Final Report

Program on Farmer-Managed Irrigation Systems and Support Services

Phase II

VOLUME 6

FARMER-MANAGED GROUNDWATER IRRIGATION WITHIN THE EASTERN GANDAK IRRIGATION SYSTEM IN BIHAR, INDIA

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Contents

FINAL REPORT

Program on Farmer-Managed Irrigation Systems and Support Services

PHASE II

Volume 1	Overview of the Program
Volume 2	Comparison of Support Services for Farmer-Managed Irrigation Systems in Sri Lanka and Nepal
Volume 3	Irrigation Resource Inventory: A Methodology and Decision Support Tool for Assisting Farmer-Managed Irrigation Systems
Volume 4	Farmer-Managed Irrigation Systems in Chitral, Pakistan: Technology, Management Performance and Needs for Support
Volume 5	Self-Assessment of Performance of Farmer-Managed Irrigation in Bicol, Philippines
Volume 6	Farmer-Managed Groundwater Irrigation within the Eastern Gandak Irrigation System in Bihar, India
Volume 7	Lift Irrigation in West Africa: Challenges for Sustainable Local Management

Figures

Tables

Abbreviations

BSD	Bishunpur Sub-Distributary of the Vaishali Branch Canal
CAPART	Council for Application of People's Action in Rural Technology
CCA	Culturable command area
cumecs	Cubic meters per second
cusecs	Cubic feet per second
GCADA	Gandak Command Area Development Authority
GCA	Gross command area
IIMI	International Irrigation Management Institute
O&M	Operation and maintenance
PADI	Peoples' Action for Development India
PVC	Polyvinyl chloride
RD	Reduced distance = 1,000 feet
Rs	Rupees
TMC	Tirhut Main Canal of the Eastern Gandak System
VASFA	Vaishali Area Small Farmers' Association
VBC	Vaishali Branch Canal of the Eastern Gandak System
WALMI	Water and Land Management Institute
WRD	Water Resources Department

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Foreword

THIS STUDY IS an outgrowth of collaboration between the International Irrigation Management Institute's global study on Farmer-Managed Irrigation Systems (FMIS) and the Bihar portion of the IIMI-India Collaborative Study carried out by the International Irrigation Management Institute (IIMI) together with the Water and Land Management Institute (WALMI) in Patna and with the Centre for Water Resource Studies at Patna University.

The IIMI-India Study in Bihar was concerned with a macro understanding of the problem of conjunctive water use management within the Eastern Gandak Command in North Bihar. That study touched only peripherally on questions of how farmers actually managed the multiple sources of irrigation water available to them. Yet those questions were critical to understanding what was happening.

Therefore, as Project Leader for the FMIS Study, I suggested that the FMIS would be interested in funding a study of farmer-management of irrigation sources, particularly of groundwater irrigation, within the area of the IIMI-India Study. Dr. R. Sakthivadivel, IIMI's Project Leader for the IIMI-India Study, and Dr. Jeffrey D. Brewer, as the IIMI person most directly concerned with Bihar in the IIMI-India Study, felt it was an excellent idea and got the agreement of Mr. A. K. Verma, IIMI-India Project Coordinator for WALMI. Dr. K.V. Raju was recruited to head the study in the field.

Initially under my direction and later under Dr. Brewer's, Dr. Raju spent from August 1992 through April 1993 collecting data in the field. During that period, he had the assistance of a locally recruited team consisting of Dr. B.N. Singh, Mr. Ram Kumar Sinha, and Mr. Rajeshwar Dayal. Specific help with evaluating the performance of tubewells was provided by a consultant, Dr. David Purkey. Considerable assistance was given by WALMI. They provided Dr. Raju with a place to live, provided his team with office and computer facilities and helped with field arrangements, including permissions, introductions, and transport arrangements.

Dr. Raju prepared a draft report while in the field. This was circulated among various government officers in April 1993. A workshop was held at WALMI in April to discuss the officers' reactions to the report. Dr. Raju came to IIMI in May 1993 to prepare a draft of this study. Because of deficiencies in the canal management section, we arranged for him to return to Bihar to collect additional information in November 1993 under the guidance of Dr. Sakthivadivel. Since then, Dr. Brewer and Dr. Sakthivadivel rewrote the draft report and put it in the present form.

Douglas L. Vermillion
International Irrigation Management Institute
October 1994

Farmer-Managed Groundwater Irrigation within the Eastern Gandak Irrigation System in Bihar, India

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CHAPTER 1

Groundwater Development in Canal Commands in Eastern India

1.1 GROUNDWATER DEVELOPMENT IN CANAL COMMANDS IN INDIA

MANY OBSERVERS HAVE noted the phenomenon of the large-scale installation of wells in the command areas of canal irrigation systems in India. Although there have been government attempts to restrict such wells, researchers have pointed out several reasons why this development is to be welcomed. These reasons include:

* Introduction of irrigation water from canals has, in many areas, led to major rises in water tables and to waterlogging (Planning Commission 1993:64-65). The use of groundwater for irrigation can lower or maintain water tables (Vohra 1985).

* Many canal systems, particularly the very large systems of Northern India, are river diversion systems without storage. Canal water supply is dependent upon the flow in the river which can vary greatly. Often the largest demand for irrigation water comes when rains have ceased and the river is at its lowest. Use of groundwater to supplement the surface water supplies allows farmers to overcome this problem (Prasad and Sharma 1991).

* Indian canal systems are generally designed for extensive irrigation; that is, they have been designed to spread water thinly over a large area. One result is that even when water is available at the source, system managers may not be able to supply adequate and timely water supplies to all farmers in the command. Having access to groundwater gives farmers precise control over water supply so that management problems with the system need not lower yields. Since a large part of the groundwater recharge is likely to originate from the surface system, wells serve to make the irrigation system more efficient in delivering water as needed by farmers (Svendsen 1991).

* Economic analysis shows that investments in wells located in surface systems often have better returns than other wells because seepage from the canals and fields stabilizes the water table (Dhawan and Satya Sai 1991).

These reasons explain quite well why groundwater development is to be expected in canal commands in India.

The great majority of wells are owned and managed by farmers themselves. The Planning Commission (1993:61) says that "groundwater development is under private sector to the extent of 90 percent." In canal commands this fraction may be higher because most state governments have prohibited the development of state tubewells within canal commands.

Certain problems with groundwater development in canal commands have been noted, including the following:

* It has been argued that to help the surface system most and to prevent problems with the water table, wells should be located near the head of the canal system. However, since surface water is generally cheaper to farmers, just the opposite frequencies are found (Shah 1991).

* It has been suggested that the presence of extensive groundwater development can weaken the farmer and other institutions designed to control the surface systems since it weakens individual interests in the surface systems (Reddy 1992; Vaidyanathan 1991).

* Overuse of groundwater is possible even in canal commands, particularly in drier areas.

* Groundwater development may favor the wealthier farmers because of the capital needs, thus increasing inequity (Vaidyanathan 1991).

Despite these problems, the rapid development of groundwater in India in canal commands, particularly by farmers themselves, suggests that the advantages well outweigh the disadvantages. In particular, the advantage of having the system under direct control by farmers is likely to be found to be of utmost importance.

1.2 GROUNDWATER DEVELOPMENT IN EASTERN INDIA

The Gangetic plains of Eastern India—including major portions of Eastern Uttar Pradesh, Bihar, and West Bengal—have a very large groundwater potential. The plains consist of alluvial soils and are traversed by very large rivers, including the Ganga and its tributaries, the Brahmaputra, and others. Together with annual rainfall ranging from 1,000 mm in the west to well over 3,000 mm in the east, there is a great deal of easily accessible groundwater in the area. Also, the agricultural potential of the region is very high since the region has deep and productive soils and a generally good climate.

Eastern India is the poorest region in India; Bihar has by far the lowest per capita income in India and both Uttar Pradesh and West Bengal have below average per capita incomes (Tata Services 1992:16). Also the area is highly dependent upon agriculture; Bihar has the highest percentage of agricultural workers in the country and Uttar Pradesh also has a very high percentage (Tata Services 1992:7).

Although the annual rainfall is adequate, it is both highly seasonal—well over half falls during the months of June to September—and highly variable. Development of irrigation to stabilize water availability to allow use of modern agricultural technologies, including high-yield varieties, and to provide water for crops outside the rainy season and thus raise cropping intensities is a necessity for development in the area.

Because of the alluvial soils and abundant groundwater in the region, development of groundwater for irrigation is both cheaper and far faster than development of canal systems. There is ample reason for government and other support for the development of groundwater for irrigation in the area. Indeed, some have argued that the basic irrigation development strategy in the region should have focussed solely on groundwater development (Chaturvedi 1988; cf Kolavalli et al. nd:2).

It is not surprising therefore that virtually all irrigation in Bangladesh—at the extreme eastern end of the region—is from groundwater. There has also been important developments of groundwater resources for irrigation in Uttar Pradesh, Bihar, and West Bengal as well. Groundwater irrigation has been encouraged by the government through many programs, including the installation of state tubewells, and subsidy programs for privately owned or cooperative tubewells. In Bihar, for example, the area irrigated by tubewells has risen from under 100,000 hectares in 1950/51 to almost 1,300,000 hectares in 1984/85. Over the same period, the area under canal irrigation has doubled from 662,000 hectares to 1,370,000 hectares and the area under other sources, including tanks and dugwells, has significantly decreased (Prasad and Sharma 1991).

However, despite the high potential and government support, groundwater development in Eastern India is much less than expected. Only 31 percent of the groundwater potential in the Ganga Basin has been developed; less than 24 percent has been developed in Bihar; in contrast, 79 percent of the groundwater potential of the Indus Basin has been developed (CGWB 1991). Another source (World Bank 1991, Annex 2:10) gives the groundwater potential utilized in 1985 as only 26 percent as contrasted with 79 percent in the Indus Basin. Pant (1991) claims that "low use of available groundwater is the main cause of the eastern region's agricultural backwardness." Others (e.g., Kahnert and Levine 1993) have also recommended focussing on groundwater development to alleviate poverty in the region.

Why, when the benefits appear to be so obvious, has groundwater development lagged in Eastern India? One study (Kolavalli et al. 1989) suggests the following reasons:

* Lack of demand—farmers prefer to use cost-free rain and Eastern India has higher rainfall than much of the rest of the country.

* Lack of high-yield varieties—other varieties do not require well controlled irrigation.

* Easy availability of canal water.

* Low returns to irrigation.

* Adverse ecological effects.

* Limited electrical power—since electricity for agricultural uses is highly subsidized it is the preferred power source for pumps.

* Small landholdings—a farmer with very little land may not be able to justify the capital investment for a well and pumpset.

* Lack of credit to purchase wells and pumps.

A detailed study of groundwater irrigation in Eastern Uttar Pradesh (Kolavalli et al. nd) identified low returns to investment in wells on small holdings (1 hectare or less) as the major reason for the slow rate of groundwater development there. Most farmers have small holdings; the study sample showed that 75 percent had less than 0.5 hectare. Returns were low not only because of the size of the investment relative to the availability of land, but also because the small farms are often the most affected by waterlogging, soil salinity, and other adverse ecological problems thus lowering their value. Moreover, because of the relatively high rainfall, farmers can produce crops without irrigation, thus giving the small farmers an alternative. The study found, however, that access to markets that gave opportunities to produce high-value crops increased the relative value of investments in wells even for small farmers.

1.3 GROUNDWATER DEVELOPMENT IN CANAL COMMANDS IN EASTERN INDIA

As with groundwater development in general, development of groundwater in canal commands in the region has also lagged. There are very good reasons to develop the groundwater potential within canal commands in the Gangetic plains of Eastern India, including:

* Rainfall is relatively high, natural water tables can be high, and waterlogging in canal commands is a problem. The presence of tubewells can help.

* All of the surface systems are run-of-the-river systems subject to variation in canal supplies. Having tubewells can help compensate for the variations.

* All of the surface systems are large and are subject to major management problems making canal deliveries unsure. Having tubewells can help compensate for delivery problems.

From Das Gupta et al. (1979) through CWRS (1993), groundwater development in the canal commands in the region has been recommended to help solve these problems. Yet there appears to be relatively little development in some canal commands, even in the tails of the commands.

Unfortunately, there is a significant problem in actually estimating the areas irrigated by groundwater in canal commands. Since data on areas irrigated by groundwater and by canals is collected or estimated by different departments, there may well be significant overcounting of both areas wherever the land is irrigated from both sources (cf Vaidyanathan 1991).

Depending from the starting point, the questions that can be asked about groundwater development in canal commands differ. Someone interested in the canal system usually wants to know how to make the canal system work well so that groundwater use is unnecessary. Someone interested in groundwater is interested in knowing why there has been relatively little development of groundwater in canal commands in Eastern India. Those interested in conjunctive management of surface and groundwater want to know to what extent it is occurring and how to manage the two sources as a single resource.

These questions can only be answered by investigating the use and management of all water resources by the farmers and government agencies involved. The key nexus are the farmers. They are the persons who actually use the water provided by canals and tubewells. However, there have been few studies focussing specifically on farmer interests and farmer institutions for management of multiple sources of irrigation water in canal commands. Of course, farmer actions will be based on how they understand and perceive their environment. With regard to irrigation, the environment is created, in part, by the agencies responsible for the sustainable development and management of water resources.

The key issues are:

* What are the different sources of irrigation water and the extent of their use within a canal command area?

* In a canal command area laced with rich groundwater resources, how do farmers evaluate and manage multiple sources of irrigation water?

* What are the institutions developed by farmers to manage groundwater resources and under what circumstances are the different institutions most advantageous?

* What features of the canal management systems determine its performance relative to groundwater extraction?

* What features of the government programs determine farmers' attitudes toward use of canal water and groundwater development?

The present study is aimed at answering these questions in order to throw more light on the overall problem of underdevelopment of irrigation resources, especially groundwater resources, in Eastern India.

1.4 THE PRESENT STUDY

As part of the IIMI-India Collaborative Research Project, a study of conjunctive management of surface water and groundwater resources was undertaken in the Eastern Gandak Command in Bihar by the Centre for Water Resources at Patna University, the Bihar Water and Land Management Institute, and the International Irrigation Management Institute (IIMI). The project was funded by the Ford Foundation and by the United States Agency for International Development through the Water Resources Management and Training Project. The study (CWRS 1993) focussed primarily on macro level management of the surface and ground water within the tail area of the Gandak Command. One finding was the relative lack of groundwater development in the Gandak Command.

The present study was developed to supplement the larger study described above by focussing specifically on micro level (farmer) management of multiple sources of irrigation water within the tail of the Gandak command in order to understand why farmers have not made more use of groundwater. The present study was funded by the German Government through the Farmer-Managed Irrigation Systems Project at IIMI. Fieldwork was carried out by IIMI personnel with the collaboration of the Water and Land Management Institute (WALMI), Patna.

The basic approach was to study (a) the development and management of tubewells and river lift pumps in detail within specific sub-areas of the Gandak Command, and (b) the key aspects of the management of the canal system and on the management of irrigation as a whole in the area.

1.5 METHODOLOGY

The area selected for study is the same as that selected for the IIMI-India Collaborative Research Project—the command of the Vaishali Branch Canal (VBC) in the Eastern Gandak Command Area in North Bihar.

The following steps were taken:

1. A map of the command area of the VBC was obtained from the Executive Engineer's Office, Gandak Project, of the Water Resources Department. Based on this map, official data was collected both for hydrologic areas and for villages which are partly or fully irrigated by the VBC.

   * The VBC has 32 hydrologic sub-areas, including minor canal commands, and 208 villages supposedly, partly or fully irrigated from the VBC. For each village, the area irrigated was listed by source, based on the 1981 demographic census and the 1986-87 groundwater census.

   * Based on the area irrigated in kharif 1992 as reported and verified in the field, three minor canals—Chakwa Minor in head area, Madan Chapra Minor in the middle area, and Shampur Minor in the tail end of VBC—were selected for detailed study. For each minor, the actual command area (much smaller than the designed command area) was defined and used as the study area.

2. Initially, key informants were selected from each village. These were persons who had knowledge of the whereabouts of all or most irrigated village plots, who knew the crops and irrigation sources (by current and previous seasons) for different plots, who could make village-level maps, and who could move easily with all categories of farmers of the village. Later, more direct contacts with the farmers became more important.

3. Study team members walked through the sample minor commands with village-level maps and informants and located each tubewell and identified its location on the map.

4. A systematic survey of farmers in the study area was carried out. The survey covered the last four crop seasons: kharif 1991, rabi 1991-92, hot weather 1992, and kharif 1992. The data collected from each farmer included owner's name, crop grown, and source of irrigation for each irrigation.

5. A systematic survey of well owners and operators in the study area was also carried out. The survey covered the location of each tubewell, status (functioning or not) of the tubewell, fields irrigated from each tubewell, and specifics on diesel pumpsets installed.

6. A detailed study of a sample of tubewell was carried out.

   * The water table at the well location spot was measured by allowing an ordinary thread with a small stone tied at one end to drop slowly in the tubewell till it reached water. After removal, the string was measured with tape. For cross checking, the water table was also measured in nearby open wells.

* The owner was requested to operate the tubewell. While operating the following measurements were taken: diesel consumption, water discharge, and position of engine. Discharge measurements were made by measuring the time taken to fill a 165 liter drum.

* The owner was also questioned about repairs, spare parts replacement and availability in local markets, previous and present diesel and oil prices, water selling rates and the justifications for the present water selling rate, fields irrigated by the tubewell, the buyers of water and their field locations.

* The field channels used for conveyance of tubewell water were mapped by walking them with the well owner or water buyer.

7. The surveys were supplemented by participant observation and informal interviews with selected informants on issues dealing with the role of agencies, technical details of groundwater extraction mechanisms, spatial pattern of tubewell location, number of plots and area irrigated across the irrigations within a season and across the seasons.

8. The results were written up into a single report. This report was then discussed with officers from various irrigation agencies in a workshop. Modifications were introduced in response to comments at the workshop and to some written reactions. In addition, various portions of the report were discussed with farmers in the field to check the accuracy of the facts and conclusions. The present report is an extensively modified version of the draft report discussed with officers and farmers.

1.6 ORGANIZATION OF THE STUDY

The objectives of this report are:

* To describe how farmers evaluate and use different sources of irrigation water in the tail of the Gandak Canal Command Area, including describing the farmers' institutional arrangements for management of irrigation water.

* To describe the various features of canal management and other governmental actions that help define the environment that farmers respond to when evaluating and managing irrigation water.

* To identify the implications of these micro-level findings for the major questions about groundwater usage identified earlier.

* To identify actions that can be taken to improve the existing situation.

The report is organized as follows:

* Chapter 2 provides a general description of the study area.

* Chapter 3 describes the management of the Eastern Gandak Canal System to show just what the problems and limitations of canal water delivery are.

* Chapter 4 describes tubewell installation and management by farmers in detail.

* Chapter 5 describes the use of farmer-owned river lift pumps.

* Chapter 6 describes the groundwater market in the study area.

* Chapter 7 discusses how farmers actually choose among the multiple sources of water available to them.

* Chapter 8 summarizes the findings and considers their implications for irrigation development in the area.

CHAPTER 2

Description of the Study Area

2.1 THE STUDY AREA

THE STUDY AREA consists of areas commanded by three minor canals of the Vaishali Branch Canal (VBC) in the Eastern Gandak Canal System in North Bihar. The VBC is a direct offtake from the Tirhut Main Canal—the main canal of the Eastern Gandak System—and is located in the tail reach of the system.

The three sample minor canals are:

* Chakwa Minor in the head reach of the VBC.
* Madan Chapra Minor in middle reach of the VBC.
* Shampur Minor in the tail reach.

Chakwa Minor is located in Sahebganj Block of Muzaffarpur District; Madan Chapra Minor is located in Paroo Block of Muzaffarpur District; Shampur Minor is located in Vaishali Block of Vaishali District.

As used in this study, the term "designed area" refers to the area planned for irrigation from the canal system. This is the area defined in all official documents and field office records of the Gandak Project. The designed area was the basis on which the original expenditure plans were drawn. In addition, irrigation staff have been assigned to field offices and fund allocations are made on the basis of the designed area. The VBC has a designed area of 64,289 hectares. However, because construction has not been completed, the potential so far created is only 17,250 hectares.

However, after walking the command areas of the selected minor channels with the relevant *Amins* (officials responsible for assessing irrigated areas for revenue purposes), we found a significant difference between the designed area and the area supposedly irrigated by canal water. To help us, the Amins demarcated the area getting canal water on the village maps. The demarcated area is substantially less than the designed area for these minor channels. The area demarcated by the Amins is called the "Study Area." Our surveys were conducted within the "Study Area."

Further, we found that within the Study Area not all fields are irrigated with canal water. The area where fields actually get canal water is called the "actual irrigated area."

This chapter provides background data on the area and its population. Details of the irrigation in the Study Area are given in the following chapters.

2.2 PHYSIOGRAPHY, AND CLIMATE OF THE GANDAK COMMAND

The Eastern Gandak Command (see Figure 3.1, page 16) is located in the Gangetic plains of North Bihar. The Gandak Command lies between longitudes 83°15' and 85°15' east and between latitudes

Table 2.1. Rainfall in the study area (mm).

Month	Sahebganj Block (Muz. Dist.)		Paroo Block (Muz. Dist.)		Vaishali Block (Vaishali Dist.)		Muzaffarpur District	Vaishali District
	1991	1992	1991	1992	1991	1992	(average)	(average)
January	11.8	-	29.8	6.8			13.8	12.2
February	-	-	2.0	-			19.7	18.3
March	1.4	-	10.4	-			7.0	9.5
April	-	-	-	-			15.8	7.7
May	44.6	49.9	16.4	33.2	32.6		47.8	28.4
June	119.2	49.2	105.4	107.0	69.2	38.0	172.7	152.1
July	65.0	287.9	306.2	228.2	162.4	263.2	301.1	256.5
August	355.6	224.6	637.0	323.2	436.8	169.2	297.0	294.5
September	165.7	91.5	325.8	58.0	92.5	117.2	241.2	294.0
October	-	88.8	-	38.0	-	17.0	57.5	47.7
November	-	-	-	-			5.1	7.8
December	0.6	-	16.4	-			2.6	3.6
Total rainfall from June-Sept	705.5	653.2	1,374.4	716.4	760.9	587.6	1,074.6	1,052.6

Sources: The figures for the blocks come from the respective block offices. The district figures are from CWRS (1993:42).

25°40' and 27°25' north. In the north, the Gandak Command is bounded by Nepal, in the west by Uttar Pradesh, in the south by the river Ganga, and by the districts of Sitamarhi, Darbhanga and Begusarai in the east.

The Gandak Command area is flat except for the hilly tracts of West Champaran District. The slope of the command in West Champaran is about 1 in 1,500 which flattens to 1 to 3,500 in East Champaran. Further, east in the districts of Muzaffarpur, Vaishali, and Samastipur the slope further flattens from 1 in 5,000 to 1 in 20,000.

North Bihar as a whole may be treated as a vast inland delta; all the principal rivers emerging from the Himalayas enter the plains of North Bihar and ultimately flow to the Ganga. The process of delta formation has been in progress from thousands of years by the heavy silt and detritus load brought by the rivers from the Himalayas. The principal rivers that pass through Bihar are the Gogra, the Gandak, the Bagamati, the Kamala and the Kosi. In the process of land building the rivers shift channels. It is likely that the Burhi Gandak River was once the bed of the Gandak but the latter moved westwards. This movement of rivers leaves depressed areas, now known locally as *mauns* or *chaurs*. These areas are generally flooded seasonally by the rains.

The Gandak Command Area lies in the monsoon subtropical zone. It is characterized by a wet monsoon season from June through September, followed by cooler and drier weather from October through February, and then followed by a hot summer season with occasional thundershowers and dust storms from March to the middle of June.

Temperatures vary from highs of 41° C in May or early June to lows of around freezing in January. The Gandak Command area is one of the humid areas of the state. Humidity is lowest (52%) in the months of March and April and highest (83%) during the rainy months of July and September.

As shown in Table 2.1, rainfall in the area shows a markedly skewed seasonal pattern. As shown by the district averages, over 80 percent of the rainfall falls from June through September. However, as shown by the values for 1991 and 1992 in the respective blocks, rainfall can vary markedly from year to year and from location to location.

During the 1992 rainy season, the Government of Bihar declared drought in most districts, including all three of the blocks listed in Table 2.1. However, as shown in the table, both Paroo and Vaishali blocks suffered a severe drop in rainfall but the drop for Sahebganj Block was rather small.

2.3 DEMOGRAPHIC CHARACTERISTICS OF THE SAMPLE AREA

Table 2.2 shows some selected demographic features of the state of Bihar and of the Muzaffarpur and Vaishali districts taken from the 1991 Census. Table 2.3 shows changes in selected demographic indices over time for the three sample minors. These figures give some idea of the problems faced by the people in Bihar and in the study area.

First, the population density in the study area is very high and is almost double the statewide population density. This is a general characteristic of North Bihar.

Agriculture is the main occupation in the area. In Bihar as a whole, about 80 percent of the working population is involved in agriculture (Tata Services 1993:7). Table 2.2 shows that, as in the rest of Bihar, more than a third of the men working in agriculture do not work their own farms.

The sex ratio (the number of males per one thousand females) in the study districts is similar to that for the whole state. However, in the area of selected minors, the sex ratio was very high during 1961 and has gradually dropped over the years. Given the preference for male children, this change seems to reflect increasing seasonal or permanent outmigration from the area. During the study, we found that seasonal migration in search of employment, mainly to Punjab, Assam and metropolitan cities like Delhi and Calcutta, is common.

The literacy rate is low in the area. For the three minors, the literacy rate in 1991 varied from 21.38 percent to 29.64 percent while the literacy rate for Bihar as a whole is 52.63 percent (Tata Services 1993:7). Overall, these figures indicate low levels of social services and social development in the area.

The population in the area is overwhelmingly Hindu and consists of a variety of castes, including Harijans. Multiple castes are found in all villages in the area. Caste membership remains very important for social relations in the area.

Table 2.2. Selected demographic features of the study districts, 1991.

		Muzaffarpur district	Vaishali district	Bihar
Total population		2,946,000 persons	2,144,000 persons	86,338,000 persons
Population density		928 persons/sq km	1,053 persons/sq km	497 persons/sq km
Literacy rate				38.5 %
Population working in agriculture:	Male Female	39.63 % 65.87 %	33.97 % 66.90 %	33.02 % 57.92 %
Revenue villages		1,813	1,569	

Sources: District Census Handbook 1991, Muzaffarpur District; District Census Handbook 1991, Vaishali District.

2.4 AGRICULTURE IN THE GANDAK COMMAND

Three agricultural seasons are recognized. The agricultural year begins with the *kharif* (rainy) season from mid-June through mid-November, followed by the *rabi* (cool) season from mid-November through the end of February or mid-March, and then followed by the summer, also called the hot season, from mid-March until the monsoon rains come in mid-June.

Table 2.3. Selected demographic features of the sample minors.

Year	Total population			Sex ratio			Literacy rate		
	Chawa	Madan Chapra	Shampur	Chakwa	Madan Chapra	Shampur	Chakwa	Madan Chapra	Shampur
1961	4,363	1,938	2,281	1,190	1,108	1,088	15.15%	13.05%	12.89%
1971	5,622	2,210	3,615	1,000	997	1,077	15.67%	16.33%	18.06%
1981	6,479	2,627	4,127	na	na	na	na	na	na
1991	8,852	3,417	5,163	928	920	998	23.17%	29.64%	21.38%

Notes: Data for each minor is derived from all the villages partly or fully irrigated by the concerned minor. In Shampur Minor, literacy percentages are from 2 villages in 1961, 4 villages in 1971 and 3 villages in 1991.
Sex ratio = The number of males per one thousand families.
na = Not available.

Sources: District Census Handbook 1961, Muzaffarpur District; District Census Handbook Part X 'A and B', Muzaffarpur District.

The Gandak Command is primarily a kharif rice growing area. Wheat, maize and barley are the principal rabi crops. Mustard is the major oilseed crop and sugarcane, jute, mesta and tobacco are the most important cash crops. A wide variety of other crops are also grown, including some perennial crops.

Canal irrigation has not brought major changes to the area. As shown in Table 2.4, the cropping intensity in the tail reach of the Gandak Command was 155 percent during 1984-85, only 5 percent more than the cropping intensity in 1966-67 before canal irrigation began and only a little more than the cropping intensity outside the command. Gandak Project planners, however, had projected a cropping intensity of 180 percent within the command after completion of the irrigation project.

Table 2.4. Change in cropping intensities in Gandak Command.

Location on the Tirhut Main Canal	Cropping intensity in command area		Cropping intensity outside command area
	1966-67	1984-85	
Head reach	161 %	163 %	149 %
Middle reach	160 %	172 %	153 %
Tail reach	150 %	155 %	149 %

Source: AFC (1986).

Table 2.5 shows the change in crops over the same period for the whole Gandak Command. Over the period, the total annual cropped area increased about 6 percent. There were significant changes only in a few crops. One major change was a doubling of the area under wheat (during rabi) largely replacing coarse grains. The areas under tobacco and vegetables, although only small portions of the total, also went up a great deal. However, our surveys in the study area indicate that trends may have changed since 1985; and the areas under oilseeds and fruit and other trees have been increasing.

Table 2.5. Cropping patterns and canal irrigation in Gandak Command.

Crop	1966-67		1984-85	
	Area ('000 ha)	Percentage of GCA	Area ('000 ha)	Percentage of GCA
Rice	871.42	40.57	955.81	41.71
Maize	228.85	10.66	252.83	11.03
Wheat	231.13	10.76	529.60	23.11
Other cereals	245.14	11.41	68.44	2.99
Total, cereals	1,576.54	73.40	1,806.68	78.84
Arhar	55.30	2.57	28.10	1.23
Gram	40.69	1.89	10.85	0.47
Other pulses	161.23	7.51	129.00	5.63
Total, pulses	257.22	11.97	167.95	7.33
Rape/mustard	17.00	0.79	18.83	0.82
Other oilseeds	25.29	1.18	15.19	0.66
Total, oilseeds	42.29	1.97	34.02	1.48
Potatoes	23.36	1.09	40.17	1.75
Other vegetables	19.97	0.70	33.46	1.46
Total, vegetables	38.33	1.79	73.63	3.21
Fruits	58.85	2.74	60.09	2.62
Other foods/spices	59.27	2.76	34.51	1.51
Total, other food crops	118.12	5.50	94.60	4.13
Total, food crops	2,032.40	94.63	2,176.92	95.99
Sugarcane	89.33	4.16	87.41	3.81
Jute/mesta	17.29	0.81	7.04	0.32
Tobacco	8.57	0.40	20.07	0.88
Total, industrial crops	115.19	5.37	114.52	5.01
Grand total	2,147.69	100.00	2,291.44	100.00

Source: AFC (1986).
Note: GCA = Gross Command Area.

CHAPTER 3

Sources of Irrigation Water: The Gandak Canal System

3.1 THE EASTERN GANDAK CANAL SYSTEM

THE GANDAK RIVER flows from the Himalayas in Nepal into the western side of Bihar, then flows southeastward through North Bihar until it joins the Ganga near Patna. Diversion of the Gandak River for irrigation in Bihar was first considered in the 1870s. Two diversion systems were constructed before although planning had begun much earlier.

After independence, a large project to use the waters of the Gandak, incorporating most of the two existing systems, was developed and taken up as a joint project among Bihar, Uttar Pradesh, and Nepal. Initial planning was completed in 1959 and work began in 1961. The project included construction of a new barrage on the Gandak at Valmikinagar, right on the international border. A 200 kilometer right bank canal running through Nepal and Uttar Pradesh before reentering Bihar was constructed and came to be known as the Western Gandak Canal System. The portion of the Main Western Canal in Bihar—the lower portion of the canal—is called the Saran Main Canal. The Western Gandak System was designed to irrigate a gross command area (GCA) of 563,000 hectares in Bihar and 533,000 hectares in Uttar Pradesh. Also a 34 kilometer canal from the Gandak's right bank known as the Nepal Western Canal was constructed to irrigate an area of 16,200 hectares in Nepal. These two systems have been completed.

Construction also began in 1961 on the left bank canal system serving North Bihar. This system came to be known as the Eastern Gandak Canal System shown in Figure 3.1. Work on the Eastern Gandak System continued through 1985 when Phase I was declared finished although the system was not complete.

The Main Eastern Canal takes off from the left bank of the river. The Don Branch Canal takes off from the Main Eastern Canal at about 3 kilometers and runs about 99 kilometers before entering Nepal where it is known as the Nepal Eastern Canal. The Nepal Eastern Canal runs for a further 85 kilometers. The Don and Nepal Eastern Canals irrigate some 23,600 hectares in Bihar and 46,000 hectares in Nepal. At RD 9.05, the Tribeni Branch Canal takes off from the Eastern Main Canal, runs for about 150 kilometers, and irrigates a GCA of 215,000 hectares. Beyond the Tribeni Canal Offtake, the main canal is called the Tirhut Main Canal (TMC). The Don and Tribeni Canals and their distribution systems had been completed by 1985.

In Bihar, canal lengths are generally measured in Reduced Distance (RD): 1 RD equals 1,000 feet. The Tirhut Main Canal was designed to extend to 909 RD (about 226 kilometers). A schematic diagram of the Tirhut Main Canal as planned is given in Figure 3.2.

When work stopped in 1985, the main canal had been completed to RD 790. The distribution system had been completed only to the offtake for the Vaishali Branch Canal (VBC) at RD 554, but some parts of the distribution system had been developed from RD 554 to RD 704. Overall, about 70 percent of the planned Eastern Gandak System has been completed. The total planned command area for the Tirhut Main Canal is over 600,000 hectares in eight districts comprising West Champaran, East Champaran, Muzaffarpur, Vaishali, Samastipur, Gopalganj, Siwan and Saran.

Figure 3.1. The Eastern Gandak Irrigation System.

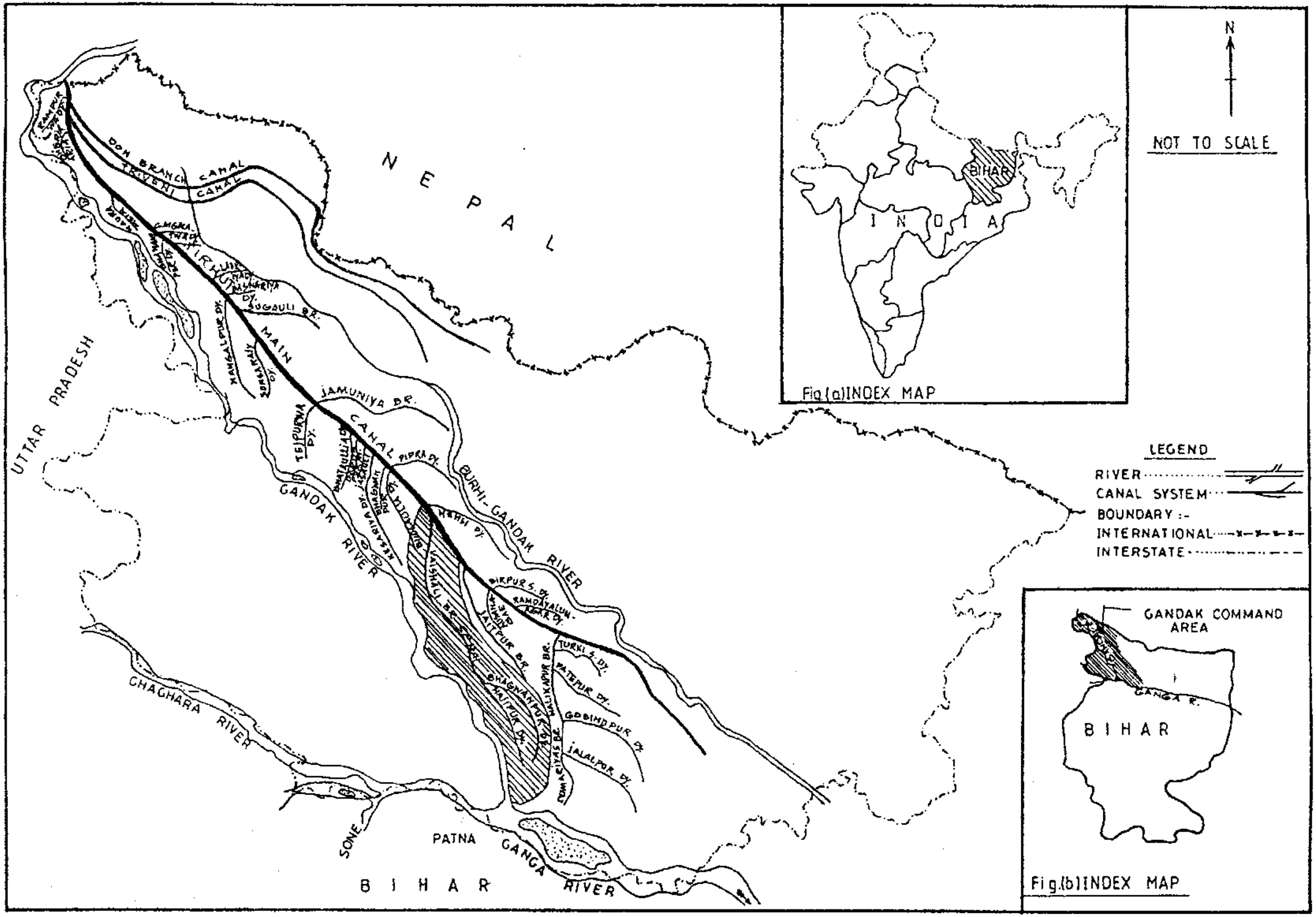
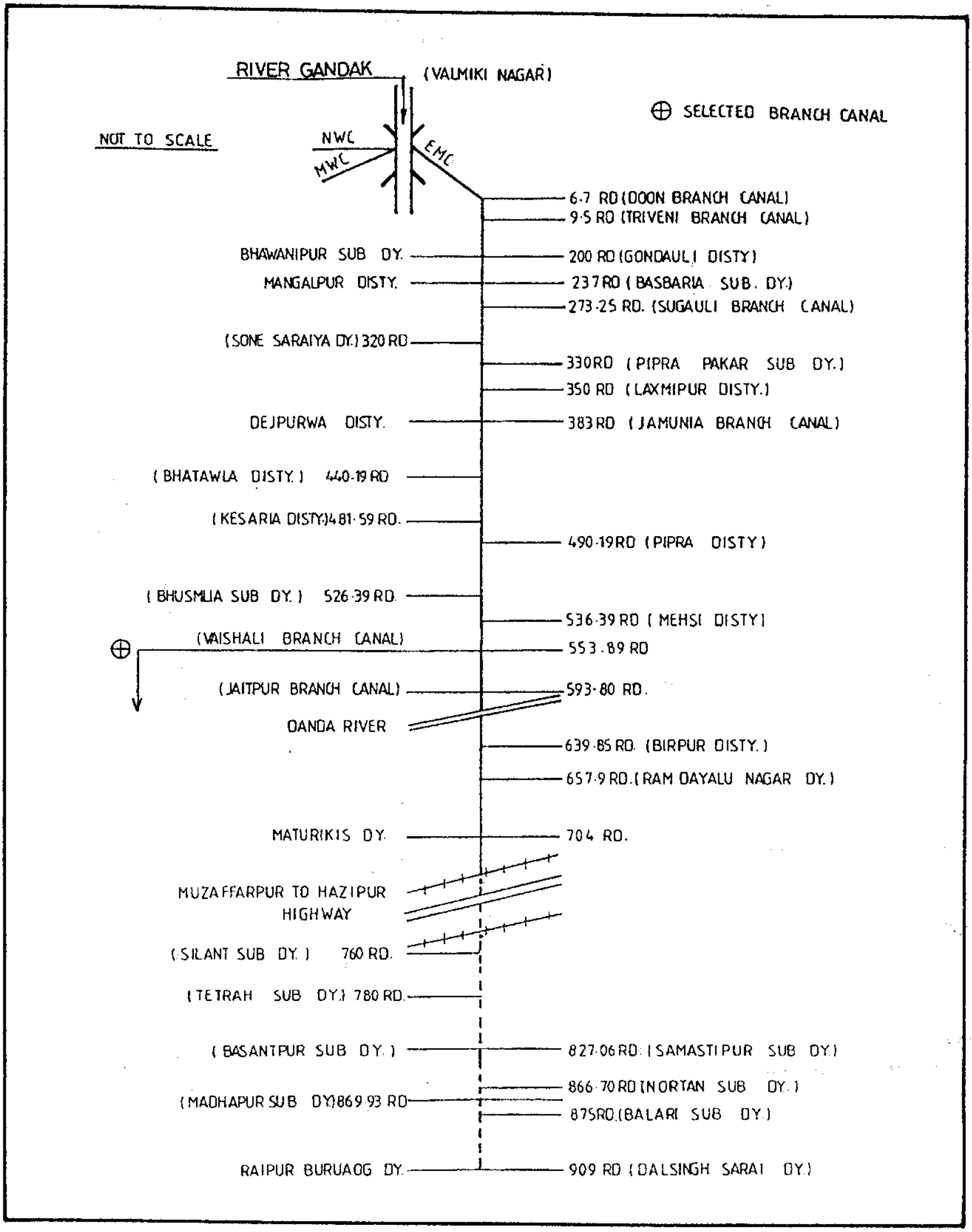


Figure 3.2. Schematic diagram of the Tirhut Main Canal.



Consideration has been given to completing the development of the Tirhut Main Canal Command beyond RD 704. A committee constituted by the Government of Bihar—generally called the Ghosh Committee after its chairman—looked into the matter. Their report (WRD 1985) pointed out some problems created by the canals and recommended that drainage problems be solved first. The Government of Bihar, however, has submitted a proposal to the Government of India to fund Gandak Project Phase II to complete the system. This proposal has not been funded.

3.2 IRRIGATION MANAGEMENT POLICIES AND AGENCIES

3.2.1 Changes in Policy

The British colonial authorities constructed irrigation projects on a commercial basis. To make these projects economically and financially viable, they not only framed appropriate rules and regulations but also empowered officers to manage the systems efficiently. Prior to 1974, the Eastern Gandak Canal System was managed under the Bengal Irrigation Act of 1876 through a system popularly known as the "satta system."

Under the satta system, canal officers issued permits to take water, called *satta*, on farmers' written requests. Double water rates were charged for unauthorized irrigation. One farmer per outlet was appointed as *sattadar* to oversee water distribution. He was paid 2 percent of the canal revenue collected in his area. The canal authorities were responsible for getting the water to the outlet and the sattadar managed distribution below the outlet. Village channels were constructed and maintained by villagers. Informants claim that water would be denied to a village if the village channels were not maintained properly. Alternatively, the canal authorities might carry out necessary repairs and charge the costs to the villagers. Assessment and collection of water rates was done by the revenue wing of the Irrigation Department with help from the sattadar.

After India's independence in 1947, water came to be regarded as common property which every individual had a natural right to use (MOWR 1987). The independent government came to view irrigation not as a commercial venture but as a form of welfare. This had three consequences:

* The government made an effort to spread irrigation to as many farmers as possible leading to heavy demands on the systems.

* Water rates were kept low, leading to inadequate revenues for operation and maintenance.

* Power to manage irrigation became more centralized in the state-level bureaucracies and political entities. The powers of the field level officers were gradually reduced making it more difficult for the officers to control the system well and to punish farmers who abused the system.

Consequently, farmers began paying less attention to filing the applications for water knowing that if the monsoon failed they could always pressure the government to supply water. To do their jobs without appropriate powers, field staff, including the sattadars, started harassing farmers. The situation eventually became unmanageable and the government abolished the satta system in 1974.

Next >>