal, the river enters Indian Territory near Bhim Nagar (Supaul district). From Bhim Nagar, the river flows in a south-westerly direction for about 100 km until it reaches Mahishi in Saharsa district of Bihar. From Mahishi, it turns south-east and, after going a further 33 km; it crosses the Saharsa-Mansi rail line, south of the Kopadia railway station, and joins the Ganges near Kursela in Katihar district.

The total catchment area of the Koshi is 74,030 sq.km, and this does not include the catchment areas of two of its important tributaries, the Kamla (7,232 sq.km) and the Bagmati (14,384 sq.km). (These two tributaries of the Koshi are important in themselves and should be dealt with separately.) Out of the total catchment of the Koshi, 11,410 sq.km are located in India and the remaining 62,620 sq.km lie in Nepal or Tibet. The catchment area of the Sun Koshi, the Arun Koshi and the Tamar Koshi is 19,000, 34,650, and 5,900 sq.km respectively. Thus, the catchment area of the river at Triveni is 59,550 sq.km. This includes a glacial area of 5,700 sq.km. The average rainfall in the upper catchment of the Koshi is 1,589 mm while in the lower reaches it is 1,323 mm.

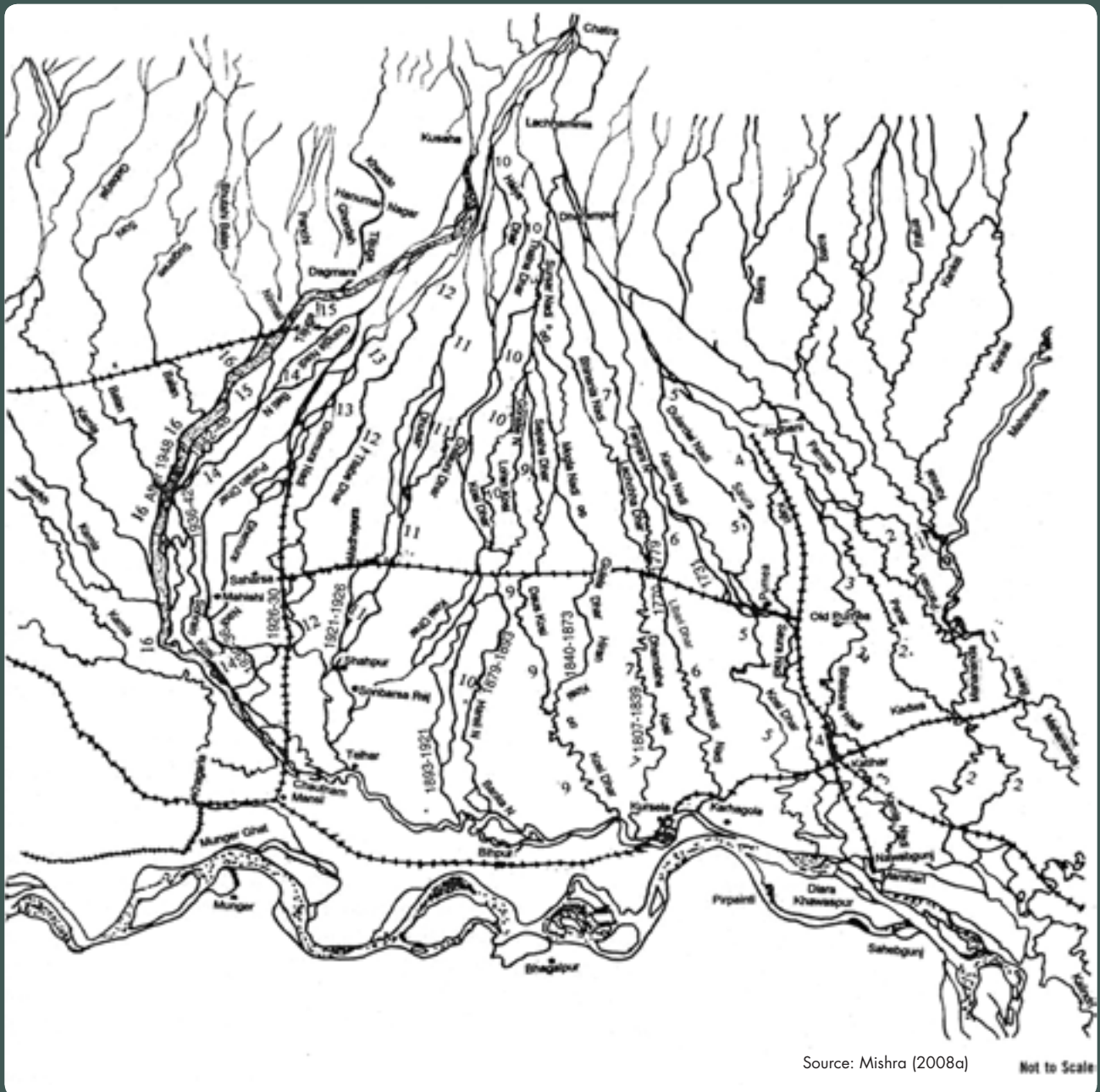
## Floods on the Koshi

Floods on the Koshi differ from floods on other rivers. Because the river changes its course regularly (Figure 2), the areas affected by floods on the river have three distinct features. First, being the areas which form the bed of the Koshi they were directly hit by its floods. These areas not only faced the direct onslaught of the floods but also suffered from land erosion, sand casting, waterlogging, scarcity of drinking water, total collapse of health services, disruption of roads and communication systems, engulfing of villages, smallpox, cholera, Kala-Azar, snakebites, large-scale deaths of livestock because of lack of fodder, and much more. All these problems used to be the lot of the direct flood victims of the Koshi concomitantly. Even if one calls them a bad dream, an accident, or a natural calamity, it is almost impossible to imagine how the flood victims could withstand such a grim situation (Mishra 2008a).

A piece of land was an immediate necessity after the floods descended, so that you could build a hut for the family. Usually, one's own land was washed away by the river or, if you were lucky enough, it lay submerged under water. To have two meals a day and arrange for farming inputs on any remaining piece of land was a heroic job. Whether there were crops or not, rent had to be paid. The entire situation favoured the landlords and moneylenders who could grab the remaining land of the flood victims by advancing loans. It was really impossible to get the land out of the clutches of the landlords. Thousands of acres of land in the Koshi basin must have changed hands under these circumstances. There was a movement in Saharsa, in 1944, led by Rajendra Mishra, against the Darbhanga Raja; and he had 1,600 to 2,000 hectares of land restored to the original owners, although the restoration was not complete. But after that nothing more happened (Mishra 2008a).

Those areas the Koshi had passed through already were no better either. The only consolation was that, instead of the mainstream of the Koshi, many small rivers flowed through this region. The ditches would fill with sediment, the land was always in the process of levelling out but tangles of *jhava* (tamarix), *kas* (patch grass), and *pater* (typha) would replace the crops in the fields. To do away with these and bring the land into a shape in which agriculture could be resumed was time consuming but, if that could be done, there were possibilities for cultivation. It was hard, but the magnitude of hardship was less than previously when it took between eight to ten years to get back to normal.

Figure 2: Changing course of the Koshi river



In the areas that the Koshi was about to invade, small streams would become active carrying some of the load of the Koshi. The overflows from these streams carried fertile silt which helped nourish bumper crops in the rabi (October) and kharif (June) seasons. But all this was a brief respite as in a few years the main stream of the Koshi would take over and destroy everything (a brief account of this phenomenon can be found in Singh 2008).

### A history of flood control in the region

Bihar, more particularly its northern Gangetic plain, has for a long time been a victim of floods and shifts in the courses of the rivers. At the same time, the spill over from the rivers containing the fertile silt brought by them annually was responsible for the growth of civilisations around the rivers. This is the reason why the population density in flood-prone areas is greater than in drought-affected areas. Communities opted to stay in the fertile flood plains; and they developed the means to live with the floods.

Colonial rulers, on the other hand, tried to check the flooding and meandering of the rivers by embanking them, only to find later that the embankments not only prevent the spill over of a river in flood but they also prevent the entry of flood water. This led to a major problem as the embanked river was no longer able to fulfil its primary function – draining out excess water. With the tributaries prevented from discharging into the river and accumulated rain water finding no way out, the surrounding areas quickly became flooded. The situation was aggravated by seepage from the embankments. The areas outside the levees remain waterlogged for months after the rains. Theoretically, sluice gates located at these junctions could solve the problem but, in practice, such gates quickly became useless; as the bed of the main river rose above the surrounding land; and operating the gates lets water out instead of allowing outside water in. When the sluice gates failed, the only option left was to embank the tributaries also. This resulted in water being locked in between the embankments. Moreover, no embankment has yet been built or can be built in future that will not breach. When a breach occurs, there is a deluge. Calculating as they were, the British found that the benefits accrued over, say, ten years of successful embanking were washed away in one year's breach of the embankment.

By the 1930s, a consensus was reached among the majority of the colonial administrators and engineers about the inefficacy of controlling the rivers in the plains. By then, however, strong interest groups on the issue of the embankments had developed both inside the government and outside it; and these groups continued to grow. Zamindars competed with each other to control the shifting rivers and their floods. The debate, centred around technological choices for the most part, continued in post-independent India (Singh 2008; Mishra 1997).

The political legitimacy to tame rivers by embanking was given in 1953 with the sanctioning of the Koshi Project and the technical legitimacy came after the visit of Dr. K.L. Rao and Kanwar Sain to the Hwang Ho basin in China where the two veteran engineers observed the embanking of the rivers there (for details of this debate see Singh 2008 and Mishra 1997). In 1955, the Koshi project began: the embankments; 125 km long on the eastern bank of the river from Birpur to Kopadia and 126 km long from Bhardah in Nepal to Ghonghepur in Saharsa on the western bank; were completed by 1959. These embankments were supposed to protect 214,000 ha of land from the recurring floods of the Koshi. A barrage across the river was also constructed in 1963 near Birpur to facilitate irrigation of 712,000 ha of land through the Eastern Koshi Main Canal. Another canal, called the Western Koshi Canal, the foundation stone of which was laid in 1957, is also being constructed to irrigate 325,000 ha of crop land on the western side of the barrage. Work on this canal is still progressing!

Massive construction activities followed in the decades after the embanking of the Koshi. Starting with an existing embankment length of just 160 km in 1952, Bihar added another 3,305 km by 2003. The state now has 3,430 km of embankments, 2,952 km in the north and 478 km in the south (Figure 3). The state claims to have protected 2.9 million hectares of land against floods by constructing these embankments. Of this total, 2.7 million hectares are located in North Bihar and the remainder falls in South Bihar.

### Impact of flood control

Despite the additions in total length of embankments, Bihar remains one of the most flood-prone states in India and has the highest number of flood-affected people per capita. About 16.5% of the designated flood-prone area of the country is located in this state which is home to 22.1% of the flood-affected population of the country as a whole (GoI 1980). The area threatened by floods has risen continuously since Independence: According to the assessment of the Second Irrigation Commission of Bihar in 1994, the flood-prone area had increased to 6.9 million hectares in 1993 from 2.5 million hectares in 1952 (GoB 1994). Within Bihar, the North Bihar plains are affected most by floods. According to official reports, 73.6% of the area of North Bihar is prone to flooding (GoB 2009). This has been aggravated by the construction of poorly designed roads and railway networks.

Agriculture and cattle rearing were the two main occupations of the people in the area before and even after construction of the embankments. Before starting flood-control measures, the river was free to wander and most of the Koshi water used to pass through the various channels of the river. The floods were moderate because of the flood waters spread over a vast area and the flood levels never grew to an alarming degree. The trouble, however, was that the occupants of the flood plains did not know which stream of the river would become the main course, although there was a pattern in the shifting of the flow. Once that was ascertained, the problem in the rest of the basin used to be resolved to a great extent. A good paddy crop followed by a good rabi (winter) harvest was normal in the area. The region was not as densely populated as the rest of the river basins in North Bihar.





has done nothing for these people. The common argument is that: "It is not the job of the government to protect such villages. The villagers have been paid compensation and they should vacate the place. The land within the embankment is meant for agriculture and not for dwelling purposes."

Nonetheless people living in the protected part of the countryside but close to the embankment have their own tales of woe. For instance, in Chandrain and Tilathi, significant portions of agricultural land remain waterlogged for most of the year and no cultivation can take place. People live in constant dread of the embankment being breached and do not sleep at night during the rainy season. (So far the Koshi embankments have breached eight times, details of the first seven breaches are available in Mishra 2008.) They have very little time to move to high ground in case of a breach. The distress is very evident in this strip of land about five kilometres wide along the embankment. Further, areas that came directly in the path of the Koshi discharge after embankment breach take years to recover. This was witnessed in Chandrain which came under the direct flow path of the Koshi discharge after the 1984 breach.

Large sections of the population who live in unprotected stretches of the river also face the adverse impacts of embankments upstream. Beyond Ghonghepur, the river is free to wander on its western side. Rivers like the Kamla and the Bagmati join the Koshi on its western bank. The combined waters of the Koshi and its tributaries make life difficult for these unprotected villages. The residents of Dhamara, which falls in this zone, shared their tribulations with the team.

Areas that are further away from the embankment of the river have benefited from the Koshi projects as they do not have to deal with the wanderings of the Koshi. Most of these areas came under the command of the Koshi canals and were promised improved conditions. Unfortunately, things have not been as promised; and there is massive underutilisation of the irrigation potential created (Gol 1973): Rahuamani falls into this category. Further, as the experience of the floods in 2008 shows, even this zone is not safe from devastation caused by embankment failure. Figure 4 shows the present course of the Koshi after the 2008 embankment breach.

The impacts of the changing landscape and nature of floods on the general well-being of the people have been immense. People's livelihoods, mostly related to agriculture, were affected adversely due to the increase in waterlogged areas and sand casting; and also due to the land lost because of erosion. Again the impact is different in different zones. For instance, people from the first three zones do not have any other option but to migrate for work from June to October (or even to December, depending on the location of their village) when agriculture is not feasible because of floods or waterlogging.

Animal husbandry and pisciculture are two livelihood options that supported large sections of the population in the pre-embankment days. The construction of embankments, barrages, and other infrastructure has resulted in reduction of the vast open 'ramnas' (grasslands); and this has led to a significant decrease in the cattle population. Obstruction in the flow path of the rivers and neglect of ponds and reservoirs resulted in reduction of fish stock and fish varieties. This had adverse impacts on the livelihoods of the fishing community ('Mallah') which had to shift to other activities.

The impact on education, drinking water, disease, and other aspects of human well-being is also adverse. It is reported that the construction of embankments led to a sudden boom in agriculture which attracted many people to farming because the vagaries of the river were checked. That brought many rural artisans to agriculture leaving their own profession. Thus, now there are weavers who do not know how to weave, carpenters who have forgotten their trade, and so on. They had nothing to fall back upon when agriculture started to be unsuccessful for various reasons (Mishra 2008b).

While the people continue to suffer, the technical debate continues. Some scholars (Mishra 2002) contend that the politicians and engineers take advantage of this inconclusive debate to further their own pecuniary interests. At another remove, the government is promising to remove the threat of floods in Bihar with dams in Nepal. Engineers insist that floods cannot be prevented in Bihar unless these rivers are tamed in the hills before they spill over into the plains. One such dam across the Koshi at Barakhshetra in Nepal was proposed as far back as 1947. Nearly six decades later, this proposal is still under the 'active' consideration of the two governments. Numerous other high dams across other major tributaries of the Ganges have been proposed and continue to be discussed by the two governments. (It is another matter that critiques of dams (WCD) have questioned the role of dams in flood moderation.)

Figure 4: Present course of the Koshi after the 2008 embankment breach



### Droughts in flood-prone areas

If Bihar suffers from too much water and floods, it also has faced regular droughts. The state receives about 1,300-1,700 mm of rainfall each year (GoB 2009), most of it falling during the four monsoon months. Since the rains are uncertain, in terms of quantity and timing, most farmers practising rainfed agriculture are regularly affected by poor crop yields; if crops do not fail completely. Lack of rain during critical phases of the crop cycle can result in loss of three-quarters of the crop, especially in the case of 'kharif'(summer) crops.

A comparison of the records from 1966/67 to 1986/87 reveals an interesting fact: the flood-prone districts of North Bihar are as susceptible, if not more, to droughts as the districts of South Bihar and Jharkhand. Table 2 shows the number of times each of these districts recorded droughts. Interestingly, Khagaria district, also known as 'dooba zila' (submerged district) suffered from drought in seven out of 20 years! The Irrigation Commission defined all areas 'suffering from drought for five to six years in the period of 20 years as drought-prone and those suffering from seven to eight years may be classified as chronic drought-prone areas' (GoB 1994). Elsewhere in the same report, however, the Commission suggests that there is no drought-prone area in North Bihar (GoB 1994).

Table 2: Frequency of droughts between 1966/67 and 1986/87

District	Number of times suffered drought from 1966/67 to 1986/87
<b>In north Bihar</b>	
Khagaria	7
Saharsa, Begusarai and Samastipur	6
Madhepura and Vaishali	5
Katihar, Purnea, Madhubani, Darbhanga, East Cahmpran, Sitamarhi, Muzaffarpur and Saran	4
Siwan	3
Gopalgunj	2
West Champaran	1
<b>In south Bihar</b>	
Munger	8
Bhagalpur, Rohtas, Gaya, Jehanabad, Nawada and Aurangabad	7
Patna and Nalanda	6
Bhojpur	4
<b>In Jharkhand</b>	
Hazaribagh and Giridih	8
Deogarh	7
Dhanbad, Palamau and Godda	6
Gumla and Lohardagga	5
Ranchi, Sahebganj, Dumka and Singhbhum	4

Source: Report of the Second Irrigation Commission of Bihar, 1994

### Socioeconomic and political context of the study villages

The previous sections have given a broad context of the Koshi basin. Although the study villages share a number of characteristics of the basin, they are unique in their own right. A brief account of the geographical location describing the nature of water stress and hazards that each place experiences has been given above; in the following section, we present a more detailed account of these villages – sociocultural, economic, and political.

#### Sociocultural history of the study sites

All the study villages seem to have a long history. They have existed for more than 200 years, although some or all parts of the main village might have shifted location, but only within the revenue boundary of the village. This change in most instances occurred as a result of the shifting course of the Koshi and the changing agroecology of the region brought about by the construction of the embankment. The social composition of these villages has also changed over time, again mainly due to the dislocation caused by the Koshi project and other political changes (abolition of the 'zamindari' system).

The village of **Aina** seems to be ancient. Several myths exist about the place, and these are still transferred by word of mouth to the next generation. One can draw several conclusions from these stories, but what is important is that the village has existed for a long time. It has survived the floods also, as it is located over a mound. In common practice the village is known as Aina Dih the latter word meaning a mound. No wonder, the village is one of the highest in the region.

The settlement has witnessed a constant influx of people coming in from various places and land has also been transferred several times. Land now is mostly owned by Rajput families (who are few in number), the Kurmi, and other underprivileged castes. The Musahar, who are in the majority and seem to be the oldest residents in this village, are landless. This is also the case with the Muslims who seem to be only slightly better off than the Musahar. The post of 'Sarpanch' (head of the panchayat) has been occupied by one single Kurmi family for several decades. The current Sarpanch is politically ambitious and has changed parties several times. Clearly his interests lie elsewhere and he has neglected village development as he is not interested in the affairs of the village.



The village of **Dhamara** too appears to be quite old, at least 200 years old (this calculation is based on the family tree of the oldest Musahar man). Here too, the Musahar are the oldest residents. In pre-independence times, the Musahar were the tenants and share-croppers of absentee landlords (zamindar), and used to pay annual rent. At that the time they were much better off than they are today. There were only a few Yadav families who were also tenants, although the sizes of their holdings were bigger than those of the Musahar. Because of the grasslands and riverine forests, the area received seasonal migrations of large herds of cattle. The cattle herders, mostly the Yadav people from south Bihar, bought land in the post-independence period from the erstwhile zamindar class and settled in the villages.

The Musahar, considered by many to be the indigenous inhabitants of the Gangetic belt (as opposed to other caste Hindus), were late in coming to terms with the monetary economy: even today many of them remain illiterate. They did not understand the changing times in post-independent India where abolition of the zamindari system brought huge opportunities to the middle castes. As a result, they could not reap the benefits of the various legislations in favour of tenants. Suddenly they were ousted out of their tenancies. The Yadav families, on the other hand, bought most of the land in the villages and converted the Musahar from tenants to landless labourers. The latter now have to deal with a dominant caste and class on a day-to-day basis. This has led to exploitation of various kinds: sexual, forced or bonded labour, and debt traps. Even now a number of Musahar men work for the Yadav as milkmen as they are trapped in the debt cycle. As in other villages, they remain at the bottom rung of the social order in this village.

Considering the changing social composition in the village, and the growing animosity between the Musahar and Yadav families, there is no strong community feeling at the village level, although members of the same caste do share a strong community bond which is galvanised during inter-caste conflicts and also during disasters.

**Chandrain** village too is considered by the locals to be an ancient village: at least 400-500 years old. The village is dominated by Brahmins who not only occupy the highest status in the Hindu caste order, but also own most of the land. (The claim of indigenous status is also made by the Maithil Brahmins in this region and, as a rule, people believe that Brahmin inhabited villages have older pedigrees than others. It is difficult to find out whether this is a myth propagated by the Brahmins themselves.) The Yadav come next in terms of land ownership along with other middle castes. Since the Yadav families are more numerous and also slightly better off economically, they dominate the politics in the village and hold the post of Sarpanch. This post gives them better access to government welfare schemes. Most of them have diversified their livelihood bases and have some non-land occupation or business.

**Tilathi** village too seems to be an old one – at least 200 years old. This becomes obvious after talking with the residents. There is no doubt though that the social composition of the village has changed over the years, as new people came and settled in the village. The Chamar (a scheduled caste or SC) were the original landlords in this village but lived in Sarauni village. The village was inhabited by a caste group called the Chaupal who tilled the land of the Chamar. The Yadav community started coming to this village from an unprotected part of the Koshi basin, Kusheshwar Sthan, after the construction of the embankments.<sup>2</sup> The Chamar community started to sell off their lands to the Yadav, who cultivated the lands themselves leaving the Chaupal as landless labourers. Now only the Yadav community has any significant landholdings, while the other castes barely have a patch of land for a house. The Musahar (SC) also came later after their village was trapped between the embankment and the river. Because of the changing composition of the social structure and landholdings, there is no strong social organisation in this village. Even the old caste-based social organisations are disappearing.

**Rahuamani** is an old village dominated by the Rajput community in both numbers and landholding status: the other communities (Yadav, Mistry, Dalit, and Muslims) own very little or no land. The Rajput landlords now staying in this village were earlier staying in another village and used to monitor agricultural operations through their officials in Rahuamani. The rest of the population were tenants, some of whom earned the titles of the land they tilled after the abolition of the 'zamindari' system. Some of the landlord families later shifted to this village and monitored agricultural operations directly with the help of share-croppers and labourers. Since the district town of Saharsa is close by, most of the landless and marginalised farmers find alternative employment easily. The more entrepreneurial among them acquire a one-year lease to a piece of land from the landlords and grow cash crops for sale in the nearby town; mostly vegetables and fruit.

<sup>2</sup> Kusheshwar Sthan is a block and lies on the west of the Koshi. The entire block was declared a bird and fowl sanctuary by the Government of Bihar due to the perpetual waterlogging after the completion of the Koshi project.

## Landholding and income levels

In all the villages land is held mainly by the upper castes (Brahmin and Rajput) and to some extent by the middle castes (Yadav, Kurmi, and Taati). The lower castes (Musahar and Ravidas) are mostly landless and some among them do not have homes in their name. Landlessness is rampant in all these villages; only 20-30% of the people own some land and the rest are labourers (Annex, Tables A2, A3). Despite the sluggish growth in agriculture in the region most of the workforce is employed in this sector. There are no other avenues (industries or urban centres) which can employ the growing workforce (Annex, Table A3).

The income level falls into the same pattern. While the upper castes do not engage in any manual labour and most of their land is either leased out or cultivated by the lower castes, the middle castes till their own land and share crop on the farmers' land. The lower castes are mostly labourers: although most of the households have at least one member of the family outside the village, migration is more common among the middle and lower castes. Muslims are either landless or small farmers. Most of them either lease in land for vegetable cultivation, in which they are considered experts, or have small businesses.

## Agriculture in the study villages

The main crops grown in the 'bhadai' (sown in May-June) season are maize, marua (millet), and paddy. Paddy is the only crop grown during the 'aghani' (sown in June-July) season. During the 'rabi' season the main crops grown are wheat, khesari, masoor, mustard, potatoes, and vegetables. Maize and 'moong' (a variety of pulse), along with vegetables are grown mainly in the 'garama' (December-January) season.

As is evident from Table 3, considerable areas in all the villages have 'garama' season crops (sown from December to January and harvested in April and May). The highest percentage of area under this crop season is found in Tilathi and Chandrain, and both villages suffer from acute waterlogging problems. The total waterlogged area in Chandrain and Tilathi is 83 ha (204 acres) and 14 ha (35 acres) respectively; the total land under fallow (because of waterlogging) in Tilathi is 103 ha (256 acres). In Tilathi, where waterlogging is more acute, a very small proportion of land is under 'aghani' crops. The areas under 'rabi' and 'garama' crops are highest in Chandrain because a lot of its land is inside the embankment.

Table 3: **Total acreage in different cropping seasons (in acres) in 2008-09**

Village	Total land	Bhadai		Aghani		Rabi		Garama	
		Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Chandrain	1388.18	60.02	144.00	181.70	506.15	415.15	68.20	206.10	117.50
Rahumani	600.00	76.40	27.47	30.38	298.45	155.62	—	5.02	117.04
Tilathi	747.12	75.15	81.55	18.15	107.67	174.33	13.18	147.31	111.71

Source: Village land-use data, Revenue Department; 1 acre = 0.4 ha approx.

One interesting fact is that crops are mainly irrigated in the 'rabi' and 'garama' seasons during which times wheat, maize, and paddy crops have to be watered two to three times. Irrigating 'aghani' paddy is impossible or economically unviable, and this is reflected in the low figures shown under 'irrigated' in Table 3. Most of this irrigation in all the villages, including in Rahumani, is carried out by means of private bore pumps. Although Rahumani comes under the command area of the Koshi canal, the canal has not been supplying any water to the village for the last five to six years: this is clearly reflected in the figures under 'irrigated' (Table 3).

## Animal husbandry

When embankments were built along the rivers, many grazing grounds were either waterlogged or sand cast. This put pressure on those involved in rearing cattle. We were informed that there were three blanket-weaving cooperatives in Saharsa which were closed following the construction of the embankments. A ghee (clarified butter) factory in Jhanjharpur also suffered the same fate in the late 1950s. Despite all that, rearing cattle, especially milch cattle, still continues to be an important occupation.

Waterlogging in the area has added to the vulnerability of cattle and their survival rate has fallen substantially. In the absence of dry land during the flood season, cattle have to stand in water for many days, and this triggers foot and mouth disease. Lack of fodder during monsoon forces the cattle to live on water hyacinths, which otherwise they do not consume. This causes stomach disorders and foot and mouth disease; and, in the absence of proper medical facilities, it often results in death. Veterinary services for cattle are as bad as medical facilities for human beings in flood areas.

With the decline in area under common land and pastures, animal husbandry has declined substantially over the years in the study villages. This decline is brought about by the increase in waterlogged areas also. Most households today still keep at least one cow or buffalo because milk and milk products (curd, clarified butter, and sweets) are staples in the area, especially among the well-to-do. Very few people, except those from the Yadav community, rear milch cattle commercially. People from the lower castes rear goats mostly for income generation. The Muslim community rears poultry, but mainly for business and not so much for their own consumption.

### Migration

Due to the disruption in agriculture, mainly caused by construction of embankments on the rivers, the people have been dislodged from gainful employment in their own villages. With the decline in local employment opportunities, people have started to migrate for employment elsewhere. This exodus commenced at the beginning of the Koshi project in the early 1960s. The earlier destinations used to be towards the east: Kolkata, the coal belt of West Bengal, and tea gardens of Assam. Political unrest erupted in the mid 1960s in West Bengal and the trend reversed in the late 1970s; labourers from the area started migrating west and north as a result of the so-called Green Revolution in Punjab and Haryana. The construction boom in Delhi at the time of Asiad-82 attracted many Bihari workers there to the building industry, and they migrated all over north India from there. Slowly, migration took workers to Gujarat and Maharashtra and Bihari labourers now work in South India too. Biharis are engaged in all sorts of jobs: from textile workers to diamond cutters in Gujarat; stitching sacks in Tamil Nadu; as industrial workers in Maharashtra; and as road builders in Himachal Pradesh. Back home in Bihar, the remittances from this work force keep the economy of the state buoyant.

According to a crude estimate, Bihar received Rs 800 crore (\$US167 million) through money orders in 2000-2001, and it is estimated that an equal amount of money must have come through banking channels. The state receives about Rs 2,000 crore (\$US420 million) through 'hawala' (money laundering) channels from abroad. Thus, the total remittances are over Rs. 2,000 crore (\$US420 million) and this compares favourably with the annual state budget.

Local moneylenders finance most of this migration with interest rates varying from five to eight per cent per month. It touches the 10% mark for emergency financing. The interest rate varies from village to village and the repayment history of the borrower. The interest rate also depends on the destination of the migrant. Earlier remittances were sent through fellow villagers or the post offices. With improvements in the banking system, bank drafts are slowly replacing money orders.

### Pisciculture

Fisheries suffered after the construction of the embankments and barrages. There has been a marked reduction in varieties of fish. Obstruction in the flow path of the rivers is stated to be the major reason for this. Says Rajendra Chaudhary of Saharsa district

"...the construction of the embankments started in our area around 1963. We were school-going kids in those days. The trouble with fish started around 1970. Until then we used to get plenty of 'rohu' (Labeo rohita), 'gagar', and 'golhai' (Notopterus notopterus or pallas, and 'boari' (Wallago attu) varieties of fish. The lightest fish used to weigh at least, five kg. A long procession, called 'pengar' or 'ujahia' in the local language, of these fish could be observed during the rains in the river waters. These fish are not seen anymore. Along with them varieties of fish like 'kokcha', 'kaua', 'dhellai', 'aruari' (Rhinomugil carsula), 'belauni' (catfish-Mystus menoda), 'seran', and 'rewa' (Chaquinius chaquini) disappeared also. There used to be big crabs in the river and those too have gone. Uncontrolled use of fertilizers and pesticides in agriculture has also led to the end of the fishing occupation. Harmful chemicals get washed down into the rivers and other water bodies and harm the fish."

Neglect of ponds and reservoirs has also led to the dwindling of the fish population. Because varieties of fish have disappeared in some places, they have been forced to breed somewhere else. The 'hilsa' fish used to breed in cool waters near Rishikesh, but the Farakka Barrage prevented their movement according to Anil Prakash of Ganga Mukti Andolan,

'...(because of Farakka Barrage) the movement of fish from the sea has stopped. The varieties of fish called 'jhinga' (shrimp), 'hilsa'(Tenuosa ilisha), and 'banas' are extinct. In eight states the river waters join the Ganges. Fish reach there from the sea through the Ganges via Farakka. Three-fourths of the fish were destroyed owing to the Farakka Barrage, causing heavy loss to the country. Nearly one and half a crore (500,000) a fishermen have lost their livelihoods.'

This is evident, as will be discussed in detail in the Discussion, from the fact that most of the Mallah (the caste group involved in pisciculture), had to diversify their livelihood base and become involved in 'makhana' (fox nut) cultivation.

### Amenities in the selected villages

That the villages falling in the Koshi basin are underdeveloped is evident from the poor amenities found there (Annex, Table A1). No doubt the situation has improved in the last 20 years or so, but a lot still remains to be done. Most of these villages remain inaccessible to the outside world during monsoon months. Although the communication network has improved mainly due to the inroads made by mobile telephones, more needs to be done to facilitate the connectivity of this region with the rest of the country, especially in light of the cross-regional livelihood network (through seasonal migration).

### Education

Under normal circumstances, it is the state that ensures the education of its population, oversees health programmes, and promotes safe drinking water and sanitation. Bihar's government has been unable to provide the leadership or funding necessary to provide these services. Of particular significance is the fact that Bihar has fallen behind every other state in terms of providing educational opportunities, and this has been reflected in the literacy rates, and it will take generations to turn it around. Currently, Bihar is last among the states in terms of literacy (Figure 5). According to the 2001 census, Bihar has the lowest literacy rate in the country: 48% against a national average of 65%. It is the only state where primary enrolment fell between 1993 and 1999, and 80% of the bottom quintile heads of household have no education.

Figure 5: Literacy rates by state, 2001

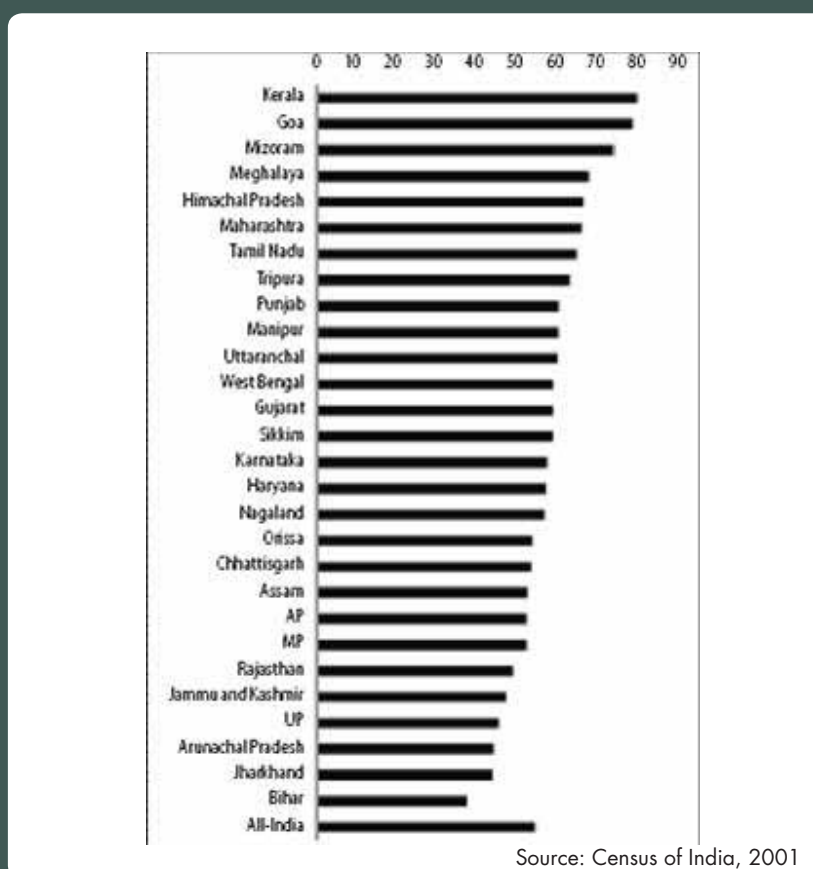


Table 4 shows the gender differentiated literacy rates for the Koshi districts. The literacy rate for these districts is significantly low by national standards and lower than the state average. It is quite clear from this table that whereas the literacy rate for most of the districts of North Bihar has increased by 10% in the last decade, it still remains significantly lower than the all India averages.

A comparison of the literacy rate in the study villages (Table 5) gives some interesting insights. The literacy rate in the relatively inaccessible villages, Aina and Dhamara, is lower than the other villages, but the literacy rate in Tilathi is the lowest. This can be explained by the fact that most of the village of Tilathi remains waterlogged during much of the year: the literacy rate is highest for Rahuamani, a village that does not experience any water stress or hazard and which is accessible and close to the district headquarters.

Table 4: Literacy rate by gender for the state and its districts

State / district	Persons		Males		Females	
	1991	2001	1991	2001	1991	2001
India		65.38				
Bihar	37.49	47.53	51.37	60.32	21.99	33.57
Supaul	28.11	37.80	40.96	53.23	13.74	21.02
Araria	26.19	34.94	36.99	46.50	14.01	22.14
Purnea	28.52	35.51	38.92	46.16	16.80	23.72
Madhepura	27.72	36.19	39.31	48.87	14.41	22.31
Saharsa	29.98	39.28	42.37	52.04	15.83	25.31
Khagaria	32.33	41.56	42.97	52.02	19.79	29.62

Source: Census of India, 1991 and 2001

Table 5: Population and related data for study villages

Village	Total population	Gender ratio (females per 1000 males)	Total SC population	% of SC	Major caste groups	Income levels	Literacy rate*			Major occupation /livelihood pattern
							Total	Male	Female	
Chandrain	4,954	916	620	13%	1. Brahmins 2. Yadav 3. Musahar 4. Muslims	Medium to high for 1 & 2; low for rest	34%	50%	18%	Agricultural, labour, migration, small business
Tilathi	2,188	943	163	7%	1. Yadav, 2. Taati, 3. Musahar, 4. Ravidas	Medium to high for 1; low for rest	16%	26%	6%	Agricultural, labour, migration
Aina	5,202	925	1,576	30%	1. Rajput 2. Kurmi 3. Yadav 4. Musahar 5. Muslims	Medium to high for 1 & 2; low for rest	23%	36%	10%	Agricultural, labour, migration
Rahuamani	2,673	913	115	4%	1. Rajput 2. Brahmins 3. Yadav 4. Musahar 5. Muslims	Medium to high for 1 & 2; low for rest	55%	72%	37%	Agricultural labour, Small business, worker in Saharsa
Dhamara	2,492	874	1200	48%	1. Yadav 2. Musahar 3. Halwai	Medium to high for 1; low for rest	20%	26%	13%	Agricultural, labour, migration

\*Percentages have been rounded to the nearest whole number.

Educational facilities are poor in most of these villages; apart from in Rahuamani which is close to the district headquarters. Although there are primary schools in all the villages, they are not in such good condition. For instance, the school building in Aina is still incomplete and does not have a roof. There are Middle Schools in Chandrain and Rahuamani only and, in the rest of the villages, children have to travel more than five kilometres to attend one. None of the villages has either a high school or a college.

The apathy of the teachers, lack of amenities, lack of school buildings or unauthorised occupation of schools by local toughs and corruption in the functioning of the institution are some of the reasons for the low literacy rates in the region. In many villages, the residents complain of connivance between the teachers and the school administration. The government has introduced a school incentive scheme for children through which they will receive Rs 20 (41 cents US) per month and free midday meals when they attend school. This facility is made available for schools that have a 75% attendance rate on a regular basis. The villagers complain that the rice (at the rate of 100 grams per student) is picked up from the stores even if students do not come to school, and it never gets distributed. They charge the school committee members of manipulation.

### Health services

Diseases like malaria, tuberculosis, and Kala-Azar are widespread and prevalent and the local health infrastructure is incapable of handling the situation because of the apathy of the medical staff and lack of medicine, equipment, and laboratory facilities. Health facilities such as a primary health centre (PHC), maternity and child welfare centre, and hospitals are non-existent in most villages, except for Rahuamani (Annex, Table A1). People from the villages have to travel about 10 km to get medical treatment. Kala-Azar has been a particular irritant for the health authorities because its symptoms resemble those of malaria initially and much time is lost treating a patient for malaria by the time Kala-Azar is diagnosed, it is already too late.

Lack of medicines and the expense of medical services are other reasons why people don't get proper treatment. The health services fail miserably to reach the population during and after the floods when diarrhoea, dysentery, and typhoid acquire sizeable proportions. It is on rare occasions that a doctor or nurse is seen at health centres in the interior. Medicines are not available and the health centre buildings lie abandoned in most cases. The villagers in the area rely more on quacks for medical treatment than on doctors in the health centres. Should someone fall sick in a village located within the embankments, it is very difficult to take him or her to a doctor, especially from inaccessible villages.

### Transport networks

The transport network has improved in the last few decades as new highways have been built in the region. Rural road networks have also increased and their quality has improved. Although Bihar State Transport Corporation remains in a shambles, private bus and small vehicle operators have been able to provide basic services. More trains now ply from this region to big cities and other important destinations. The frequency of services from older train networks has improved also. Despite these improvements, the situation is still bad, and it becomes worse during the rains when most of the roads are submerged in water and develop big potholes which can only be crossed by tractors; these are the only means of transportation for most villages for transporting both men and materials.

The situation of villages trapped between the embankments and those not protected by embankments still remains dismal. There is no road within the embankments and only tractors and motorcycles can ply on the 'kuchha' (untopped) roads that exist there. Most of the trading within the embankments takes place with the help of mules. During the rainy season when the river overflows its banks, boat transport is possible if the main channel of the river is avoided. The Koshi flows in a braided channel within the embankments and one has to cross these streams on boats many times, at least during the rainy season. During a normal season, boats are needed at least at one point to cross the mainstream. People can wade across the other channels.

When the embankments were built in the 1950s, the government promised the farmers free access to the fields from their rehabilitation sites. This, however, has not happened and the residents of the villages within the embankments have to pay for the services. They have to pay the boatmen to transport their agricultural produce even if it is brought back home. One has to pay the cost of transshipment to the boatmen even if one is using one's own boat and labour; as the boatmen are ruthless about extorting money from farmers. This makes agricultural produce costlier. Matters do not end there. Even if a person brings his boat to the 'ghat' (water front) himself, he has to pay the 'ghatwallas' (people who look after the jetty or water front) if he chooses to pass through the 'ghat' or anchor his boat there.

Behind all this is the fact that the District Board awards the contract for transporting people to a particular 'ghat' to bidders. Baluaha Ghat, four kilometres north of Mahishi in Saharsa district, was auctioned for Rs. 700,000 (\$US146 million) in 2003-04. This is a huge sum and, unless the contractor collects this money ruthlessly, he will be running at a loss.

All the villages, except for Rahuamani are far away from any urban or market centres. Although Chandrain and Tilathi are connected by road, reaching Saharsa is a difficult task considering the poor condition of the roads and paucity of transport facilities. No doubt the condition has improved over earlier times. Aina and Dhamara are relatively inaccessible; the former is only accessible by boat and the latter only by train. Aina residents have to first cross the Koshi by boat and then take private transport to Saharsa. At times, especially in medical emergencies, this causes problems. Transporting goods and agricultural produce is a costly exercise. Dhamara residents always find it difficult to transport goods and agricultural produce as they are harassed by the railway police; and there are no special goods' trains plying in this stretch. During monsoon, residents from Aina and Dhamara have to use boats even to move out of their homes.

### Drinking water

Tap water is not available in any of the villages in the study area. In all of the villages, people are dependent on privately-owned hand pumps (Annex, Table A1). There are very few hand pumps constructed by the government in these villages. Water from these hand pumps does not seem to be potable as it has a high content of iron. Some villages (Chandrain, Tilathi, and Dhamara) also have open wells. The water from these wells is considered better, surprisingly, than the water from hand pumps although the wells are under water during high floods and become contaminated.

### Banking and post and telegraph services

Although banking facilities have improved over the last 20 years, people from the study villages still have to travel more than five km to access them. Cooperative banks and agricultural credit societies likewise are not easily accessible. Apart from the distance, poor and marginalised groups in the villages are faced with administrative difficulties in using these facilities. Post Offices have fared better than the banking sector, the former are there in all the villages except Tilathi and Dhamara (Annex, Table A1).

### Electricity

None of the study villages has electricity, although a high-tension wire connecting the hydel power plants in Bhutan to the northern grid passes through the area. The people have to make do with other sources of lighting: kerosene lamps, solar lamps (mostly through government schemes), and privately-owned and distributed power through diesel generator sets.

### Political change and socioeconomic stagnation

Bihari rural society has remained dominated by rich landlords who usurp all the benefits of state assistance for development and poverty alleviation. Although the 'zamindar' of Bihar were legislated out of existence in the 1950s, their legacy has not been eliminated. They continue to dominate rural Bihar and live as parasites. The 'Abolition of Zamindari Act', 'Land Ceiling Act', and 'Tenancy Act' have not been implemented properly. Little has changed for the large masses of people who live without land and even without secure tenancy. The continuation of absentee landlordism has prevented investment in agriculture, leading to its stagnation over the decades.

Politics too remains dominated by these traditional elite groups. Although there has been a rise in the 'other marginalised' and 'lower' castes in the political sphere since the 1980s, little change has taken place because politics remains caste dominated and 'real' issues get sidelined. The most disturbing issue of all is the growing 'criminalisation of politics' and lately 'politicisation of criminals'.<sup>3</sup> The bureaucracy, too, especially at the lower level, seems to be hand in glove with politicians, and, together with the latter, bureaucrats grab their share of development funds.

There seems to be no role for the people in governance of the day-to-day issues. Decentralisation of governance through the 'Panchayati Raj Act' has not changed much on the ground. Only recently elections for the panchayats were held after some decades. Even panchayats are riddled with caste politics and have become battle grounds for state and

<sup>3</sup> The area enclosed between the embankments is a haven for criminals as it is virtually impossible for law-enforcing agencies to keep track of the criminals there. The Koshi offers an effective link between the Ganges and Nepal, and the local people suggest that a lot of illegal transportation of contraband and spurious articles takes place through this route with full knowledge of the police. Various gangs of criminals operate throughout this area and the inaccessibility helps them evade discovery. Organised looting and activities of dacoits are quite common.



national-level political parties. The elected representatives of these bodies are more accountable to state and national-level politicians than to the people they represent. This was very evident in Aina where the 'Mukhia' (village head) fought elections for the state legislature from a prominent political party, and yet he does not seem to be very interested in local affairs. The school building remains incomplete and the school operates only on paper. The 'Mukhia' on being questioned on this matter, however, blamed the people for the ills of the village. Most of the development funds for the village go for the benefit of his relatives and acolytes.

Bihar has a poor record on poverty alleviation programmes and government services, for example, serious mistargeting in the public distribution system (PDS) and chronic absenteeism among teachers. Electricity supplies are erratic: in 2003-04, per capita consumption of electricity was 44.85 kWh compared to 606 kWh at the national level. Transmission and distribution losses for the state are 37.69%. Less than eight per cent of the 81,655 km of roads in Bihar are national or state highways. Approximately 45% of the road network is unpaved. Although 50% of the assessed ultimate irrigation potential from major and medium irrigation schemes has been created, the use of these is only 60% (Deshingkar et al. 2006).

## Responses to water stress and hazards

### Experiences of past water stress and hazards

#### Individual and community memory of past events

Communities living in the Koshi basin have had to deal with the adverse effects of the westward shift of the river. The Koshi left behind huge swathes of sand-cast land where only wild grass could grow. It took about 10 years and a massive effort to bring these lands back under cultivation. Even after great effort had been expended, the soil characteristics and crop cycle changed a great deal. People adapted to these changes often without help from the government or any external organisation. Things changed after the construction of the Koshi project in the late 1950s. People were assured that the Koshi had been almost 'tamed' and its wanderings stopped; and the inhabitants of the basin led a more or less settled existence in most areas of the basin, except in a few instances when embankments were breached. This sense of protection led to people losing their traditional knowledge about flood preparedness and adaptive cropping systems in many protected villages. Other forms of knowledge and systems have developed since to deal with the changed agroecological settings. Nevertheless certain villages still suffer from river floods (those trapped between the embankments or the unprotected villages) and are better prepared to deal with the annual floods, having learned from past events. So the level of preparedness and readiness to learn from past events stems from the flood history of each location.

In Chandrain, the accounts of horror, loss, and helplessness during the floods of 1984 are well etched in many people's minds (Box 1). The people maintain a high level of alertness during the flood period: they have their own early warning system and also follow alerts sent out by government departments (discussed further on in this section). Nevertheless, their lifestyles seem to have changed through years of living a protected life. Several households now have 'pucca' houses (made of bricks with concrete roofs) with high plinth levels. Although this does help during normal floods, floods caused by any breach in the embankment will destroy even these houses. These houses have been built from remittances sent by the younger generation. This is not the case in Aina and Dhamara where the people continue to live with the river's eccentricities in a manner that does not affect their lives adversely. The houses in these villages have been re-built over the debris of older houses, and hence the plinth levels keep increasing. The level of their houses is higher than the level reached in the last big floods. Remittances have been used in most cases to buy boats and construct bore wells on raised platforms. The houses in the majority of cases, moreover, are built with materials found locally (bamboo, mud, and thatch): they are not very expensive to build and can be re-built easily.

#### Historical perceptions of vulnerability and risks at local level

Policy makers often do not understand the concept of vulnerability and frequently use the term as a substitute for poverty or the state of being poor. Vulnerability means not just lack or need but defencelessness, insecurity, and exposure to risks, shocks, and stress (Chambers 1988). The perception of vulnerability within the project area differs according to the location of the embankment and income levels and is integrally linked to net assets. Marginalised communities within the project area who have few or no assets feel that their vulnerability is caused by their poor asset base, especially with respect to land. The unpredictable nature of the Koshi causes insecurity and a feeling of defencelessness among the local population. Those among the poor who do not even own a piece of land for a home constantly feel threatened that they might be



**Box 1: Recollection of the horror days**

"There was so much chaos during the 1984 floods. We did not know where to go and what to take. I rushed with my wife and children along with the rest of the villagers towards the embankment. The speed of flow and [rise in] water level was too high; I lost two of my children in the floods. I had put my old parents on the wooden beams near the ceiling as I could not safely manage movement of so many of us all together. I was under the impression they were safe there and once the water recedes I would bring them to the embankment to join us. To my horror when I went after 2 days I saw they had died of snake bites. It was painful to see my entire family almost wiped out in front of my eyes in a few days time," recalls Ghanshyam Yadav in Chandrayan village.

evicted from their houses. This sense of vulnerability among the poor and lower castes was more pronounced the more inaccessible the village, particularly in Aina and Dhamara which become waterlogged for three months every year.

Although socioeconomic vulnerability has decreased with the gradual improvement in communication and information networks, vulnerability to environmental hazards has increased in villages located outside and within embankments. Lands or villages lying inside the embankments have become more prone to the river's eccentricities after construction of the embankments. The river now barely has a few kilometres to wander and it continues to shift and deposit the detritus it carries in this limited area. While it deposits a fertile layer of silt on some lands, on others sand is deposited; and such lands lose their fertility. The river at times 'eats up' land. Hence, lands within the embankments and in the unprotected zone go through a cycle of good and bad times. This cycle reflects the economic status of the owners of these lands. In villages with this category of land, landholding status does not have any great influence on vulnerability. There are several 'once rich' people who live impoverished lives now because their land has either been engulfed by the river or has been covered with sand. Whereas both Aina and Dhamara have witnessed bad times in the past, they are enjoying a 'good harvest' and the 'blessings' of the Koshi currently. These villages get very good harvests of 'rabi' and pre-monsoon crops; and villages outside but close to the embankments do not.

Historically, landless communities or groups are more vulnerable than others. Yet it is argued that poor and landless people have better adaptive capacities as they have had to cope with change and poverty for so long that their survival instinct is the result of their flexibility or adaptability to dire circumstances. For the landless section of the population, migration is one of the key means of income diversification. Seasonal migration to adjacent states as agricultural labour or to urban areas to work on construction sites and in other temporary labour activities helps to maintain income levels. At least one able-bodied man undertakes seasonal migration while the women, children, and elderly people remain in the villages. The workloads of women during these particular time periods are confined to collecting water, fuelwood, and fodder and to caring for the rest of the household.

The relative inaccessibility of Aina and Dhamara villages increases their vulnerability. In Aina, the only means of transport is by boat. The people in these villages are completely dependent on the boat operators who want to maximise the profit from their leases by over charging for the boat service; and yet the boats are poorly maintained. Transportation of men, harvested crops, vehicles (including cycles, motor-cycles, and tractors) is only by these boats. Crucial time is lost when there are medical emergencies, especially in cases related to pregnancy. (Those who have the means have built houses in the nearby block headquarters of Mahisi or in Sharsa). While most of the other households in Aina and Dhamara own a boat which is used for different purposes, families in the Musahar 'tolla' (district of the marginalised community) do not have a single private boat and have to wait for the local government to sanction a boat for them. Similarly, the Musahar 'tolla' in both villages have limited access to government tube wells and solar street lamps. The inaccessibility of these villages makes them more dependent on irregular functioning government programmes, adding to the existing hardships of the local community.

In the villages outside but close to the embankment, the main cause of increased vulnerability is the acute waterlogging caused by drainage congestion. Most of the lands, though officially 'protected' from floods, remain uncultivated in this zone mainly because they are under water throughout the year. Even the drainage projects have not been able to drain these lands; rather they have exacerbated the flooding. Rainwater and seepage water coming through the embankment

completely drowns these villages. Apart from this, villages like Chandrain that faced the direct onslaught of the Koshi due to embankment breaches, still suffer from the effects of sand casting and undulations caused by the breach of 1984. Things have improved since then, but not enough to make life any easier than before. The villagers, in general, and landowner's, in particular, feel cheated as they did not receive any government support for reclaiming their land and livelihoods. The fact remains that, in all the villages along the embankment within a distance of three to four kilometres from the embankment, the word 'protection' is seen as a cruel joke played on the inhabitants.

The perception of vulnerability is quite different among the women. Although caste-related cases of sexual exploitation of poor and lower-caste women have decreased over the years with the strengthening of government machinery, it is still something which these women have to face. This is the reason why at least one man from each joint family stays behind while others migrate outside. Almost all of the agricultural activity is carried out by the men in the family before they leave; most men migrate only during off-farm season. Even then, women have to deal with day-to-day matters: collecting fodder, fuelwood, and food during times of floods, and looking after the family during disasters (embankment breaches and sudden rises in flood waters).

The most important concern for women during floods is to do with sanitation and defaecation. Since there are no proper toilets above flood level, the women have to go out in a group in a boat or use 'machhan' (a bamboo shelter) toilets. Lack of proper sanitation also renders menstruating women vulnerable to infection. These conditions are more severe in trapped and unprotected villages. In these villages most pregnant women face death during flood season because of the inaccessibility of the villages and lack of health facilities.

### **Community initiatives related to past floods and/or droughts**

Community initiatives that the project team witnessed were in Mahisi village where the villagers re-built a drainage channel embankment to protect a huge portion of land from flooding. Koshi Seva Sadan, a local grass-root organisation based in Mahisi, organised the local community to repair the damaged embankment (1,200 feet). Funds were mobilised from both private and government sources. About 800 feet of the embankment were repaired through financial contributions provided by the Centre for World Solidarity (CSW) and voluntary labour provided by local villagers. The remaining 400 feet was constructed through contributions from the local panchayat. This local initiative has converted waterlogged lands to cultivable land, and 'garama' and 'aghani dhan' (both varieties of paddy commonly cultivated in this region) are being cultivated currently. This initiative helped the local population to bring this land back under cultivation.

### **Individual and community attitudes towards external help in relation to natural hazards**

There has been a transformation in terms of communities' attitudes towards external help in relation to natural hazards. Local communities are now much more dependent on and open to accepting external help. Discussions with senior inhabitants in all the villages revealed that, in earlier times, there used to be caste-based social mechanisms to protect the most vulnerable members in the villages. Different materials, in terms of both cash and crops, were collected by designated members within each caste and then redistributed among the most vulnerable households. (Details of this mechanism are discussed later under the 'social network' section). With the advent of government-sponsored relief operations through the panchayat and the land revenue department, such autonomous mechanisms seem to have disappeared. It was difficult to estimate the effectiveness of the two systems as opinions varied from location to location. It is clear, nevertheless, that the government programme has replaced the indigenous social protection system, and this has made the community dependent on external help. Increasing government investment in relief operations is no doubt a welcome change, but the community seems to be excluded from this activity.

Initially there was a 'social' stigma attached to acceptance of relief materials, especially for the upper castes within the village. Acceptance of relief from the government or any other agency was looked upon as something that would automatically put someone in the 'poor' category. The social stigma seems to have become diluted now. In fact, there is now competition among everyone, including the upper caste groups, to hoard relief materials, so much so, that the poor and powerless in most cases do not get relief. This was also very evident during field work. The project team was often mistaken for government officials visiting the village to assess the relief situation. People gathered in large numbers and wanted to enrol and give their names and household details along with their losses. The expectation was that enrolling would automatically entitle them to relief materials.

## Monitoring change

People living in the flood plains literally have their 'ears to the ground' in terms of any abnormal happenings in their surroundings. People living within the basin have different sets of skills and knowledge systems which are based on the area in which they are domiciled. The population living within the embankments and those unprotected by embankments are the best prepared for any eventuality and do not fear the river, while those living outside live in fear during the four monsoon months. Apart from this difference, one also sees a varied level of preparedness in different sections of the community; while better-off families are well prepared because of the resources they have, the poor develop their own strategies with their limited resources.

## Early warning systems and emergency measures

People living close to the river or embankment keep a constant watch on the river at least during the monsoon months. Those living within the embankments keep a watch on the changing course of the river and its rising waters. Most of the villages falling within the embankment have shifted their location more than once in the last 50 years. Aina is an exception as the main village is situated on high ground and people have built their houses with high plinth levels: they increase the plinth level after watching the flood level. They claim that flood waters will never enter their houses; and even then the flood waters would first have to overtop or breach the remaining embankment. This confidence stems from a very close understanding and careful monitoring of the river's behaviour and its bed level.

Apart from anticipatory preparations based on their own observations, they also listen to news and announcements made by government agencies. The evening news bulletin in All India Radio (AIR) gives information about river flows, but these are too general and pertain to the region as a whole. They follow the regional news assiduously, however, as these evening news' bulletins carry news about rainfall and river discharge and the impending dangers, if any. Although they do not understand the actual measure of a 'cusec' of river discharge, the word has entered their lexicon and acquired a new meaning. People have figured out that a discharge of certain 'cusecs' of water will lead to flooding in their village. AIR also provided a help line so that people could access real-time information in advance. The people say, however, that during emergencies this number either does not work or it is always busy.

The villagers have devised their own methods to measure danger. For instance, the people in Chadrain and Tilathi informed us that when water starts flowing out of their hand pumps (without pumping) it is a clear indication that water in the river has risen above danger level. At these times a member from each household goes to the top of the embankment to keep a watch on the river. In fact, several households have built (encroachments) a small dwelling unit over the embankment where they keep their cattle and store fuel and fodder. They get an idea of the river's behaviour in this way, about whether it is beginning to encroach upon the embankment and the condition of the embankment, and they make preparations accordingly.

It was also stated by the elders in Chandrain that announcements were made by irrigation department staff before a breach occurred in 1984. They also remember the 1984 and 1987 floods when announcements were made through loudspeakers by irrigation department officials about the danger of floods and warning people to go to safe locations. Although they did not have enough time to save their belongings and prepare for making do without basic comforts (shelter, food, fodder, and fuel), they could save their lives: only a few people died during that event but the material losses were heavy. With increased penetration of mobile telecommunication systems, access to information about possible flood events is disseminated much more quickly between the people upstream and downstream. Information about the discharge of water is shared between the upstream and downstream population and then spread by word of mouth. As yet, however, there is no particular early warning system in villages located far (more than eight kilometres) from the embankments. In these villages the feeling of 'protection' is deep rooted and people believe that the waters of the Koshi will never reach them. Nonetheless as the floods in 2008 proved, even these so-called 'protected' areas can face devastating floods. The damage to life and property in the 2008 floods was also partly because of people's inability to react to the news that the Koshi could breach and its waters could reach their villages.

To sum up, in most of the project areas there is an interconnected informal mechanism in place to disseminate early flood warnings. Villagers close to the river listen to the news on AIR. Villages located within the embankment keep a constant watch on the river and also on the rising water levels. Water gushing out from hand pumps (without pumping) acts as a clear indication of rising water levels. Telecommunication networks have also strengthened the connectivity between these seemingly unconnected upstream and downstream groups.

### Movement to safe places

Movement of the local community to safe places begins based on their assessment of increasing water levels in the river. For communities within the embankment, access to safe places becomes problematical. In Dhamara village, people move towards the railway track and start building temporary shelters around it. People from Aina either move towards the high land within the village or shift their essentials away by boat (Figure 6). The boat is then tied between two trees to prevent it from moving into the main stream. Plastic sheets cover the boat and act as protection from the rain. This option is only open to those who have a boat or who can afford to rent one; the poor have to resort to rafts made from the stems of the banana tree (palm) (Figure 7).

In Chandrain and Tilathi, people quickly shift towards the embankment. A number of households have built temporary structures on the embankment for smooth transition. Our discussions revealed that when the water rises gradually people generally take their resources, such as money, ornaments, utensils, food, fuel, and fodder, with them. Transferring the animals to a safe place becomes a challenge for most households. The situation is more difficult when there is a flash flood.

### Physical and structural adaptation strategies

The role of assets in facilitating the adaptation strategies of different communities is currently being recognised and discussed throughout the international donor community. Asset-based approaches to poverty reduction and social protection are being adopted at an increasing rate by international development agencies. At the heart of the 'asset-based approach' is the assumption that assets are central to increasing the adaptive capacity of the poor in the south (Prowse and Scott 2008). Assets, therefore, are defined as resources 'that people use not only to generate additional flow and stocks' (Moser 2007) but which also provide 'the capability to be and to act out' (Bebbington 1999). Therefore assets in this definition include both 'tangible' capital (natural and physical) and 'intangible capital' (human, financial, and social). Here we discuss the tangible or physical assets and the following section highlights the role of intangible or non-structural assets.

### Housing structures

The nature and extent of structural adaptation primarily depends upon the location of the village and the possibility of flooding with respect to the river. The buildings constructed in Aina and Dhamara are primarily temporary structures because of the great potential of being affected by floods. Concrete buildings are much more common in Rahuamani (a village located about 10-12 km away from the embankment) because of the fact that there is little chance of flooding. The section below explains in detail the structural adaptations adopted by different parts of the community based on the potential of being affected by water hazards.

The housing structures within the selected project area can be roughly classified into three broad types:

1. 'pucca' houses (a house constructed of bricks with a concrete roof);
2. semi 'pucca' houses (a house constructed of bricks with a thatched roof) ; and
3. kachha houses (a temporary structure constructed of bamboo and mud with a thatched roof).

Figure 6: In flood-affected villages, boats are the only means of communication



Figure 7: A raft made from banana stems, poor man's transport in waterlogged villages





Apart from a few government-funded community structures such as primary schools (Figure 8), most of the households in Aina and Sarsuwa villages have 'kaccha' (non-permanent) structures. Fears about destruction of the houses due to regular waterlogging and about the potential for flash floods have been the main reasons for constructing kaccha houses in these two villages. For the majority of the houses, bamboo and mud are the basic building materials. Generally a bamboo screen is prepared and then it is covered with mud. When floods or prolonged waterlogging occur the mud washes off but the bamboo structure remains. Thus it is easy to rebuild it. The thatched roof is constructed using a bamboo frame, polythene sheets, paddy straw, grasses found in the flood plains, and palm or coconut leaves. The plinth levels are increased at regular intervals to match the increasing water levels (Figure 9). The fear of floods and repeated waterlogging has led to construction of temporary structures. Most of the houses are in clusters and constructed over land which is at least five to seven feet above the level of the agricultural land. This is primarily to protect the households from flood waters.



Figure 8: Primary school at Dhamara village closed because of water logging

Other villages like Chandrain, Tilathi and Rahuamani are somewhat different. The number of 'pucca' (permanent) structures in Chandrain, Tilathi and Rahuamani is greater than the number of 'pucca' structures in the other two villages. This is distinctly different as far as the coping strategy adopted by the local community is concerned. In villages like Rahuamani and Chandrain, it has been observed that construction of 'pucca' houses has been financed by remittances (Figure 10). For example, Jamahar Chaukidar and Satyanarayan Das of Rahuamani village, in course of a transect walk, mentioned that they were able to send remittances to finance the building of a 'pucca' house. Most 'pucca' houses have high plinth levels. Considering the fact that the river bed is at least more than 10 feet above the countryside (outside the embankment) even these high plinth levels will not be enough to save its inhabitants if the embankment fails.

Ironically 'pucca' houses are primarily owned by either the traditionally rich villagers with access to substantial amounts of land or by some of the most economically marginalised people (Dalit). For the latter group, the houses have been constructed through the government housing scheme (the Indira Awas Yojana). It is important to note, however, that there are many structural problems which restrict the Dalit from accessing these provisions and therefore it would be unfair to assume that all members of the community have 'pucca' houses. Illiteracy, high-handedness of the bureaucracy, and a high level of corruption are among the most important challenges that these people have to face to get access to government subsidised housing schemes. Marginalised communities from the villages of Aina and Sarsuwa face an additional problem of high transportation costs in transferring their raw materials because of their location as river islands. Waterways are the only means of transportation for raw materials; and this leads to additional costs which are much beyond their means.

Location of the kitchen depends on the structure of the house. A 'chullah' (cooking stove) using fuelwood, dried grass, and dried cow dung is the most prevalent method of cooking in the selected villages. Improved cooking stoves are also used.

Figure 9: Temporary kaccha houses with increased plinth levels



Figure 10: A permanent (pucca) house being constructed using remittances



In 'pucca' houses and cooking arrangements are located within the house. In other cases it is in the courtyard or on the veranda of the house. In most of the 'kaccha' houses there are multiple places for cooking and the location is based on the season: in the summer it is outside and in monsoon and winter inside the house.

To sum up, construction of non-permanent brick structures has been an adaptive strategy for most of the households trapped within the river (in Aina and Dhamara). Most of the households are constructed over considerably elevated platforms and the existing plinths are also increased subsequently with the increasing water levels. The house becomes the most important asset after land for people located away from the river. Remittances have been channelised for building permanent structures.

### Sanitation facilities during floods

Open defaecation is a common practice for the majority of the population within the study villages. The majority of households do not have the means or the mind set to build latrines. Access to safe and dry places for defaecation becomes a key issue, especially in flood-affected and waterlogged villages for three to four months (from July to October) every year. Makeshift latrines constructed on an elevated bamboo platform (machhan), and covered with either a bamboo screen or cloth on three sides, were seen in Tilathi, Aina, and Dhamara (Figure 11). Since the latrine extends from a bamboo platform it remains unaffected by the rising waters and can be used for extended periods even during water logging. Access to a suitable place for defaecation was discussed during a focus group discussion as the main problem for women of Kharra 'tolla' in Dhamara village during the flood. During floods, villagers generally use a certain portion of the high land (commonly known as 'tila') within the village for defaecation. Elevated areas like roads and railway embankments are also used for defaecation.

Defaecation and access to private places is one of the main problems for women and creates a situation in which women sometimes have to wait for long periods before being able to relieve themselves. Boats are also used for relieving oneself during floods. In such cases attending to nature's call can either be done during the evenings or in the early morning. The women of the house go together in a boat a little way from the village and relieve themselves by perching on the edge of the boat (this is the prevalent practice in Aina village too, where almost every relatively well-off household has purchased a boat) (Figure 12), but it is fairly common to see poor people defaecating standing up in waist high water. This is unavoidable in an emergency situation. In Dhamara we were told that some people relieve themselves while sitting on the branches of trees. Such activities create very unhealthy and unhygienic conditions leading to diarrhoea and other water-borne diseases. Self-imposed starvation to avoid having to defaecate is a common occurrence in flood-affected areas.

Personal hygiene becomes an acute problem, with genital problems increasing substantially. Access to and disposal of sanitary napkins becomes a problem for flood-affected households. The sanitary napkins (made from old cotton sarees) cannot be washed when there are sequences of rainy and cloudy days as the chances of drying them are poor, hence they are thrown away as far as possible from the village. This is the practice of those who can afford a repeated change; but women from poor communities, such as the Musahar, sometimes have to make do with damp cloth, as they cannot afford fresh napkins every time. Some women complain of increased cases of fungal infection during the monsoons.

Figure 11: Temporary bamboo latrines constructed in flood-affected and waterlogged villages





In villages like Chandrain, the lands destroyed by sand casting in the embankment breach of 1984 are presently used for defaecation. Temporary latrines are common in villages like Chandrain Tilathi and Rahuamani. Within the Muslim 'tolla' of Chandrain village, it was observed that a couple of households had constructed a bamboo wall around a pit latrine. Although it is common for Muslim households to built latrines within the courtyard of the house, it is not so common among the Hindu community. The difference is based on the perception that latrines are unhygienic and therefore need to be constructed away from the residence. Movement of women from Muslim families in general is restricted to a considerable extent. It is often a matter of disgrace for the family if their women members go out to defaecate. A sense of pride coupled with cultural norms restricting the movement of women, especially for defaecation, has facilitated installation of latrines within most of the Muslim households in Chandrain.



Figure 12: Boats commonly used for defaecation during flood

To sum up, use of a boat for defaecation or climbing trees are among the coping activities adopted by the flood-affected villages of Aina and Dhamara. Hanging toilets are common in the above-mentioned villages. They are also common in the waterlogged areas of Chandrain and Tilathi. The sand-cast lands of Chandrain and Tilathi, which are unsuitable for cultivation, are also used for defaecation. Pit latrines are more common in Rahuamani which is located far away from the embankment.

#### Drinking water facilities

Water from hand pumps is generally used for drinking and other domestic uses. A section of the population from Chandrain, Aina, and Dhamara use the water of a nearby canal and Koshi River respectively for bathing and washing. Although hand pumps are common in most of the households, due to high water levels, most marginalised communities (from selected villages like Chandrain, Tilathi, and Rahuamani) are left to depend on and share a common hand pump installed by the government. The water level is around 25-30 feet and the cost for installation of a hand pump is around Rs 5,000-8,000 (\$US104-166): most of the households have installed hand pumps in their courtyards.

It has been observed that there has been an effort to raise the levels of hand pumps by adding pipes to place the water outlet higher than the average level of the flood waters. This mechanism gives people access to drinking water even when the surrounding area is submerged with flood water. This has been observed only in the river island villages of Aina and Dhamara and is a clear coping strategy adapted by the local community (Figure 13).

Water from open masonry wells is also used in some places for drinking. (Most of the open wells in this region have masonry walls. In flood-prone regions kachha open wells do not survive for very long and they cave in within 2-3 years.) Wells were seen in the Cutting and Kharra 'tolla' of Dhamara village. Improvisation has made it possible to use them

Figure 13: Hand pumps constructed with additional pipes to ensure collection of drinking water even during floods or prolonged waterlogging



during floods; the walls of the wells are raised to a level higher than that of the maximum level of flood waters (Figure 14). This activity was undertaken by the villagers with the help of a local NGO called Samta (Equality). The NGO provided the raw materials and technical knowledge and the villagers provided their labour to construct the wells. There are three such wells renovated within the village with support from Samta. (The NGO believes that water from these open wells is safe for drinking and is of much better quality than water from hand pumps. There does not seem to be any scientific basis to this belief.)

Collection of drinking water remains the responsibility of women and the challenge becomes more intense during flood hazards. Most women (in Dhamara village) use boats to collect water from the well. Before the wells were renovated in Dhamara, villagers were often forced to consume the flood water after filtering it through 'gamcha' (a local towel made of cotton with multiple uses). A similar activity was reported to have taken place after the embankment was breached in 1984. We were told of this in course of a discussion with a senior group of villagers at Chandrain. Samta, through the 'Megh-Pyne Abhiyan' is promoting rain-water harvesting to address the problem of drinking water during floods. This campaign has helped the people in four districts (Khagaria, Saharsa, Supaul, and Madhubani) (Box 2).

To sum up, raising the level of the hand pump by adding pipes has been a clear adaptation strategy as seen in Aina and Dhamara. Increasing the walls of the well as a means to prevent flood water from entering the well has been another strategy to ensure access to safe drinking water during floods. Since the other villages are not waterlogged, access to safe drinking water has not been a major issue.

### Use of bamboo bore wells

None of the selected villages, except for Rahuamani, has a dedicated irrigation canal flowing through it. Ironically the irrigation canal passing through Rahuamani has remained dry for the last five years. In such circumstances, people have to depend on indigenous technology to irrigate their land. Given this situation, bamboo bore wells are used to address the mismatch between increasing demand and receding supply of water for irrigation.

Bamboo bore wells were first introduced in this region in the early 1970s. The advantage of this bore well is its low cost because the materials used are available locally. Expertise in digging this kind of bore well has developed locally and hence there has been an increase in the number of bore wells in the region. The cost of a bamboo tube well of about 80 feet depth is about Rs 7,000-8,000 (\$US 146-167) (the cost of boring otherwise would be at least five or six times more), and it lasts about 10 years. A bamboo bore well can easily irrigate about one acre of land. Increased use of bamboo tube wells has not only increased the intensity of land use by small and marginalised farmers, but it is in a way addressing the wide income disparity. Use of bamboo bore wells is an effective way of using local resources to irrigate small patches of agricultural land. The use of these wells has been observed primarily in Chandrain Tilathi, and Rahuamani (villages ranging between two to 10 km away from the embankment).

### Addressing water needs: the use of portable pumping sets

Portable pumping sets are easily available on rent in the villages. These pumping sets are mounted on small bamboo carts which can be moved from field to field to service each bore well or field (Figures 15 and 16). The current rental is Rs 60 (\$US 1.25) per hour of pumping. Diesel or kerosene for the pump and plastic pipes to transport water are provided by the

Figure 14: Open masonry well before and during prolonged water logging in Dhamara





**Box 2: Megh-Pyne Abhijan: An effort to address the need for safe drinking water**

Floods in north Bihar are a recurring disaster, destroying both human lives and assets. Access to safe drinking water becomes the one of the pressing challenges for the people of flood-affected villages. Megh Pyne Abhijan (Cloud Water Campaign), is a campaign for propagating rooftop rainwater harvesting for assured safe drinking water for people staying in temporary shelters during floods and in permanent houses in rural areas in Northern Bihar. A network of local grassroot NGOs has started a campaign in the Khagaria, Saharsha, Supaul and Madhubani districts of North Bihar. The organisations involved in the campaign are SAMTA in Khagaria, Koshi Seva Sadan in Saharsha, Gramyasheel in Supaul, and Ghoghardiha Prakhand Swarajaya Vikas Sangh in Madhubani district. The entire initiative is funded by Arghyam Trust, Bangalore.

The team members from Koshi Seva Sadan explained that they are working in five panchayats within Saharsa district. Apart from rainwater harvesting, the organisation has also developed an indigenous filter to remove the iron from the water of the hand pumps. The earthen filter has three parts with sand, gravel, mesh, and charcoal in the middle section. These filter beds help to absorb the iron from the hand pump water. Mr Promod Kumar Yadav, a team member, mentioned that they demonstrate the product within their project area and it is available for sale at Rs 220 (approx. \$US 5). There is a positive response from the villagers; the filters are made by Koshi Seva Sadan based on the demand from the field.

pump's owner. Those who do not own a bore well have to pay another Rs 5-10 (10 to 20 cents US) to pump water from a private bore well. The use of movable pumping sets is indicative of the demand for water for irrigation in the villages. It is a coping strategy adopted by small and marginalised farmers used in all the villages.

**Food, fodder, and fuelwood storage systems**

Food, fodder and fuelwood storage is an essential part of disaster preparedness for people living around the Koshi River. The level of preparedness is much higher in villages like Aina and Dhamara which remain water logged for almost three to four months every year than it is in other villages. Food (mainly maize and rice) and fuel (cow-dung cakes, maize stubs, dried 'manajera' plants, and bamboo roots) are stored in every household in cylindrical structures made of strips of bamboo and covered by a plaster of mud and cow-dung. The level of these grain storage structures is raised by 5-10 cm (Figure 17).

Cow-dung cakes are round and big in size making them easy to store and transport to other locations in emergencies. Another form of cow-dung cake is made out of dung and mustard stalk and is clearly meant as a replacement for wood during floods.

Figure 15: Pumping sets placed on a handcart



Figure 16: Pumping sets irrigating agricultural land





Figure 17: Food grain storage structures



Figure 18: Construction of Machhan below the roof for storage and protection of valuables during floods

Making machhan (a structure of bamboo) is a very common practice in the villages covered by the study. Construction of these structures is more common in villages close to the river. They are used for storing food grains, and seeds. Any article that is important and which needs to be protected from the flood waters is kept above it (Figure 18). In some households, the bamboo is replaced by wood. The structure protects essential articles from rising water levels.

### Non-structural strategies

Despite natural and man-made adversities, people have tried to adapt and improve their lifestyles and general well-being. For instance, an alternative system of land use and cropping is prevalent in many parts of this basin. Most agricultural strategies are aimed at intensive cultivation of the land during the short period it is available for cultivation. Strategies that do not require much investment, unlike the hard structural ones, are generally adopted by the communities by making small changes in their livelihoods and institutional and social relations. Some of these are analysed below.

### Adjustments in the cropping cycle

In the villages that suffer from river floods almost every year, for instance, Aina and Dhamara, sowing 'aghani' paddy is a risk as the fields become flooded. Yet people broadcast paddy seeds on these lands every year in the hope that they might survive if the floods are low. This risk is well worth while if once every three years they get a bumper crop. This applies for all the lands that lie between the embankment and the river or which are unprotected. Paddy varieties which can survive standing water for a long time are generally sown on these lands. The same categories of land also support a good crop in the 'rabi' season depending upon where the river is flowing. If the river has deposited a thick layer of sand then either there will be no crops or the crop yields will be very low. If it has deposited a good layer of silt (as happened in Aina after 1990), however, then these lands will produce a very good crop of wheat or maize and some "bhadoi" crops such as 'managera' and 'moong' (pulse).

'Garama' cropping season (sown in February-March and harvested in May-June) is new in this area. This is a response to the acute problem of water logging in villages and lands close to the embankment and outside it. Acreage under this new variety of paddy, generically called 'garama dhan', has increased over the past few years (Figure 19). Most of the waterlogged and seepage areas in Tilathi and Chandrain are beginning to increase their cultivation of 'garamadhan'. 'Garamadhan', is a coarse paddy, grown mostly for household consumption unlike other rice varieties which are grown for market. Its cultivation has clearly addressed the food security problem of poor households. It should be mentioned, however, that this particular variety of paddy was not consumed by the people earlier, especially the better-off people, as it is a coarse variety.

### New and better varieties of crops

In the past few years better and high-yielding varieties of crops have been introduced. New varieties of wheat and maize give much better yields than previous varieties. High-yielding varieties of vegetable crops have been introduced also. In addition to new varieties, new crops have been introduced. For instance, introduction of the sunflower in villages prone



Figure 19: Cultivation of garama dhan



Figure 20: Makhana cultivation in waterlogged villages

to river floods, such as Aina and Dhamara (although more so in the former), was in response to land being completely under water for four months a year. Sunflower is a commercial crop and makes good profits because the cost of cultivation is low. Furthermore it destroys weeds and improves soil productivity. An early variety of maize was introduced in the late 1990s. This high-yielding variety was introduced in response to early floods. Now the crops are harvested by May, much before the first floods. This has given a lot of hope to farmers whose main crop is maize. These new crop varieties are introduced by private seed companies and often are tried out first by entrepreneurial or big farmers before others follow.

'Makhana' or fox nut (*Euryale ferox Salisb*) is the main aquatic crop cultivated in the waterlogged fields. Makhana can be processed into a nutritious non-cereal food and is used for preparation of various kinds of sweets and recipes. The plant requires a maximum of one metre deep of standing water. Its cultivation is dependent on the availability of water, soil type, and climatic conditions. Large areas of waterlogged lands and other water bodies in the basin are now under this crop (Figure 20). Districts where makhana is cultivated on a large-scale are Saharsa, Supaul, Khagaria, Darbangha, Madhubani, and East and West Champaran. As per an estimate, over 60% of the 75,000 hectares of ponds in Bihar in which makhana thrives are given on lease by the state government to the fishermen's cooperative. In most cases these ponds are then sub-leased by the cooperatives to poor farmers within the locality (Karunakaran 2008).

The fishing community (Mallah) depends upon 'makhana' for their livelihood because of the decline in fish stocks. In the last decade and a half there has been a change in their livelihood portfolio in terms of both extent and type. For instance, fishing, which was their main occupation for generations, has now become negligible as an activity; and makhana cultivation and agriculture (mainly cultivation of garama dhan) has become their main occupation. For instance, migration to Assam to districts such as Guwahati, Dibrugarh, Tinsukhia, Jorhat, Mariyani, Jagi Road-Nawagaon, and Murigaon is mainly for makhana cultivation. The difference in the timing of the harvest between the home state (Bihar) and Assam by one month enables them to engage in makhana cultivation almost throughout the year. Harvesting in Bihar ends in September and in the different districts of Assam harvesting begins in October and lasts until December.

There is a gender-based division of labour in cultivation of makhana. Whereas men take care of outdoor activities, such as collection of seeds from the pond, the women take care of indoor activities such as drying seeds and 'popping' them. In recent years, even other caste groups have started growing makhana because of the increasing demand. This clearly is a departure from the cultural norms of a society in which fishing and makhana cultivation were carried out exclusively by the Mallah. The seeds yield 'pops,' which are one third of the total seed weight. After processing, makhana is sold at Rs 250/kg (\$US5.20) in the market. It is difficult to grow, but fetches a good price.

The growing demand for makhana is evident from the increased involvement of private sector companies. A Patna-based company called 'Shatki Sudha', a food-processing company, prepares different products ranging from flakes to makhana kheer and its turnover is around Rs 50 crore (ca \$US10 million). The company collects around 3,000 tons of makhana from Bihar. The company has a tripartite agreement between the company, the panchayat, and the farmers in which the roles of all three have been defined from documentation, training in agronomic practices, and also purchase guarantee. The company plans to expand its operations to 126 blocks within the state and is expecting to touch Rs 100 crore (\$US21 million) by 2012 (Karunakaran 2008).



### Cultivation of vegetables and fruit in sand-cast areas

In lands lying within the embankments and those unprotected by embankments, sand-casting is a big problem (Figure 21). Muslims, who are expert vegetable farmers, lease-in these lands for vegetable farming. Some of the sand-cast lands are also ideal for vegetable farming, especially of cucurbit varieties. Vegetable farming is widespread in Rahuamani because it has irrigation and it is close to Saharsa. New and high-yielding varieties have increased the profitability of this type of farming and helped the landless Muslims improve their lives.



Figure 21: Uncultivated land due to sand casting

In Rahuamani some entrepreneurial farmers have taken the initiative to experiment with new ideas and crops. Banana cultivation started here a few years back and the village supplies banana to Saharsa throughout the year. Similarly, menthe and pineapple were also tried but these experiments did not succeed mainly because of the lack of support from government agencies. Some farmers complained that whatever success they have achieved is through their own means and imagination; the government agencies never come forward to help, rather they ask for bribes (see Box 3 for an example).

It has been observed that some large land owners (belonging to the Hindu religion) have invested in large-scale vegetable farming. Large-scale vegetable farming is a high-investment, high-profit business with an equally high-risk potential. It is prone to weather conditions, pest attacks, and price fluctuations. Large-scale farmers can only invest in such activities to diversify their livelihood. Using sand-cast lands for cultivation of fruit is a coping strategy to make best use of seemingly unusable lands. It has been used both by small and large-scale farmers for different varieties of fruit depending on their potentials to undertake necessary risks.

### Better cultivation methods and techniques

Farmers in the area have developed practices that prevent degradation of land or loss of soil fertility despite intensive cultivation of the already declining land available and the short period of time when land is available for cultivation. Mixed cropping and rotation cropping are used to maximise crop yields and also to keep soil fertility intact. Mixed cropping, for instance, maize with 'garama dhan', maize with 'moong', or maize with 'bajra' and 'moong' are common. In many places field bunds are used to grow teak trees or 'managera' plants. Using the same water body for 'makhana' cultivation and pisciculture is also very common. 'Managera' and 'moong' apart from their other uses are good for nitrogen fixation and are sown especially to reclaim the fertility of the soil. Improved cultivation methods have helped the farmers use the land available in the best possible manner.

### Box 3: Fruit cultivation in Rahuamani

Dolan Singh, a big farmer with about 100 bighas of land, started banana cultivation on his own. He has banana plantations on about 5.5 bigha of land and grows three different varieties – Hari Chhal, Robesta and Jahazi – and all the three varieties are spaced in such a way that there is always a crop available for marketing. He employs labour only for weeding and applying fertiliser.

Singh also tried growing menthe on the advice of the head clerk in the Horticulture Department. He could manage a grant of Rs 58,000/- from the Department for seeds and other inputs but dropped the idea as the Horticulture Officer demanded 'a cut' in the subsidy given to Singh. Singh then tried his luck in growing pineapples – which are more profitable than bananas. He had brought seeds from Siliguri but once again as the departmental people expected him to pay bribes in return for the help given by them he dropped the idea. His romance with menthe and pineapple ended thus but he continues producing bananas which are hassle free and do not require any dealings with government departments. Bananas fetch a good price at festival times.

### Migration, remittances, and impact on women

Migration plays a central role in the strategies that households employ to respond to floods in the project area. Although much of the migration was driven by floods, some of it followed a pre-existing pattern. Migration increased, however, after the construction of the embankment and increasing stress caused by changes in the agroecology. In many cases, migration for work is a central coping strategy for households and used in normal years to find jobs and diversify sources of income.

As agrarian communities, the basic source of income on which families traditionally depend is severely affected by recurrent inundation. Such is the case in Aina and Dhamara where the agricultural lands are waterlogged for three to four months every year. The disruption in the 'aghami' crop season, and to some extent in the 'rabi' season, has forced both landed and landless labourers to look for employment outside the region during these seasons. The problem of sand casting (especially in Chandrain and Tilathi as discussed before) has aggravated the situation leading to a shortage of cultivable land.

In villages, like Chandrain, Tilathi, and Aina about 80% of the adult males migrate during off-farm season. Most of the migrant workers leave their villages after completing the agricultural activities of the 'garama' season (end of May or beginning of June) and come back when their land is fit for cultivation either in the beginning of the 'rabi' season (early November) or 'garama' season (February). Seasonal migration to adjacent or distant agricultural lands (mainly in Punjab and Haryana) as agricultural labours is a common practice. Men from the project area also move to urban areas (like Delhi) to work as construction labourers and in other temporary wage labour activities to maintain income levels. The women, children, and old men do not have to do much farm work during this period, except to become involved in government-sponsored rural schemes. With the improvement in transport and communication facilities, migration to find work in distant places has become easier. Every household has their own information and social network which helps it get jobs outside.

**Patterns of migration** – During the last couple of decades, both the extent and pattern of migration from rural Bihar have changed considerably. The change has been in terms of the choice of destination and the kind of work undertaken. For instance, migration is now more widespread and from amongst all communities to destinations such as Delhi, Mumbai, Surat, Kolkata, and Guwahati. apart from their favourite destinations in Punjab and Haryana. The observable shift now is migration from rural-rural to rural-urban.

Access to loans has improved also. Although the traditional money-lending castes do not operate in this region, the relatively better-off people act as moneylenders in the villages. In most cases small amounts of money are provided without any mortgage but at high interest rates. These small amounts of money are generally required before migration to cover the cost of travel and to give some cash to the women to keep the home going. Otherwise, money is generally required before the agricultural season to buy seeds and fertilizer. Local shopkeepers also provide goods on credit and charge an interest rate on deferred payments.

**Remittances** – With the improvement in rural banking, sending remittances has become quite easy. Remittances from migrants were frequently mentioned as an important resource for recovering from floods. The extent of this, however, varies. Remittances have been used to finance construction of brick houses as seen in the villages of Chandrain and Rahuamani. Apart from improving housing, remittances are used to buy animals or even to start new business ventures (opening a small local grocery shop, for instance). In times of prolonged flooding and waterlogging, remittances help members of the family left in the village to survive the bad patch and to meet their daily expenses.

**Impact on women** – Due to the high level of outmigration, women are left with additional responsibilities for managing work outside the home (wage labour) along with care of the household. Caring for and feeding children and cattle become enormous responsibilities. Getting dry fuel is a challenge and cooking time increases drastically. Collection of drinking water becomes much more time consuming. Even simple human activities like relieving oneself become very cumbersome during floods. Living in temporary shelters without adequate food, privacy, or protection adds to the psychological pressure on women.

Problems for women increase due to the sociocultural environment and patriarchal practices prevalent in Bihar. Women are frequently denied land rights and there are marked gender differentials in agricultural wages (around 25-30 INR - about 52 to 62 cents - less than those of a man), the division of labour, and also in evaluation of women's work. Illiteracy, poor health, and lack of adequate information have played a significant role in marginalising women and increasing their vulnerability.

Absence of men for prolonged periods due to outmigration also makes women vulnerable to different kinds of exploitation. Discussions with women in villages like Chandrain and Tilathi revealed that, although they have participated in the government-sponsored National Rural Employment Guarantee Scheme (NREGS) for a few days, most of them are yet to receive their payments. Some have received partial payment. Many women in the same villages are even unaware of how to get involved in the process. Disaster situations, in a nutshell, increase the level of vulnerability for women.

Cases of coerced migration (trafficking) of children and young girls have also been reported from villages located in this basin. It was reported that from every panchayat in the Koshi region, particularly from districts such as Saharsa, Supaul, Khagaria, Madhubani, and Darbhanga at least one or two women are trafficked every year to places like Kolkata, Mumbai, Delhi, and others, and forced into prostitution. The predominant reasons for girl trafficking are a) poverty, b) inability to pay the bride price (dowry) during marriage, and c) betrayal by somebody trusted on the pretext of marriage, love affair, or a job offer as domestic help in cities. An indication about the state of affairs is evident in one of the local folklores of the region (Box 4). NGOs like 'Bachpan Bachao Andolan' and the Hyderabad-based Centre for World Solidarity (CWS) are working on these issues and to some extent have been successful in arresting this growing menace.

#### Box 4: Local folklore

"Beti chali gaile baap ke naadani mein

Lorwa pochela aapan sirhane mein"

*(Because of my father's ignorance, my life is in complete ruins, all I can now do is wipe my tears on my pillow)*

Overall, migration is a very important adaptation strategy to the changing nature of hazard and stress in the basin. Migration will increase with the growing population pressure on land resources and increasing employment opportunities in economic growth centres in other parts of India. Many observers feel, however, that it could also decrease with effective implementation of 'employment guarantee' schemes in rural India.

#### Migration and impact on the local labour market –

The bulk migration of lower caste groups is becoming a cause of concern for the landlords (Brahmins, Rajput, and Yadav) who own large areas of land, as the migrant population primarily formed the bulk of the agricultural

labour force. This was evident in Tilati and Rahuamani where shortage of labour had prevented farmers from cultivating all of their landholdings. In addition, more time and effort, according to them, now have to be put into arranging a timely supply of labour, and some of them even complain of having to dirty their hands doing their own farm work. In most cases, however, most migrants come back to their villages during farming season not only to cultivate their own small pieces of land but also to take advantage of increased employment opportunities in the village.

Lack of appropriate remuneration (both in cash and kind) for labour at the village level is often cited as the main reason for the exodus, but this is refuted by the landlords. According to most of the migrants interacted with regarding work being hard and labour-intensive, however, it is evident that the loss incurred by not migrating is greater than that of migration as there is only a certain age up to which one can toil hard and earn. Moreover, there are few opportunities at the village level and timely migration can ensure enhanced capabilities for current and future work.

#### Impacts on animal husbandry due to construction of embankments and migration

Animal husbandry is an integral part of the agricultural system and contributes substantially to rural livelihoods. The lower castes or classes (Musahar and Muslims) mainly rear small ruminants (such as goats) as they are easier to manage (even during floods) and feed and they fetch a good price.

Like share-cropping, share-rearing of goats is widespread in this region. The poor cannot even buy a goat to start this business. They are provided with one by a richer person for a year: the poor family then keeps the goat and feeds it. Whatever offspring the goat produces (goats produce three to four offspring twice a year) is then divided between the original owner and tenant, and the original goat remains the property of the owner. Since goat rearing does not require any investment, except time, this is an important source of income for the poor; and for women in particular. Further, since this is mainly managed by women with help from the children, the income accrued from selling the goats goes to the women. This activity has allowed women to save some cash for emergencies. A one-year old male goat fetches about Rs 1,500 (\$US 31) in the local market. This information came from focus group discussions with women in Dhamara and Aina, the two most waterlogged villages within the project area.

Rearing cattle was comparatively easy for most households in the villages located close to the Koshi before the construction of the embankment. The presence of huge swathes of common land, mostly the river banks and its various drainage channels, had a good variety of vegetation, and these areas were a favourite destination of wandering cowherds who came from as far away as Gaya district (in south Bihar). The construction of the embankment has increased waterlogging and has also reduced the area of grazing land considerably. People do keep cattle, but the extent to which they do so has decreased significantly, except in Dhamara village where the milk business is an important occupation.

Very few people in villages close to the embankment (Chandrain and Tilathi) and trapped within it (Aina) rear milch animals now. Most of them keep one or two cows and buffaloes for household consumption. In Chandrain and Tilathi mosquitoes, brought mainly by waterlogging, have forced people to build cattle enclosures with mosquito nets. In Aina, which goes under water during the monsoons, keeping large herds of cattle is both risky and expensive.

Labour shortage and its impact on animal husbandry—A number of people tried their hand at the dairy business in Rahuamani because of the closeness to Saharsa town; some of them used to sell about a 100 litres of milk every day. Because of a shortage of labour in the village, however, the dairy business decreased significantly. The only place where there is a significant production of milk is Dhamara and its vicinity, especially on the eastern side of the railway embankment. This area is dominated by the Yadav whose primary occupation is cattle rearing and the dairy business. A number of landless Musahar from this village work as bonded labour for many Yadav families; they are employed mainly to transport cans of milk from neighbouring villages to Dhamara railway station from where they are shipped to other places.

To sum up, animal husbandry has changed substantially because of the scarcity of cheap labour which, in turn, is a result of frequent migration.

## Factors influencing local adaptation

This section attempts to capture the different factors influencing adaptation. It is important to mention that these factors do not uniformly influence the adaptive strategies of people from different sections of society living in different areas of the basin. For example, the spread of rural banks has facilitated easy transfer of remittances only for those who have access to banks. People from the lower castes (e.g. the Musahar) often find it difficult to open a bank account. Therefore, they have to depend on the traditional system of sending their remittances through their social networks. Efforts have been made to highlight these differences in the sections that follow. Table 6 provides a summary of adaptation options and benefits.

### Enabling factors

There has been an improvement in rural infrastructure during the last three decades. Although the extent of infrastructural development is debatable, there is no doubt that there has been improvement in the quality of rural roadways, an increase in the number of trains, and an increase in communication networks.

#### Improvement of roads and railways facilitating migration

It has already been mentioned in above that migration is an adaptation strategy, especially for the poor and marginalised communities within the project sites. Most of the economically marginalised communities migrate to northern India during different periods of the year in search of work. The main factor facilitating this is the growth of a transportation network in the region. Although the region was linked by rail already, in the last decade several new trains have been running from this region to the favourite destinations for migration. The frequency of other trains has also increased. The state and national highways have also improved since the 1990s, especially in the last decade, with the infusion of huge investments in this sector. Rural roads have also improved due mainly to the Pradhan Mantri Gram Sadak Yojana (Prime Minister's Rural Road Project). The improved transportation system has facilitated movement of labour to areas with potential for labourers.

#### Penetration of the rural telecommunication system

There has been a sea change in the telecommunication sector within the selected project areas. Mobile networks have reached almost all the selected project areas. Access to mobile networks has helped a section of the influential population

Table 6: Assessing adaptation options in the context of climate variability and change

Possible local adaptation options	Who benefits from this option?	What kind of activities are necessary?	How much investment required?	Anything else required?	Potential adverse consequences?	Any other?
Groundwater irrigation	All farmers, especially smallholders	Providing credit to small farmers  for digging bamboo-tube wells,  for group ownership of pumping sets	Moderate	Formation of user groups	Carbon emission increases if existing fuel or energy sources are used	Huge groundwater potential
Maintenance of Koshi canals	All farmers in command area	Regular maintenance and de-silting of canals  Land levelling & other land improvement	Moderate to high	Encouraging participatory irrigation management (PIM)		Over-dependence on irrigation may lead to a water-intensive agronomy which might be adversely affected by reduced river discharge in the future climate scenario
Introducing new flood-adapted crop types	All farmers	Training agricultural extension officers.  Providing govt. approved seed shops  Awareness drives  Field trials	Moderate	Encouraging community involvement in crop research and development (R&D)  Setting-up farmer schools	No market for selling crops	Though there may not be markets for these crops and they do not fetch a good price, these crops can solve the food security issue for most households
Fruit and vegetable farming	All farmers, especially smallholders	Training agricultural extension officers.  Providing govt. approved seed shops  Awareness drives  Field trials	Moderate	Setting-up farmer schools  Improving transport and storage infrastructure  Information and communication technology (ICT) infrastructure in each village so that farmers can monitor markets and prices.	Price fluctuations	
Education and skill development	All	Better school facility  Committed teachers  Training centres for other skill development	Moderate to high	Separate schedule and timing for schools  Boats in each village especially to ferry school children & teachers  Flood-resistant school building	Ignoring traditional livelihood options like agriculture, iron works, carpentry, etc.	



Possible local adaptation options	Who benefits from this option?	What kind of activities are necessary?	How much investment required?	Anything else required?	Potential adverse consequences?	Any other?
Transport infrastructure	All	Boat or other alternative services in inaccessible areas  More buses  Increased frequency of trains  Better facility for transportation of goods  Better designed new roads  At least two boats in each vulnerable village	High			
Cold storage	All	Construction of cold storage in the area	High	These could be built and handed over to farmer groups / cooperatives		
Drainage	All	De-silting of drains  More waterways on existing roads and railways, and bridges  Reviving dead channels	High	A manual on minimum design requirements for roads in flood-prone areas	A drainage scheme in one part of the basin might flood others downstream	This is a recurrent activity and should be monitored constantly
Village Information Centre	All	Internet connectivity in each village  Updated information on weather  Updated information on market, prices, etc.  Early warning	High	Measures in column 3 should be accompanied by an awareness and education drive  Handed over to panchayats with adequate funds allocated for maintenance		The infrastructure might land in the wrong hands.  Danger of 'elite capture'
Rural energy access	All	Electrification of all villages  Parallel committed line for energising tube wells  Increasing access and supply of liquid petroleum gas(LPG)	High	Wherever possible, alternative non-conventional energy sources should be promoted,  Promotion of energy saving and/or efficient technology		
Improving health facilities	All	Hospitals in each village with dedicated staff  Veterinary service and hospitals  Fumigation of waterlogged villages  Building toilet facilities	High	Education and awareness drives on sanitation and health  Traditional medicine should also be encouraged and given official recognition		

to keep track of the potential 'urban job market'. It was also clear from the discussions held that penetration of mobile networks has also strengthened the position of local middlemen in terms of facilitating the movement of labour. It is difficult to assess whether or not this growth has created a new class of middle men within these villages, leading to increased exploitation of marginalised labourers.

Besides facilitating movement of labour, access to telecommunications has improved communication between the populations living upstream and downstream; and especially the flood-warning mechanism.

### **Spread of rural banking and easy transmission of remittances**

Rural banks have greatly improved. An increase in the number of branches of nationalised banks has facilitated electronic transfer of funds from labour migrants to their respective villages. E-transfer of remittances ensures the safe transfer of money. The poorest section of the community, however, has not made best use of this improvement. Illiteracy, lack of information, and class bias are sociocultural barriers that have prevented them from opening bank accounts and they still depend on their existing social networks to send remittances.

### **Increasing penetration of green revolution technology or packages**

Although irrigation facilities and other agricultural infrastructure were established in this region in the early 1970s, the 'green revolution' had a late entry because of various factors. Currently, with the relatively easy access to agricultural credit and penetration of private companies marketing seeds and fertilizers, there seems to be a revival of agricultural growth. New and improved hybrid seeds are promoted in the nearby town through an aggressive marketing strategy. New crops have been introduced also due mainly to private companies and the initiatives of individual farmers. Similarly, the access to cheap, indigenous technology (bamboo tube wells) has increased the area irrigated: new methods of cultivation; for instance, the rice intensification system, have also been popularised. Remittances have increased and facilitated private investment in agriculture. All this seems to have increased agricultural production in a seemingly adverse agroecological setting.

### **Presence of the National Rural Employment Guarantee Scheme and other poverty alleviation programmes**

The National Rural Employment Guarantee Scheme, one of the largest social security programmes in the world, aims to provide 100 days of employment locally to all households in all the districts of India. The scheme has huge potential for addressing the issues of livelihood security and poverty and can help develop the necessary infrastructure in rural areas also. During interactions with the research respondents, however, it was learned that the programme has been implemented only partially in the study villages. In fact, very few people are even aware if any work has taken place under this scheme. Further investigations revealed that most funds for this scheme in the districts of Bihar were returned (to the central government) or remain unused. This clearly shows the inefficiency and corruption of the bureaucracy. It also is evident that the formal institutions of governance (panchayats) have not been able to exert as much influence as in other states of India.

There are other government schemes such as the distribution of subsidised grain to families living below the poverty line (BPL). This scheme is clearly support without which these families might die of hunger. The BPL list has a number of problems: the most important one is the exclusion of many poor households and inclusion of others who do not deserve to be beneficiaries. Corruption in the Public Distribution System (PDS) leads to siphoning off of benefits to non-beneficiaries.

Under the Indira Awas Yojana (Housing Scheme), extremely poor families are provided with free 'pucca' houses. In reality the beneficiaries have to pay a percentage of the money in bribes to government servants. In many cases this leads to a house being half finished.

If these schemes are implemented efficiently and corruption can be eradicated, they have a great potential to increase the adaptive capacity of the poorest sections of rural society.

### **Role of social institutions and networks**

The role of social institutions has been highlighted in the literature on adaptation. Although old institutions die out or their role changes with time, new institutions emerge with new actors and roles. These institutions and social networks can play a role in facilitating access to loans, the rate of interest charged, and access to jobs. Connections in terms of knowing

someone who 'understands the job market', having relatives with good jobs, and the ability to lend money, seemed to play a crucial role in the ability to diversify risks or to obtain funds when required. A gradual change in the traditional social institutions was observed also. For example, the caste-based social mechanism to provide support (in terms of both kind and cash) to the most needy during stress is gradually giving way to government-run relief operations: the impact of such changes on the vulnerable in the community needs detailed study. Absence of operational self-help groups makes women more vulnerable, especially in times of flood. There are no formal cooperatives within the area either. To sum up, in many cases the role of networks appears to be an enabling one rather than a directly helpful one. In other words, they enable individuals to obtain access to resources rather than providing them with resources directly.

## **Constraining factors**

### **Poor transportation infrastructure**

Although transportation has improved significantly, as discussed above, in certain parts of the state there are still areas that remain inaccessible. For example, the village of Dhamara can only be reached by railroad and Aina by water. Lack of proper infrastructure acts as a serious barrier to accessing markets and also prevents the community from developing suitable adaptation techniques.

The inaccessibility of these villages has prevented smooth implementation of different government programmes. Absenteeism among teachers is very common in Aina and Dhamara and similar villages. Although both villages are very vulnerable to floods, their remoteness prevents easy movement of government relief to them. Poor transportation facilities act as constraining factors to adaptation.

### **Poor access to markets and inadequate facilities for storing food**

Inadequate roadways and improper transportation facilities have a direct impact on access to markets. In most cases, the producers are forced to sell their products near or within the village and thus have little opportunity to negotiate the prices. Although the community has its own domestic system of food storage, there is no cold storage facility within the project area. In most cases farmers have to sell their crops just after harvesting them at a time when supply exceeds demand and thus lowers the market value of the product. Poor access to markets and inadequate infrastructure for food storage are factors that hinder adaptation.

### **Lack of a suitable credit support system**

Although nationalised banks have made inroads into rural areas, they have failed to benefit the most socially and economically marginalised communities. Musahar from different villages (like Chandrayen, Tilathia, Rahuamani, and Ainadi) have not managed to open bank accounts. Even if some of them have opened accounts, they have not been able to get loans because they have no collateral. Most poor people have to depend on informal village moneylenders for credit. Lack of access to funds at a favourable rate of interest during emergencies makes the marginalised more vulnerable. This is exacerbated by lack of successful self-help groups (SHGs). Although it is clear from the literature review that self-help groups are important for enabling women to obtain income and access to loans independently, there is hardly one SHG in the project area. Thus lack of a suitable credit support system acts as a serious constraint.

### **Loss of access to productive assets**

Loss of access to productive assets due to embankment breaches, water logging, and the changing course of the river is a common phenomenon in the area. Sand deposits around fertile agricultural land after the embankment breach caused a substantial loss of assets in Chandrain. Water logging has caused substantial losses of agricultural land in Tilathi and Chandrain. In most of the villages close to the embankment and outside it, land was acquired by the government to rehabilitate people trapped within the embankment; and in Tilathi around 27 acres of land was used for resettlement and rehabilitation of villagers from the neighbouring village of Ghogsham. In Dhamara and Aina a considerable amount of agricultural land is still either under the Koshi or under sand. There is no government policy to encourage reclamation of sand-cast and waterlogged land. Drainage schemes too have failed to improve the situation. It goes without saying that there is an urgent need to maintain the embankments properly and de-silt the drainage channels.

### **Lack of civil society organisations (community-based organisations [CBOs] and NGOs) and limited voice of the people in policy making and implementation**

Unlike in other parts of India (e.g., Rajasthan, Gujarat, and Maharashtra) Bihar has never had dynamic NGOs in rural areas. Most of the NGOs working in the study area focus on relief distribution and very few have a long-term vision of rural development. This situation, together with the almost complete lack of government machinery in most parts of the basin, means that fresh ideas and technology are slow to spread here.

The formal local governance institutions (panchayats) too do not have the dynamism evident in other states (e.g., Madhya Pradesh, Kerala, West Bengal, and Karnataka). The elected representatives of these bodies appear to be more accountable to the state-level political leadership rather than to the people they represent. They also seem to be hand in glove with the local bureaucracy, and together they siphon off most of the government assistance from rural development and poverty alleviation programmes.

In sum, people in this area do not have any voice in governance. This is ironical considering the high level of political consciousness among the people and their social and political movements in the past.

### **Lack of adequate infrastructure for education and role of illiteracy**

Despite the increase in the budget for education and introduction of literacy programmes like the 'Sarva Shiksha Abhiyan' (Total Literacy Campaign) by the government, a large proportion of the population in rural India cannot get an education. The situation in Bihar is worse than in other places: in the flood-prone areas of North Bihar it is worst of all. In many villages which are relatively inaccessible, absenteeism among teachers is common. Many of the schools are badly constructed. During the four monsoon months, schools are cut off and there is an unofficial holiday. The children suffer and this is evident in the very low level of literacy in this area. Rahuamani has the highest literacy rate of 55% while Tilathi has the least of 16.3% (Registrar General of India 2001). Illiteracy is the main cause of the poor adaptive capacities of people in this area.

## **Conclusions**

As mentioned earlier, the River Koshi is known for its frequently shifting courses and the repeated devastation and destruction it causes. The conventional flood-control measures of the past have not only changed the agroecology of the Koshi basin, but also increased the frequency and intensity of water-related stress and hazards for people living in its basin. Flood-prone and waterlogged areas have increased, and erosion and sand casting has temporarily or permanently made huge areas of land uncultivable; and this, in turn, has increased landlessness and distress amongst the local community.

Vulnerability and the capacity of people to cope with flood conditions vary according to their ability to diversify income strategies and incorporate non-farm strategies. Differences in a household's ability to employ different strategies primarily depends on factors ranging from caste, asset base, location vis-à-vis the river embankment, access to information, and also on the efficacy of their social network. Small- and medium-scale farmers with tracts of land that have been rendered uncultivable due to either sand casting or prolonged waterlogging, and who have failed to diversify their income base, are as vulnerable as their landless counterparts. Migration is the only option for landless agricultural workers (as in Aina and Dhamara).

Problems for women, in general, and for lower caste women, in particular, are compounded by the sociocultural environment and patriarchal practices prevalent in Bihar. Women are frequently denied land rights, and there are marked gender differentials in agricultural wages within the entire project area. Illiteracy, poor health, and lack of adequate information and the resources that help them diversify income have played a significant role in marginalising women and increasing their vulnerability. Absence of men for prolonged periods makes women vulnerable to various kinds of exploitation.

Communities living in this basin have developed their own coping strategies to deal with the adverse situation. Additionally, strategies focused on getting away from floods rather than preventing them', and this is an ecologically sound way of dealing with rivers in flood plains. The section below classifies community coping mechanisms according to the community's location in the river basin.

As mentioned earlier, the study was undertaken in five villages spread across two districts, Saharsa and Khagaria, in the state of Bihar. The five villages can be categorised into three groups broadly based on the similarity of mechanisms used by the local community to cope with water hazards.

- Villages located between either two streams of the Koshi (Aina) or between the Koshi and Bagmati (Dhamara)(diara) and which are therefore unprotected by the embankment.
- Villages (Chandrain and Tilathi) located between 0-2 km from the embankment which suffer due to acute water logging and sand casting.
- Village (Rahuamani) located 8-10 km away from the embankment but within the command area of the Koshi irrigation canal.

Strategies adapted by different communities in the project area are as follows.

- Constructing 'kachha' houses
- Raising household plinth levels at regular intervals to match the increasing water levels
- Construction of houses in clusters on land which is elevated five or six feet from the agricultural land

These are some of the effective, structural coping strategies used in Aina and Dhamara.

- Efforts to raise the level of the hand pump by adding additional pipes to place the water outlet higher than the average level of the flood waters are common.
- This ensures the community access to drinking water even when the surrounding area is submerged with flood water.

This coping strategy is practised in the flood-affected villages of Aina and Dhamara.

- Construction of bamboo latrines on a bamboo platform to ensure they are above the rising waters and can be used for extended periods even during water logging or flooding
- Although the use of temporary bamboo toilets is seen throughout the project area, the number of toilets is greatest in Aina and Dhamara.
- Boats are used to relieve oneself during the floods. Use of boats is not common in villages like Tilathi and Chandrain.

Adjustments in the cropping cycle are evident in villages like Aina, Dhamara, Chandrain, and Tilathi.

- Post-monsoon cultivation in waterlogged areas of Aina and Dhamara has been pushed from early October to late November, but in villages like Chandrain and Tilathi post-monsoon cultivation starts from October.
- Selection of crop type and variety and improved irrigation techniques have been central to coping with and adapting to the changing environment.
- Cultivation of a new variety of paddy, known as 'garama dhan' before the monsoon (sown in February-March and harvested in May-June) is an example of introduction of new varieties to cope with the variability in climate.
- Sunflower and an early variety of maze have been introduced also into the cropping cycle. 'Makhana', or Fox Nut, a nutritious, aquatic non-cereal food crop (used for preparation of various kinds of sweets and puddings) is presently cultivated in waterlogged areas of Chandrain and Tilathi.
- Uncultivable sand-cast lands within Chandrain and Tilathi are used primarily by small farmers to cultivate fruit. Vegetable farming is also widespread in Rahuamani because of its proximity to Saharsa.
- With the gradual drying up of the Koshi irrigation canal, bamboo bore wells and moveable pump sets are used in villages like Rahuamani located far away from the embankment. A bamboo bore well can easily irrigate about one acre of land. Use of bamboo tube wells has not only increased the intensity of land use by small and marginalised farmers, but indirectly addresses the wide income disparity also.

Income diversification has been a strategy households either proactively engage in or resort to as a response to floods.

- Migration (seasonal or permanent) plays a central role. Many non-agricultural activities, particularly migration, are male-dominated and the income from them is often used for improvement of the asset base.
- Migration has increased with the increasing scale of distress and helped to off-set the losses incurred by water stress and hazards. It has been helped by the improvement in transport and communication and better access to credit and banking. Efforts are made to establish at least one family member in a secure, preferably non-agricultural occupation.

- Agriculture and animal husbandry are still the two most important occupations within the project area.
- Limited reach of the state machinery, corruption, and inefficient bureaucracy have led to poor delivery of innumerable government programmes and schemes which otherwise have a good potential to increase the adaptive capacities of the communities.

The following factors are common to all the villages.

- Improvement of the rural road and railway networks has improved labour movement and facilitated migration.
- Penetration of mobile networks among the rural population has strengthened their links with each other and has also helped them to communicate, especially when there are water hazards.
- Mobile networks have improved the early warning system and helped the downstream population to keep in touch with the upstream population.
- Spread of rural banking has facilitated easy transfer of remittances and improvement in assets for certain sections within the selected project areas; and, in turn, improved their capacity to adapt to the changing climate.
- The role of social institutions and networks is an important element that allows the local community to cope with floods.
- Knowing someone 'who understands the job market' and having 'well placed' relatives who have the ability to lend money seemed to play a key role in helping people cope.
- The role of social institutions appears to be enabling rather than direct. Unfortunately, the role of self help groups (SHG) was never mentioned in any of the different interviews and interactions. Absence of SHG is perhaps because of the lack of a suitable facilitating organisation in the region.

## Ways forward

The following are recommendations for further research arising from the study.

- Further research should be carried out to investigate how formal and informal institutions and mechanisms support or constrain each other
- Research should be carried out to understand the efficacy and resilience of informal social security institutions such as cooperatives, kin enclaves, and credit networks in the face of climate stressors; and to identify mechanisms, institutions, and policies to strengthen the reach and accessibility of formal social security mechanisms to poor and marginalised groups, and to women in particular.
- Factors facilitating and constraining effective use of remittances to address climate variability should be investigated.

Given the present global situation, stresses from water hazards are going to increase with climate change. Autonomous 'adaptive' strategies documented in this study have at best helped the community to cope with existing water stresses and hazards. Fear that the embankment will be breached haunts the local population settled around the Koshi River basin every year during a specific period. It is clear that any change in the volume of water will not only increase the level of vulnerability of the communities affected already, but may also make a huge area of land uncultivable. Therefore the effectiveness of the present strategies will primarily depend on the intensity and extent of the change. One should also note that there are no permanent or fixed adaptation strategies, including the ones documented in this study. A resilient system or community is one which is flexible enough to change its strategies easily. For that to happen, governance will have to be changed or at least reformed.

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## Acronyms and abbreviations

AIR	All India Radio	PRA	participatory rural appraisal
BPL	below the poverty line	RA	research assistant
FGD	focus group discussion	SC	scheduled caste
GGD	general group discussion	ST	scheduled tribe
NGO	non-government organisation	SANDRP	South Asia Network on Dams, Rivers, and People
NREGS	National Rural Employment Guarantee Scheme	SHG	self-help group
NRM	Natural resource management	WCD	World Commission on Dams
PDS	Public Distribution System	WII	Winrock International India
PHC	Primary Health Centre		

## Local terms

aghani crops	Crops sown in June-July and harvested in October
bhadoi crops	Crops sown in May- June and harvested in June-July: 60-day crops
Brahmin	Caste group traditionally involved with teaching, learning, and as priests. In the Koshi basin they have also been landlords.
chamar	Caste group traditionally involved with leather work. They belong to the scheduled castes (SC)
chaur	Low-lying land
chullah	Local term for a cooking stove
diara	An island between two channels of a river which is affected by river floods annually
dooba zila	Submerged district
garma dhan	A species of paddy sown in February-March and harvested in May/June
ghat	Water front
hawala	Illegal route for transfer of money
kaccha house	A temporary structure made of bamboo and mud walls with a thatched roof
Kala azar	A disease caused by contaminated water
kharif crops	Crops sown in June and harvested in October
khesari	A kind of pulse commonly grown within the project area
kokcha, kaua, dhellai, aruari, belauni, seran and rewa	Varieties of fish (see text for scientific names)
machan	An elevated platform usually made of bamboo and commonly used in flood-affected communities
makhana	Fox nut – an aquatic cash crop with a high nutrition value cultivated in waterlogged areas
Mallah	Local fishing caste
managera	A crop cultivated in the waterlogged and flood-affected lands as it helps nitrogen fixation. It is also used as fuelwood, fodder, and for thatching.
masoor	A kind of pulse commonly grown within the project area.
moong	A kind of pulse commonly grown within the project area.
Mukhia	Traditional village head
Musahar	Local term for a person from a lower caste
pucca house	A house made of brick walls with a concrete roof
rabi crops	Crops sown in October -November and harvested in March- April
ramnas	Grasslands
Rs	The Indian rupee: the value used here is Rs 48 to the US dollar. This is the average of the fluctuating exchange rates that occurred over the period.
Sarpanch	Head of the panchayat (local self-government structure in India)
Sarva Shiksha Abhiyan	The Total Literacy Campaign funded by the central government
semi pucca house	A house made of brick walls with a thatched roof
tila	A highland within the village which is often used by local people as a safe place during floods
tolla	Local term for hamlets
Yadav	Caste group traditionally involved with animal husbandry. They belong to a previously underprivileged herder caste but many of them are quite well off today.
zamindar	A person who traditionally owned and was in control of substantial amounts of land. This class of people still retains large tracts of land despite the abolition of the zamindari system.



**Annex**

Annex: **Details of the study area**Table A1: **Details of the basic amenities available in the study area** (Source: Table prepared from the Census India 2001)

Details	Chandrain	Aina	Rohuamon	Tilanthi	Dhamara
Number of households	969	1056	452	435	506
Population (total persons)	4954	5202	2673	2188	2492
sex ratio	916	925	913	943	874
% of scheduled caste	13	30.30	4.3	7.4	48.2
% of scheduled tribe	0	0	0	0	0
<b>Educational Facility</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>
Primary school	3	1	1	1	3
Middle school	1	within 5 km	1	within 5 km	0 (within 5 km)
High school	0	0	0	0	0
College	>10 km away	>10 km away	between 5-10 kms	>10 km away	More than 10 km
Other	0	0	0	0	0
<b>Medical Facility</b>	<b>Not Available</b>	<b>Available</b>	<b>Available</b>	<b>Not Available</b>	<b>Not Available</b>
Allopathic hospital	>10 km away	> 10 km away	between 5-10 km	>10 km away	between 5-10 km
Primary health centre	> 10 km away	between 5-10 km	1	>10 km away	between 5-10 km
Maternity/child welfare centre	> 10 km away	between 5-10 km	between 5-10 km	>10 km away	between 5-10 km
Family welfare centre	0	0	0		0
Other	0	PHC(1)	0		0
<b>Drinking Water Facility</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>
Tap water	0	0	0	0	0
Tube well	0	0	1	0	0
Well water	1	0	0	1	Available
Hand pump	1	1	1	1	Available
Other sources	0	0	0	0	0
<b>Post and Telegraph Facility</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>	<b>Available</b>	<b>Not Available</b>
Post office	1	1	1	within 5 km	within 5 km
Telegraph office		0	0	0	0
Telephone connection	1	>10 km away	2	1	0
<b>Communication Facility</b>	<b>Not Available</b>	<b>Available</b>	<b>Not Available</b>	<b>Not Available</b>	<b>Available</b>
Approach road	available	Available	Not available	Not available	Not Available
Bus service	> 10 km away	between 5-10 km	between 5-10 km	>10 km away	Not Available
Rail service	> 10 km away	> 10 km away	between 5-10 km	>10 km away	Available
Other (distance)	waterway > 10 km	waterway	waterway (5-10 kms)	>10 kms away	Not Available
<b>Banking Facility</b>	<b>Available</b>	<b>Not Available</b>	<b>Not available</b>	<b>Not Available</b>	<b>Not Available</b>
Commercial banks	1	between 5-10 km	between 5-10 km	between 5-10 km	between 5-10 km
Cooperative banks	> 10 km away	> 10 km away	between 5-10 km	between 5-10 km	between 5-10 km
Agricultural credit societies	between 5-10 km	> 10 km away	between 5-10 km	> 10 km away	between 5-10 km
<b>Power Supply</b>	<b>Not available</b>	<b>Not Available</b>	<b>Not available</b>	<b>Not Available</b>	<b>Not Available</b>
Domestic/agric./other					
<b>Land Use (in hectares)</b>					
Village area	552	432	238	318	794
Irrigated area	44.98	60.94	168.8	20.67	281.20
Unirrigated	281	300.21	46.1	62.71	220.15
Cultivable waste (including 'gochar-grazing land')	135	17.81	12.98	24.69	0
Not available for agriculture	91	52.83	9.67	210.41	293.04

Annex, Table A2: Breakdown of the work force within the selected project area

Village	Total Workers		Main Workers		Marginalised Workers		Non-workers		Cultivators		Agricultural Labourers		Workers in Household Industries		Other Workers									
	T	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F							
Chandrain	2188	1278	910	1277	1051	226	911	227	684	2766	1308	1458	486	413	73	1420	681	739	83	41	42	199	143	56
Aina	2419	1384	1035	1537	1273	264	882	111	771	2783	1319	1464	456	289	167	1925	1057	868	5	5	0	33	33	0
Tilathi	906	551	355	365	344	21	541	207	334	1282	575	707	263	157	106	631	383	248	1	0	1	11	11	0
Rahuamani	734	653	81	663	622	41	71	31	40	1939	744	1195	228	220	8	390	318	72	14	14	0	102	101	1
Dhamara	919	641	278	668	584	84	251	57	194	1573	689	884	190	148	42	642	441	201	10	5	5	77	47	30

T – Total M – Male F - Female

Annex, Table A3: Proportion of workforce within the selected project area

Village	Work participation Rate		Proportion of main workers%		Proportion of marginalised workers%		Proportion of non-workers%		Proportion of cultivators to total workforce%		Proportion of agricultural labourers to total workforce%		Proportion of workers in household industries to total workforce%		Proportion of other workers to total workforce%									
	T	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F							
Chandrain	44.2	49.4	38.4	25.8	40.6	9.5	18.4	8.8	28.9	55.8	50.6	61.6	22.2	32.3	8	64.9	53.3	81.2	3.8	3.2	4.6	9.1	11.2	6.2
Aina	46.5	51.2	41.4	29.5	47.1	10.6	17.0	4.1	30.9	53.5	48.8	58.6	18.9	20.9	16.1	79.6	76.4	83.9	0.2	0.4	0.0	1.4	2.4	0.0
Tilathi	41.4	48.9	33.4	16.7	30.6	2.0	24.7	18.4	31.5	58.6	51.1	66.6	29.0	28.5	29.9	69.6	69.5	69.9	0.1	0.0	0.3	1.2	2.0	0.0
Rahuamani	27.5	46.8	6.3	24.8	44.5	3.2	2.7	2.2	3.1	72.5	53.3	93.7	31.1	33.7	9.9	53.1	48.7	88.9	1.9	2.1	0.0	13.9	15.5	1.2
Dhamara	37	48.2	20.9	26.8	43.9	7.2	10.1	4.3	16.7	63.1	51.8	76.1	20.7	23.1	15.1	69.9	68.8	72.3	1.1	0.8	1.8	8.4	7.3	10.8

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