Relative Stresses on Community Managed Irrigation Resources of Chitwan Valley, Nepal

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Irrigation Management Systems Study Group (IMSSG) is a professional group of faculties at the Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, Nepal, involved in the study of issues related to irrigation development and management

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Background

Farmer managed irrigation systems (FMIS) in Nepal constitute important resource base for predominantly agrarian economy of the country, supporting irrigation needs of over 21 percent of cultivated land and producing approximately 40 percent of national cereal crop requirement (WECS, 1981; Shrestha, 1990). A recent estimate indicates the irrigated area under FMIS to be 675,000 ha as against 275,000 ha under public sector irrigation development, accounting for over 70 percent of irrigation development under FMIS (Ansari and Pradhan, 1991). Existence of more than 17,000 FMIS has been reported from different parts of the country (Yoder and Upadhayay, 1987). On the other hand, despite high priority and enormous investment in public sector irrigation development, the public sector irrigation performance has remained largely unsatisfactory. In most cases only marginal improvements have been reported in the agricultural production of irrigated areas under government run irrigation schemes when compared to neighboring rainfed areas (WECS, 1981). The effective irrigated area of many of the government run irrigation schemes have been found far short of projected area. The reasons for such state, among others, have been identified to be: ill conceived planning, unrealistic design, unsound construction, deficient operation and untimely maintenance (WECS, 1981; APROSC, 1982; Pradhan, 1989).

Some of the important strength of FMIS in Nepal are the sense of community ownership of the system, low initial cost, use of locally available resources, ability to respond quickly to the maintenance needs, strong operation and management rules and capability to mobilize resources for construction and maintenance. The major weaknesses of FMIS in the country are unreliability of physical structures mainly due to instability of environment caused due to floods, landslides and soil erosion. Lack of capital investment has been observed to be the major constraints. In most of the FMIS, a strong organization is usually found for operating and managing the system. These organizations have evolved through initiatives, trust and efforts of local community. The strong traditions of the community, operation and management rules, organizational capabilities and ownership feelings have permitted the FMIS to exist for generations (Ostrom, 1992).

Considering the role of FMIS to meet the basic needs of farming community in Nepal, sustaining the peasant economy and their impact on national economy, the FMIS have been

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recognized as potential and cost effective alternative to expand and intensify the irrigation development in the country and to increase the output from irrigated agriculture. Several intervention programs have been started with the objective to improve the performance of FMIS.

The study reported in this paper documents the characteristics and performance of a total of 88 FMIS in Chitwan Valley where a government backed intervention program, through East Rapti Irrigation Project (ERIP), is underway with credit assistance from Asian Development Bank (ADB). The original project (started in 1987) included development of irrigation facility in 9,500 ha of land by construction of diversion weir across Rapti river, which is the major water resource of the East Chitwan. The project was criticized due to it's unrealistic benefit streams and negative environmental impacts on Royal Chitwan National Park, a wildlife santuary located in the area (Khatri-Chhetri et. al., 1987; IUCN, 1990; Parajuli, 1993). The project was reformulated in 1991. The major components of the reformulated project include: i) rehabilitation of existing FMIS in the area in about 5,200 ha of land, ii) construction of River training works in Rapti river, iii) construction of approx. 60 km of farm and link roads to improve transportation and communication in the project area, and iv) construction of shallow tubewells in the areas where surface irrigation is presently unavailable or available irrigation is not adequate.

The study was carried out by a multidisciplinary research team of Irrigation Management Systems Study Group (IMSSG) at the Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal. The study focused on several key questions: how are the irrigation systems in the study area operating ? how effective are they in utilizing the local resources ? how have the users developed irrigation organization and what factors determine the operational rules and management practices ? and what are the major stresses on each system and their stress coping mechanism ? The output of the study was systematic documentation of irrigation resources of 88 mutually exclusive community managed irrigation systems located in East Chitwan, constructed at different times, different in physical and socio-institutional characteristics and operated and managed by different mixes of community.

The Study Area

The study area is located in Chitwan district, at the South-Western corner of the country, between longitudes 83°35' to 85°55' East and latitudes 27°21' to 27°45' North (Fig. 1). About three- fourths of the area of the Chitwan district is the valley where lands have high agricultural potentials and are relatively flat to almost completely flat. The valley plains are located between Mahabharat range of hills in the North and Churia hills in the South. The climate of the valley is subtropical monsoon type with hot and humid summer and cool winter. The months from June to September are hot and humid with average maximum temperature as high as 35°C. November through February are the winter months and the winter temperature goes as low as 7°C during December and January.

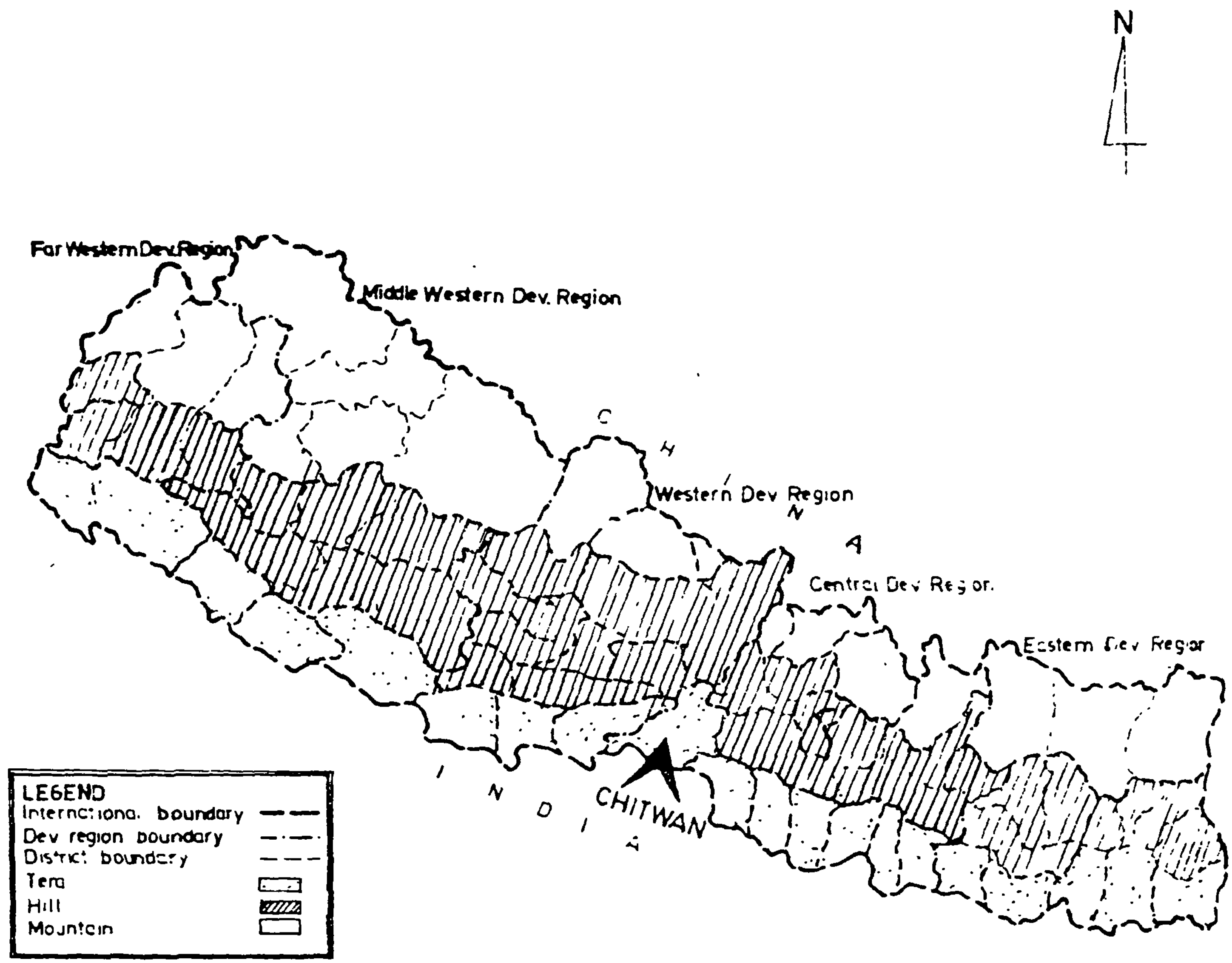

FIG. 1. MAP OF NEPAL.

The valley is divided by Khageri river into Eastern and Western area, popularly known as Eastern Chitwan and Western Chitwan. The area south of Rapti river is called Madi valley (Fig. 2). The study reported in this paper was carried out in Eastern Chitwan bounded by Lothar and Khageri rivers in the East and West, Rapti river in the South and foot hills of Mahabharat range in the North.

Several streams flow into the valley from Mahabharat and Churia hills which are perennial seasonal or ephemeral in character (Fig. 3). Rapti river is the main water resource of the East Chitwan which flows from North-East to South-West and ultimately joins the Narayani river system. Perennial rivers like Lothar and Manahari flow from the Eastern boundary. Dhongre Khola[1] originates from Lothar river and Budhi Rapti stream originates from a forest area (Kuchkuchhe forest) along the bank of Rapti river. Both of these streams flow East to West parallel to Rapti river and are perennial in nature. Rapti and it's tributaries flow at levels almost equal to average slope of the valley floor and, as such, have longer flood plains. Martal Khola, Pumpa Khola, Tanhi Khola, Chatra Khola, Kair Khola and Khageri river are the other streams flowing from North-South and East-West directions. Except Khageri river all these streams are ephemeral in nature.

The irrigation development in Chitwan valley includes both government and community built irrigation schemes. Eastern Chitwan has the largest concentration of community built and run irrigation schemes in the valley. Some of the systems have been reported to be as old as 250 years (Pradhan, 1986). The government built irrigation projects include Chitwan Irrigation Project which comprises of Narayani Lift Irrigation Project (8,600 ha), Khageri Irrigation Scheme (6,000 ha) and Panchkanya Irrigation Scheme (600 ha). Pithuwa Irrigation System (600 ha) is a government built irrigation scheme which is now operated and managed by local farmers through their water user's organization.

Methodology

The methodology used in this study include preparatory works prior to the field study and use of a resource inventory checklist to facilitate guided interviews for field data collection. The preparatory works included collection of all relevant information pertaining to the study area including previous reports and maps from such sources as District Irrigation Office (DIO), District Development Committee (DDC), Chitwan Irrigation Project (CIP), Agricultural Development Bank (ADB/N), East Rapti Irrigation Project (ERIP) and District Agricultural Development Office (DADO).

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[1] Kulo in Nepali means river or stream.

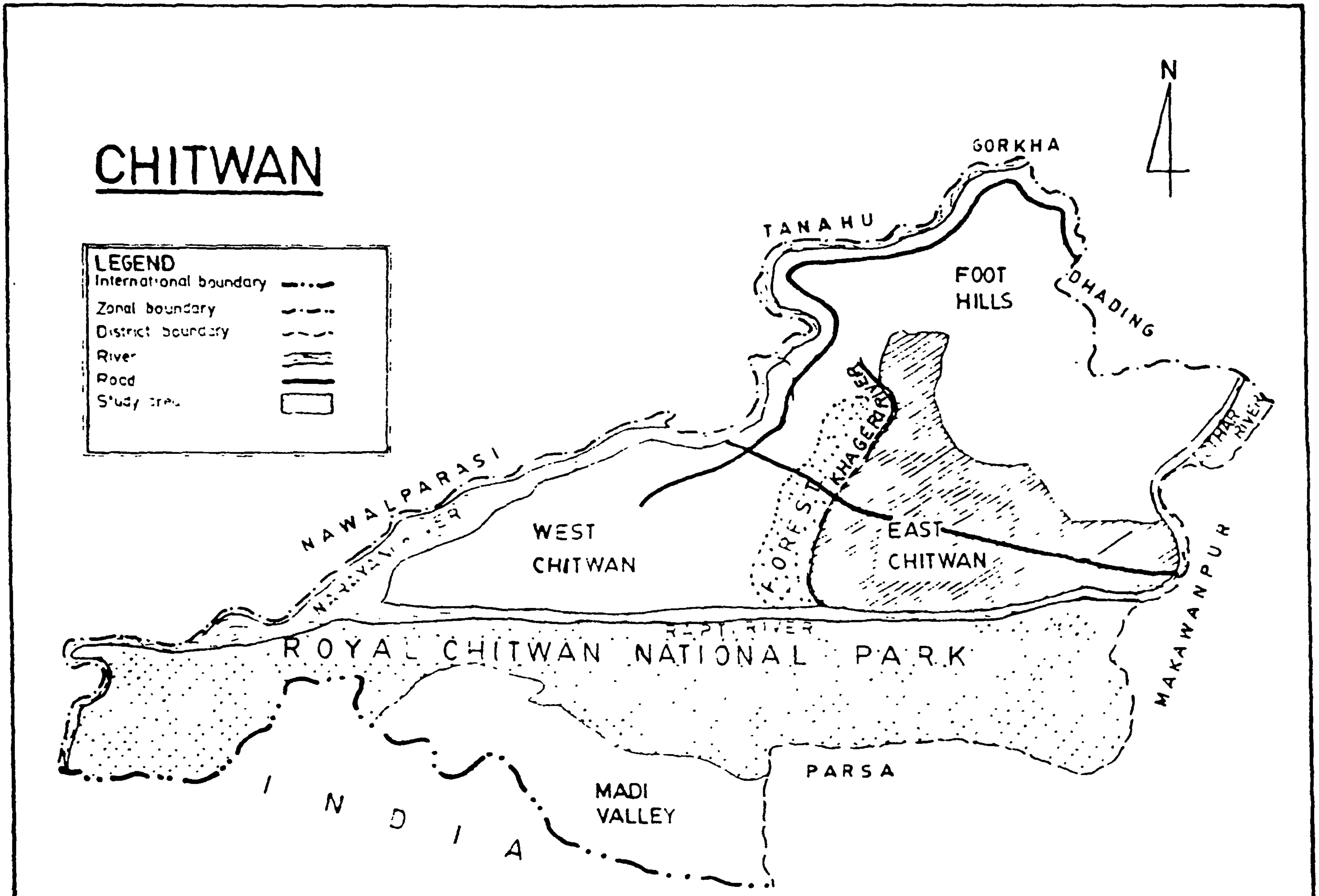

FIG. 2 LOCATION OF THE STUDY AREA.

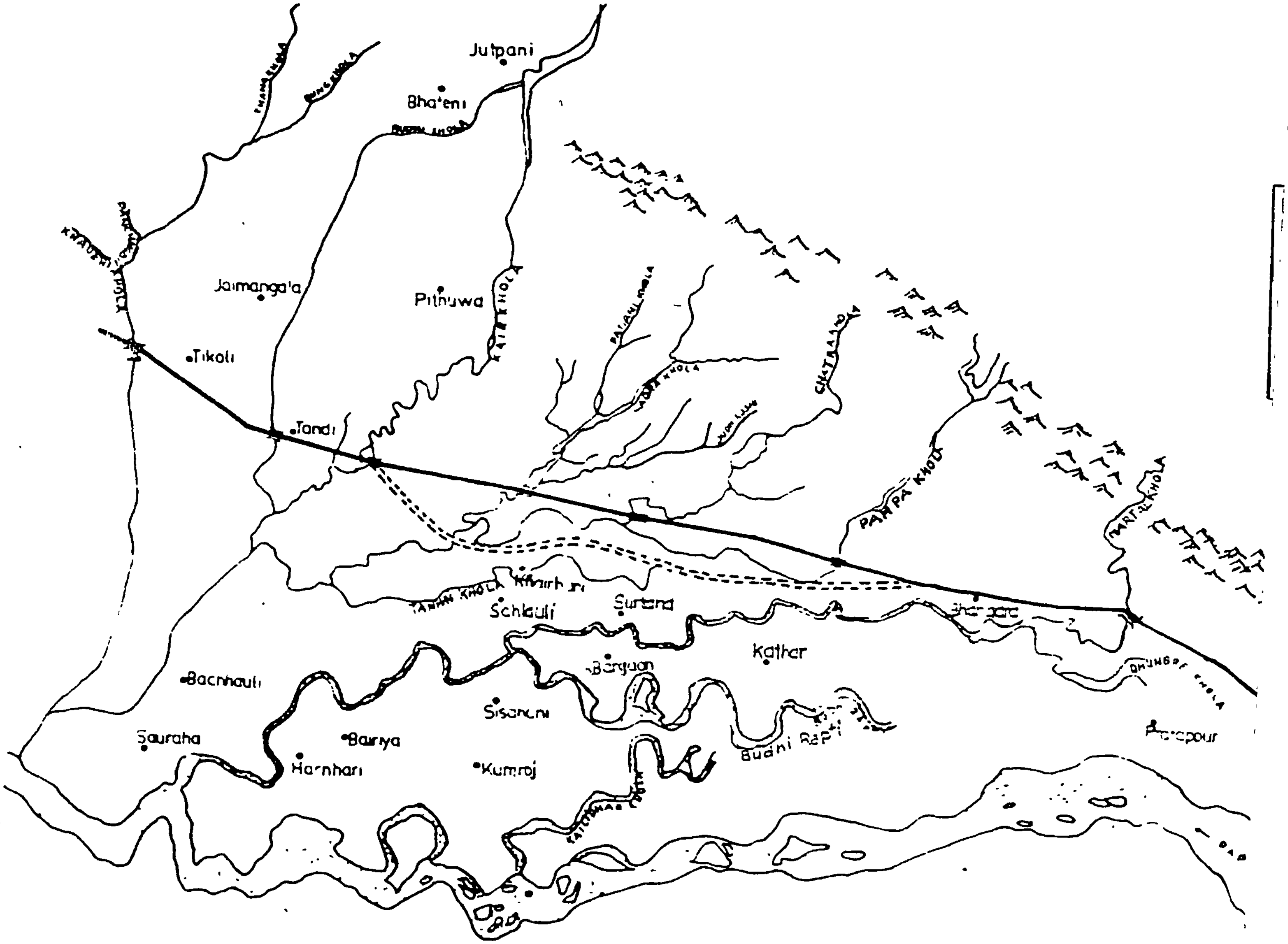

FIG. 3 Water Resources of the Study Area

A resource inventory checklist was prepared which was modified in several stages through pre-testing and experiences gathered from the field. A Nepali version of checklist was found useful in improving the communication between interviewer and respondents. The equivalent terms for irrigation management activities in local dialect of the study area, commonly used by the respondents, were incorporated in the checklist to improve the efficiency of information gathering. A list of such terms is included in Appendix - I.

Group interviews were conducted in each irrigation system using the inventory checklist. The respondents included water users, functionaries of water user's committee and local leaders. Elderly persons from the system were consulted to collect and validate information on initiation and history of development of the systems. The group interviews were made as participatory and iterative as possible. The study team walked from the head to tail end of the system along with the beneficiaries and recorded the information on physical and hydrologic characteristics of the system. The system walkthrough also helped cross checking and validating several information obtained from the respondents.

CHARACTERISTICS AND PERFORMANCE OF IRRIGATION RESOURCES

Hydrology and Water Resources

Rapti river and its tributaries are the major water resources in the study area. The irrigation systems served by different water resources and their location in the study area is presented in Fig. 4[1]. Some irrigation systems also originate from springs and ghols[2]. Which are either seasonal or perennial in nature.

Among the irrigation systems reported, as many as 4 of the systems were found to have multiple sources of supply with established rights to water use from these sources. One irrigation system was found to be based solely on drainage water from adjoining system for source of water supply (Table 1).

The classification of irrigation systems into seasonal or perennial types depending upon availability of water in more than one seasons, indicated a total of 49 (55.70 percent) irrigation systems to be perennial and 39 (44.30 per cent) irrigation systems to be seasonal in nature. The classification of seasonal or perennial irrigation system was based on

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[1] The irrigation systems in Fig 4 are coded by their source and location at different reaches of the source. Appendix - II be referred for their names and source.

[2] Ghols mean physiographically depressed areas in local dialect which are encountered at many places in Chitwan valley. Surface runoff is collected in these ghols which is recycled for irrigation.

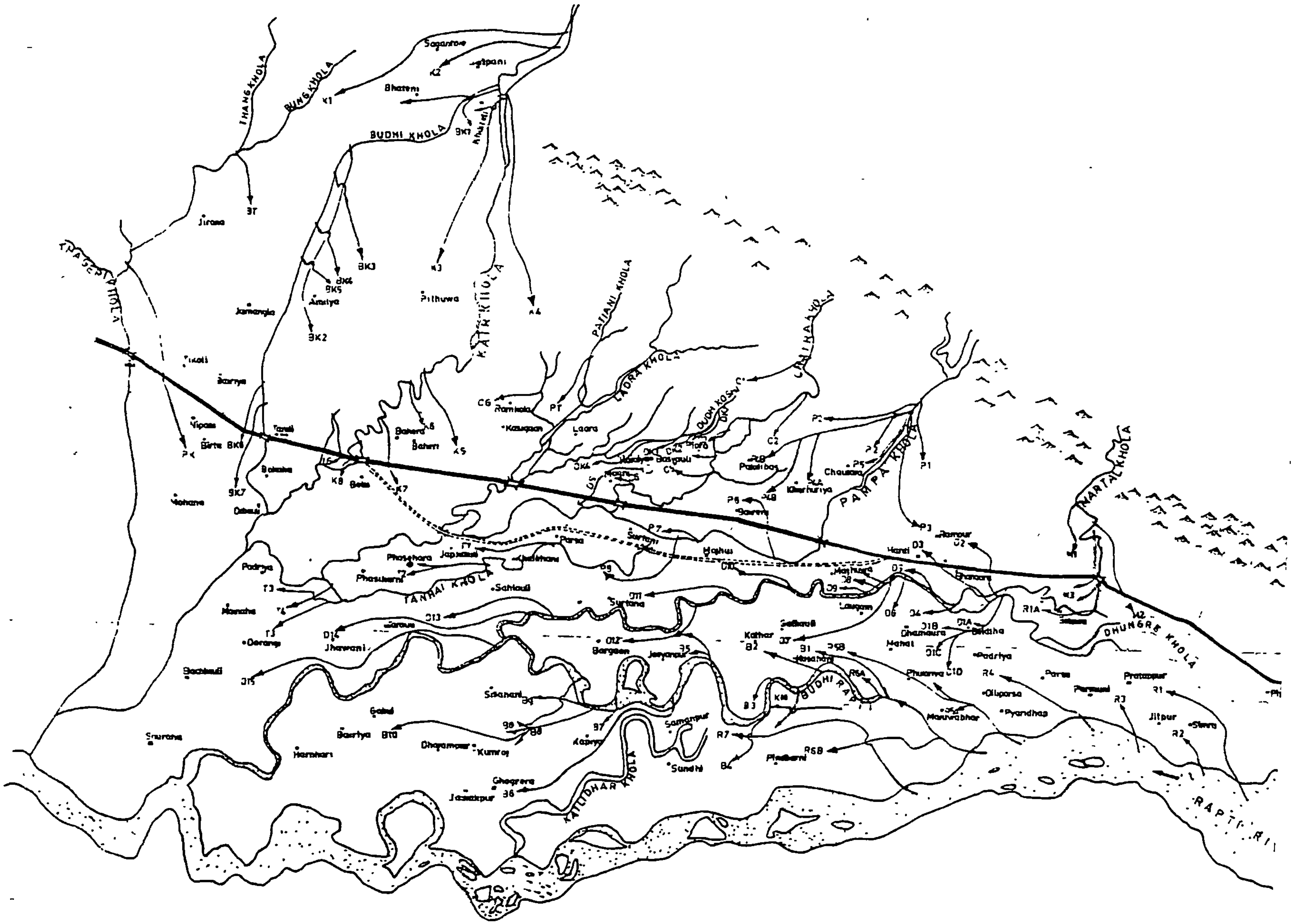

FIG. 4 MAP SHOWING IRRIGATION SYSTEMS OF EAST CHITWAN.

whether or not an irrigation system obtains water supply during spring (March - May) and monsoon (June - September). A system was considered perennial if water was available both in spring and monsoon and seasonal if it was available only during monsoon. For the winter crop either no irrigation is practiced in the study area or the area irrigated is too small. A sorting of number of perennial and seasonal irrigation systems by source indicated a large number of perennial irrigation systems in Dhongre, Budhi Rapti and Rapti rivers supplying water to 16, 10 and 8 irrigation systems, respectively.

Table 1. Number and Types of Irrigation Systems by Source.

Source	Number of Irrigation Systems		
	Perennial	Seasonal	Total
Lothar river	2	0	2
Rapti river	8	0	8
Lothar + Rapti	8	0	1
Rapti drain	1	0	1
Martal Khola	0	3	3
Dhongre Khola	15	1	16
Budhi Rapti	10	0	10
Dhongre + Budhi Rapti	2	0	2
Pumpa Khola	3	6	9
Tanhi Khola	1	3	4
Chatra Khola	0	6	6
Dudh Koshi Khola	2	1	3
Ladra + Dudh Koshi	0	1	1
Patiani Khola	0	1	1
Kair Khola	0	8	8
Budhi Khola	1	6	7
Thang Khola - Bung Khola	0	1	1
Panch Nadi (Khageri Khola)	1	0	1
Springs and Ghols	2	2	4
TOTAL	49	39	88

The average size of irrigation systems in the study area was found to be 125 ha. with the range 7 to 1005 ha. In terms of service area Rapti Pratappur Kulo[1] (R1) was found to be the largest and Khairghari Kulo (B3) the smallest irrigation system. The total irrigated area under 88 irrigation systems account for 10,658 ha of which 6,580 ha was found to be irrigated under perennial and 4,078 ha irrigated under seasonal irrigation systems. A summary of area under irrigation by season is presented in Table - 2. The area irrigated during monsoon (10,650 ha) was found higher than winter (5,417 ha) and spring (5,556 ha) which is due to higher available water supply at the source during monsoon.

Table 2. Irrigated area under Perennial and Seasonal Irrigation Systems by Season.

System type	Perennial	Seasonal	Total
Service area (ha)	6626.0	4078.0	10704.0
Irrigated area by Season (ha)			
Monsoon	6580.0	4078.0	10658.0
Winter	5294.0	123.0	5417.0
Spring	5556.0	-	5556.0

Inter irrigation system water use was observed in several of the irrigation systems in the study area (Table 3). As many as 11 of the irrigation systems were found to be using water from other systems and 12 of the systems were found to be providing water to other systems. The basis for water acquisition from other systems was found to be cash and labor mobilization in repair and maintenance. Cash payment, genuine demand, mutual consensus of water users and resource contribution in initial construction were among the other bases. A total of 9 irrigation systems were found to be using drainage water from other systems as source of supply.

The sub-surface formation in most parts of Chitwan district has been reported to be gravelly and porous (Joshi 1981; Khatri-Chhetri, 1982). Due to porous subsoil the water applied on the upstream side reappears and drains into the streams located downstream. The farmers reported that the water supply in Dhongre Khola and Budhi Rapti river starts resuming after the farmers in Rapti Pratappur (R1) and Sisabas Kulo (R3) begin to irrigate during spring. This shows hydrologic interlinkages among the irrigation systems.

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1 Kulo in Nepali means Irrigation Canal

Multiple uses of irrigation water was observed in 6 irrigation systems in the study area. In Dadhuwa Kulo (M1), Martal Dhamili Ko Kulo (M2) and Bhateni Ko Kulo (K2), water from irrigation canal is used to operate water mills. Martal Dhamili Ko Kulo was initially built for operating a water mill and the use of this system for irrigation started only later. In Rampur Kulo (D2), Fasera Fascrni Kulo (T2) and Panchkanya Irrigation Scheme water from the system is used in fish ponds. Rampur Kulo was built primarily to supply water to a Government Fishery Development Program.

Table 3. Inter System Irrigation Water Use.

Provision	Number	Percent	System Code
Use of water from other systems :			
From 1 system	11	7.30	R2, D1A, A1B, D1C, D1D, P3, P5, C5, BK4, BK5, BT
From 2 systems	-	-	-
Drainage water	9	10.20	R3, R5B, R1A, P4B1, P7, P8, T1, C4, DK4
None	68	77.30	-
Provision of water to other systems :			
To 1 system	9	10.20	L1, L2, D11, B10, P2, P3, C5, DK4, K2
To 2 systems	3	3.40	R1, R4, R5A
None	76	86.40	-

Initiation and History of Development

A summary of age of the irrigation systems based on year of initial construction is given in Table 4. A majority of irrigation systems were found to be atleast 25 years old. Only 33 (38.37 per cent) of the irrigation systems were found to be of recent origin ($\leq$ 25 years). As many as 23 (26.74 per cent) of the irrigation systems were constructed more than 100 years back.

Out of the 88 irrigation systems reported, 46 (52.27 per cent) were found to be initiated by the original settlers (Tharus and Darai) and 40 (45.45 per cent) by the migrant community (Table 5). Two of the irrigation systems were initiated by external agencies, these are: Pithuwa Irrigation Scheme (K3) and Rampur Kulo (D2).

The resettlement program in Chitwan valley began in 1953 A.D. (2011 B.S.) under Rapti Valley Development Project. Among 41 irrigation systems constructed before 2011 B.S., 35 of the irrigation system were found to be initiated by the original settlers and only 6 by the migrant Pahadiya[1] community. Contrarily, among 47 irrigation systems constructed after 2011 B.S., 34 were initiated by migrant Pahadiya community and only 11 by the original setters. This reflects a good correlation between migration and irrigation system development pattern in the study area. The Tharus are the pioneers of irrigation development in East Chitwan. After the resettlement program people from adjoining hill districts migrated and settled in the study area.

The population of Chitwan valley is multi-ethnic in character. A broader classification of settlement in the valley by community can be conceptualized as : Tharu community settled areas, Pahadiya community settled areas and mixed community settled areas.

Table 4. Age of the Irrigation Systems in the Study Area.

Age (years)	No. of Systems	Percent
Less than 25	33	38.37
25 - 50	18	20.93
50 - 75	10	11.65
75 - 100	2	2.32
More than 100	23	26.75
TOTAL	86	100.00

[1] People who originally belong to hills are called Pahadiya

Table 5. Community Responsible for initiation of the Irrigation Systems.

Community/Agency	No. of Systems	Percent
Original settlers	46	52.27
Tharu	43	48.86
Tharu + Darai	1	1.14
Darai	2	2.27
Migrant Pahadiya Community	40	45.45
Agency Initiated	2	2.27
TOTAL	88	100.00

The classification of irrigation systems based on community responsible for management as : Tharu Community Managed Irrigation System (TCMIS), Pahadiya Community Managed Irrigation Systems (PCMIS) and Mixed Community Managed Irrigation Systems (MCMIS) is presented in Table 6. It was observed that out of 88 irrigation systems 20 are TCMIS, 45 are PCMIS and 23 and MCMIS. Out of the 46 irrigation systems initiated by the original settlers, 20 irrigation systems were found to be managed by the Tharu community, 6 systems by Pahadiya community and 17 irrigation systems by mixed communities. Contrarily in 40 of the irrigation systems initiated by the migrant Pahadiya community, 35 systems were found to be managed by pahadiya community and 5 systems by mixed communities.

Table 6. Distribution of Irrigation Systems by Initiators and Management Types.

Initiator Community	Types of System Management			Total
	TCMIS	PCMIS	MCMIS	
Original settlers	20	9	17	46
Tharu	20	6	14	43
Tharu + Darai	0	1	0	1
Darai	0	2	0	2
Migrant Pahadiya Community	0	35	5	40
Agency Initiated	0	1	1	2
TOTAL	20	45	23	88

In most of the systems the resources for initial construction were mobilized by the users from within the systems. External supports, either full or partial were observed only in 5 irrigation systems. The resources mobilized by the users included cash and labor in most cases however in some cases resource mobilization in terms of food grains were also observed to pay for the hired laborers. Cash resources at the time of initial construction were found to be mobilized on the basis of landholding size (21 out of 25 systems) and the labor resource on the basis of household (18 out of 24 systems). Since the irrigation systems were constructed at different phases of times and in many of the old systems (51 out of 88) no records of resource mobilization was available. It was not possible therefore to make the cross comparison of resources mobilized in the systems during their initiation.

The rehabilitation and improvement works done in the irrigation systems of the study area included Construction of permanent or semi permanent diversion structures, head regulators, provision of cross drainage works and construction of water allocation and distribution structures. These also include improvement of carrying capacity of canals, of their lengths, expansion of irrigated area and of acquisition of water from other systems in the neighbouring areas to augment the water supply.

Rehabilitation and improvement works of some form, were observed in 64 out of 88 irrigation systems (Table 7). In 24 irrigation systems no rehabilitation and improvement, whatsoever were noticed. In 14 irrigation systems rehabilitation and improvement works were observed to have been done more than once. The frequency of rehabilitation and improvement were observed to be higher in PCMIS as compared to TCMIS and MCMIS.

Table 7. Frequency of Rehabilitation and Improvements in the Irrigation Systems.

Number of rehabilitation and improvement works	Types of System Management			Total
	TCMIS	PCMIS	MCMIS	
0	3	15	6	24
1	13	24	13	50
2	4	5	3	12
3	0	1	1	2
TOTAL	20	45	23	88

Physical and Structural Characteristics

The major types of headworks in the studied irrigation systems include temporary brushwood check dams, gabion boxes - used as semipermanent diversion structure and permanent cement-concrete gated diversion weir. Some systems also use inverted syphons and direct offtakes through inundation canals from springs and ghols. The distribution of irrigation systems by the types of diversion structure is presented in Table 8. The irrigation systems with permanent diversion structure are of recent construction.

The main and secondary canals in majority of irrigation systems were unlined. The average length of main canal was found to be 2.98 km. Piped culverts and flumes are the major types of cross drainage structures provided in many of the systems. These cross drainage works are mostly permanent in nature except in few cases where users have designed and constructed wooden flumes, aqueducts and culverts with their own knowledge and resources.

Provision of cement concrete or wooden proportional weirs for water allocation was found in 17 irrigation systems. In the irrigation systems with no provision of proportional weirs or gated outlets, presence of piped outlets or temporary outlets of specific sizes were observed. In most cases the size of the outlets was found to be proportional to the area irrigated. The quantity of water to be allocated in each branch or outlet was found proportional to the supply or time-area relationship. In the absence of permanent water allocation structures, the farmers erect temporary checks of wooden stakes, bushes, stones and earthen materials across the main canal to ensure near proportional allocation of irrigation water.

Table 8. Distribution of Irrigation Systems by the Types of Headwork.

Original Diversion Structure	Existing Diversion Structure			
	Brushwood	Semi-permanent	Permanent	Inundation type
Brushwood	40	37	4	0
Semi-permanent	0	3	1	0
Permanent	0	0	2	0
Inundation type off-take	0	0	0	1
TOTAL	40	40	7	1

Social and Organizational Characteristics

The original settlers of the study area include Tharus, Darais, Rais, Kumals and Botes. Among the original settlers the Tharus are in majority as their settlement was observed in 81 per cent of the systems. The migrant Pahadiyas were found to have settled in 97 per cent of the systems. The Pahadiyas migrated mostly from the Central and Western hills of Nepal. The average members of households served by the irrigation systems in the study area was found to be 140. In most cases the farmers were owner operator through share cropping and lease holding were also observed in some cases. The size of land holding of majority of the farmers was found to be less than one hectare.

Nearly one-tenth of the systems had no formal water users' organizations (WUOs). Eighty five percent of WUOs were unifunctional where the organization was meant only for the operation and management of the system. All the systems, except Pithuwa Irrigation Scheme (K3) were found to be unitary in nature with only one tier of organization. In Pithuwa Irrigation Scheme however branch canal committees function at secondary canal level and federation of all branch canal committees function at main system level. Contrarily, no such federation was observed in Beldiha (D1A), Dhamaura (D1B), Mahal (D1C) and Phularia (D1D) Kulos through they use water from the same intake. These systems have separate WUOs without any formal linkage among themselves.

The functionaries of water users' committee (WUC) were found to be selected by the general consensus of the appropriators. The tenures of the functionaries was not specifically mentioned in majority (73 per cent) of the systems. It was however reported that the members would not be changed or replaced unless their honesty and capabilities are no longer valued high or the individuals no longer had interest to remain in the committee. No ex-officio functionaries were observed except in Pithuwa Irrigation Scheme where the elected chairman of village level political unit (Village Development Committee) was the chairman of water users' committee by position.

The distribution of number of functionaries in water users' committee by management types of irrigation systems is presented in Table 9. A maximum number of systems (41 per cent) had one to five functionaries in WUC. It was also observed that the Tharu managed systems have a smaller number of functionaries than Pahadiya managed systems.

Table 9. Distribution of Functionaries of Water Users' Committee by Management Types of Irrigation Systems.

Number of Executive Members	Types of Irrigation Management			Total
	TCMIS	PCMIS	MCMIS	
1 to 5 members	13	13	10	36
6 to 11 members	5	11	4	20
Above 11 members	1	15	6	22
TOTAL	20	45	23	48

Agricultural Systems

The prevailing cropping patterns in the study area is summarized in Table 10. The prevailing cropping patterns were categorized by type of irrigation systems as seasonal and perennial systems. To obtain a more specific assessment of cropping pattern, the perennial irrigation systems were further categorized as water adequate and water deficit system. A perennial irrigation system was defined as water adequate system, if round the year irrigation is possible and a water deficit system, if irrigation is not possible in any one of the seasons. In most cases, however, winter season irrigation was not found in water deficit perennial systems.

In terms of coverage of area the most popular crop sequences in the perennial/adequate; perennial/deficit and seasonal irrigation systems were found to be: spring paddy - monsoon paddy - mustard, spring paddy and spring maize - monsoon paddy - mustard and spring maize - monsoon paddy - mustard, respectively. Other crop sequences consisting of lentil, wheat, winter maize, mustard + lentil, lentil relayed with monsoon paddy were also observed. The cropping intensity, in general, was found to be 300 per cent in perennial irrigation systems and approximately 200 percent in seasonal irrigation systems.

Table 10. Cropping Pattern Under Perennial and Seasonal Irrigation Systems in the Study Area

	Perennial		Seasonal	
	System Code	Cropping Pattern	System Code	Cropping Pattern
1	Water Adequate System R1 R2 R3 R4 R5A R5B R6A R7Km B1 BK1 D1A D1B D1D D3 D4 D5 D6	 Sp-Mp-Wm Sp-Mp-Wh Sp-Mp-Mu Sp-Mp-Lt Sp-Mp-Mu+Lt Sp-Mp/Lt	 M1 M3 T3 T4 P8 C1 C2 C3 C4 C5 C6 C2 P3 P4A P4B P5 Pl PT BK2 BK3 BK4 BK5 BK6 BK7 K1 K2 K3 K4 K5 K6 K7 K8 T2 CG Bt DK1 DK2 DK3 DK4 DS	 Mp-Mu-Sm Mp-Lt-Sm Mp-Mu+Lt-Sm Mp-Mu+Lt-Fa Mp-Wh-Fa Mp-Wm-Sm Mp-Fa-Sm Mp-Po+Wh/Sm Mp-Fa-Fa Mp/Lt-Fa
2	Water Deficit Systems L1 L2 R1A R6B M2 D1C D7 D8 D9 D10 D11 D12 D13 D14 D15 P6 P7 B2 B3 B4 B5 B6 B7 B8 B9 B10 Pk T1 LG	 Sp & Sm-Mp-Lt Sp & Sm-Mp-Mu Sp & Sm-Mp-Wm Sp & Sm-Mp-Wh Sp & Sm-Mp-Mu-Lt Sp & Sm-Mp/Lt		

Sp = Spring Paddy
Mp = Monsoon Pady
Mu= Mustart

Sm = Spring Maize
Wm = Winter Maize
Po = Potato

Lt = Lentil
Wh = Wheat
Fa = Fallow

The area and productivity of major crops in seasonal and perennial irrigation systems are summarized in Table 11. During the monsoon most of the area under seasonal (4,078 ha) and perennial (6,577 ha) systems was found to be under paddy. Diversification of crops and their area coverage was observed during winter and spring both in perennial and seasonal irrigation systems. During spring season however, larger area under spring paddy and smaller area under spring maize was observed in perennial irrigation systems. Contrarily, in the seasonal irrigation systems area under spring maize was found larger than the spring paddy.

Table 11. Area and Productivity of Major Crops Under Seasonal and Perennial Irrigation Systems.

Season / Crops	Type of Irrigation System			
	Perennial		Seasonal	
	Area (ha)	Productivity (qtl/ha)	Area (ha)	Productivity (qtl/ha)
Monsoon				
Paddy	6577	36.9	4078	30.3
Winter				
Wheat	579	27.3	516	14.0
Mustard	4113	6.6	1924	4.0
Lentil	1224	7.6	868	6.5
Maize	136	17.6	72	1.2
Spring				
Paddy	4684	45.9	34	43.8
Maize	1349	19.6	1565	12.5

ENVIRONMENTAL STRESSES ON THE IRRIGATION SYSTEMS OF EAST CHITWAN

Migration and Population Pressure

Chitwan valley is one of the recently settled area of the country. Owing to malaria infestation this valley was under dense forests and left uncultivated for a long time. Before being opened for planned settlement there were Tharus and Darais, the indigenous inhabitants, whose settlements were scattered. The valley was known as " the valley of death " or as " the malariahell " (Elder et al., 1976; Toni Hagen, 1961).

In 1953, floods and landslides washed out hundreds of villages in the hilly region. During the same time the government started Rapti Valley Development Project in Chitwan. The project started malaria eradication program. Since one of the goal of the project was to convert the forests into farmland, the government decided to encourage the flood victims to settle into the valley and to clear and cultivate the lands of which, in time, they would become the owner (Elder et al., 1976). During 1958-59, people from all parts of the country, with major influx from adjoining hill districts, migrated and settled in the valley.

The total population of Chitwan district has been estimated to be 3,55,298 (CBS, 1992). There was an unprecedented increase in the population of the Chitwan district from 68,500 in 1961 to 183,644 in 1971 with the average annual growth rate of 16.81 percent. In 1981 the total population was estimated to be 2,59,571, the annual growth rate between 1971-1981 being 3.52 per cent (CBS, 1981; CBS, 1982). The migration to Chitwan valley is still continuing though at a relatively slower rate.

The rapid population growth in the valley is the major factor responsible for land use changes due to rapid deforestation and land clearing for cultivation. This has turned the intact ecology of the valley to be fragile.

Though the major credit for agricultural development in the valley goes to the new settlers who were more innovative in the adoption of new technologies, it has also brought about several social institutional changes in the study area. One of the institutional changes which is distinctly visible is shifting of operation and management responsibility of irrigation systems from one community to another. As apparent from Table 6 there has been changes in management systems in the irrigation systems initiated by the original settlers. Whether the effects such changes are positive or negative, is the issue of further investigation. Considering this analysis to be due, some of the initial observations that were made during the study are -

i. The Tharus and Darais who are the pioneers of irrigation development in the study area have been streamlined by the migrant communities in terms of their roles in the governance of the systems.

ii. The changes in the management responsibilities of the systems have brought changes in the resource mobilization pattern in the systems which is discussed later in this paper. Such changes have put the systems in constraints of labor resource mobilization at the time of annual repair and maintenance.

iii. The original settlers have very strict set of rules for the operation and management of the system which is, among others, important strength for their long term viability. The management transfer may have bearing, atleast partially, on the sustained operation of the systems.

Hydrology of Water Resources

Lothar, Rapti, Dhongre Khola, Budhi Rapti and Khageri river are perennial rivers and streams in the study area. Other streams like Martal Khola, Dhongre Khola, Pumpa Khola, Tanhi Khola, Chatra Khola, Kair Khola, Dudh Koshi Khola, Budhi Khola and Thang Khola - Bung Khola are either seasonal or ephemeral. The seasonal streams have been reported to have undergone major hydrologic changes in past two decades. Most of these streams originate from Churia hills or foothills of Mahabharat range. Due to rapid deforestation and uncontrolled land clearing operations in the upstream watershed of most of these streams, the incidence of high flood has increased and the lean season flow has reduced. The farmers, for example, in Martal Khola reported that they were getting enough water about 10 - 12 years ago, which was dependable, through limited in quantity and were irrigating spring paddy.

Budhi Rapti is a perennial stream originating from springs in forest area located along the banks of Rapti river. There are two way encroachment in this forest - due to uncontrolled settlement and rapid inundation of land by Rapti river. The farmers in the study area reported of gradual reduction in the amount of flow in Budhi Rapti over time. This has been a threat to even existence of Budhi Rapti river which is the source of ten irrigation systems covering an area of 1331 ha of land. Similar changes were also reported in Dhongre Khola which gets it's supply from natural runoff of Lothar river and drainage water from Rapti and Lothar irrigation systems.

Though the water supply in Rapti river has increased beginning 1982 due to augmentation of water released from Kulekhani No. 1 power plant, the incidence of high peak flood has also increased. This river brings massive boulders and gravels during floods in monsoon as a result the river bed is rising. Serious inundation of prime agricultural land during the floods and stream bank erosion along the north bank in Piple, Bhandara, Kathar and Kumroj Village Development Committees have been reported. For last few years the irrigation systems getting their supply from Rapti river have been facing problems of water scarcity during spring season due to erratic rainfall and low flow at the source.

Further the number of irrigation systems on each source has increased over time (See Table 1 and Table 4). In Budhi Rapti river alone there are ten irrigation system in merely less than 10 km of river span. Such a situation has resulted in reduction in the available water supply in the downstream systems. This is more so in dry season even in perennial irrigation systems. In such situations, the users from the downstream irrigation systems approach the water users of upstream systems and make informal request for share of water. Cases of stealing of water by breaking the diversion structure of upstream system were also observed in some systems.

October through May were found to be water deficit months in the study area. March through May are the months to grow Spring Paddy where there is dependable irrigation. The water allocation pattern followed in the study area during water adequate and deficit months is presented in Table 12. During Water adequate periods, majority of systems (38) adopt continuous supply method as there is no limitation of water supply in the canal. However, in order to meet the demand, about 12 systems were found to allocate the water on genuine demands of users. As many as 31 systems were found to adopt a combination of continuous and demand based supply. Few irrigation systems in the study area suffer from scarcity of water even during monsoon due to ephemeral nature of the streams. Consequently five systems were found to have adopted more restrictive water allocation methods even during monsoon. Panchkanya irrigation system is one such example where water is allocated on the basis of type of land to be irrigated.

During water deficit months the users in most cases are forced to formulate more restrictive rules to ensure equitable allocation. As reflected in Table 12, allocation of water by secondary canals has been found most practicable and adopted in 24 irrigation systems. Time - area relationship, which is the time required by a given stream size to saturate or wet a specific size of plot, was found another viable method adopted in 23 irrigation systems.

Table 12. Distribution of Irrigation Systems by Water Allocation Methods During Water Surplus and Deficit Periods

S. No.	Water Allocation Methods	Water Surplus Period	Water Deficit Period
1.	Free flow in the canal/Continuous supply	38	1
2.	Need based supply/water allocation on demand	12	-
3.	Continuous supply + need based supply	31	-
4.	Based on time-area relationship	2	23
5.	Based on the assessment of time required to wet/ saturate a given size of land	-	7
6.	Based on the level of flow in the canal	-	1
7.	Based on the number and location of outlets directly connected to the field plots from the main canal	-	1
8.	Based on the number and location of secondary canals	1	24
9.	based on ward numbers/blocks or 'Maujas' comprising of one or more than one branch canals within a VDC	-	7
10.	Based on mutual understanding among users	1	2
11.	Based on number of users within an irrigation system	-	2
12.	Based on location (i.e. Head, Middle and Tail reaches)	-	5
13.	Based on type of land to be irrigated	1	3
14.	Based on priority given to particular segment/branch/user(s)	-	1
15.	Based on time of delivery (i.e. day and night time or paddy transplantation time and other time)	-	3
16.	No allocation method		
	# Due to adequacy of water in the system	1	4
	# Due to non existence of formal water users' organization	-	2
	# Due to scarcity of water in the system	1	1
	# Due to availability of drainage water from other systems most of the time	-	1
	TOTAL	88	88

Hydrologic Interlinkages Among the Systems

The irrigation systems in the study area particularly those deriving their water supply from Rapti river, Budhi Rapti and Dhongre Khola are hydrologically related to each other. The inter-system water use in the study area is depicted in Table 3. This illustrates complex water rights among the systems. Water drained from one system becomes source of supply for another. This also applies to sources such as Budhi Rapti and Dhongre Khola, which receive their supply, atleast partially, from the drained water of irrigated lands. The water supply in Dhongre Khola for example starts resuming during spring season when the farmers on the upstream side like Rapti Pratappur (R1) and Sisabas Kulo (R3) start irrigating their lands.

Rapid deforestation and land use changes due to conversion of forest into agricultural lands are expected to bring changes in such linkages. The stress on any one of the system on the source will have linked effect on other systems and sources.

Further, East Rapti Irrigation Project (ERIP), a large public sector irrigation development and rehabilitation program is underway in East Chitwan which is expected to bring changes in the physical and hydrologic characteristics of the irrigation system. At present majority of the systems use brushwood or semi-permanent gabion diversion structures at the headwork. A change in the nature of diversion structure of the upstream system could bring changes in the availability and reliability of water supply in the downstream system. Any change proposed under ERIP must therefore be based on thorough investigation of effects on the characteristics and performance of the system and those linked to it.

Crop Intensification and Soil Fertility Variations

The planned settlement in Chitwan valley, fertile soil, favourable agro-climatic conditions and agricultural support services have lead to changes in the cropping pattern and intensification in the agricultural practices. Two successive rice crops during Spring and Monsoon are common in the perennial irrigation systems with no limitation of water supply during Spring. The prevailing crop sequences in the study area is depicted in Table 10.

The soils of Chitwan valley which were considered most fertile soils in the country are depleting faster owing to multiple cropping, decreased supply of organic matters and increased dependance on chemical fertilizers. The trend of reducing the number of livestock due to increased constraints on feed, fodder and forage supply has resulted in reduced supply of composts and farm yard manures (FYM).

With regards to fertility variation information were obtained on soil type and their fertility status from head, middle and tail reaches of each system (Table 13). The enquiry was based explicitly on physical characteristics and agricultural performance of the soils as perceived by the farmers. Out of 261 total canal reaches (head, middle and tail) enquired

100 (30.0 per cent) reaches were found to have fine loam, 93 (35.5 per cent) reaches have coarse to medium loam, 56 (22.2 per cent) reaches of sandy soils and 10 (3.9 per cent) reaches have gravelly to sandy soils. This depicts the dominance of medium to heavy textured soils in the study area which is consistent with the findings of Khatri-Chhetri (1982) and Joshi (1981).

The farmers in general reported the soil fertility to be depleting. The soil fertility of 99 (37.9 per cent) of the canal reaches were reported to be good, moderate in 103 (39.5 per cent) reaches and poor in 59 (22.6 per cent) of the canal reaches. The comparison of fertility depletion over time revealed 79.3 per cent of the irrigation systems experiencing declining fertility and in 14.9 per cent of the systems no appreciable changes in the soil fertility. Only in 5.8 per cent of the systems improvement in soil fertility was reported. Fertile silt carried in the irrigation water, particularly those coming with the first flood of monsoon was reported to be good for agricultural production. This might have contributed for improved soil fertility in some of the irrigation systems.

The farmers of nearly all the irrigation systems (94 per cent) had not had their soils tested before. The farmers showed their concerns about their irrigated lands turning to saline due to continuous use of irrigation water. Similarly, many seasonally irrigated systems with well drained soils have shown indications of turning to be acidic.

Resource Mobilization for System Maintenance

Annual repair and maintenance of the irrigation systems in the study area included: desilting of the main and major secondary canals, repair of intake structures and strengthening of the canal dikes. In most of the perennial irrigation systems the desilting of the main and branch canals was found to be done twice a year, once before Spring rice season during February - March and before Monsoon rice during May - June. The seasonal irrigation systems, however, the desilting of the canal network was found to be done only once before the start of Monsoon during April - May.

Major forms of emergency repair and maintenance included repair of the diversion structure and the main canal embankment. The brushwood type diversion structure is required to be repaired every time it gets washed due to flood. The frequency of repair of the diversion structure was in general found to be higher in the irrigation systems getting their supply from Rapti and Lothar rivers. Dhongre and Budhi Rapti are though perennial streams their flow is steady with almost no incidence of high flood. In the irrigation systems getting their supply from these two sources, the frequency of repair of diversion structure was found to be lower. In the irrigation systems taking-off from the seasonal streams like Pumpa Khola, Tanhi Khola, Chatra Khola, Budhi Khola and Dudh Koshi Khola, the frequency of repair of the diversion structure was found to be relatively higher due to higher incidence of floods during monsoon.

Table 13. Relative Distribution of Soil Types and Fertility in the Study Area

S.No.	No. Systems	Texture (No. of canal reaches)					Fertility (No. of canal reaches)				Overtime changes in fertility (No. of irrigation systems)				Soil tested	
		Vcs*	Cos	Cml	Flc	Total	G	M1	P	Total	I	M2	D	Total	Yes	No
1	Highway North (n=39)															
	Head	2	15	9	13	39	10	10	19	39	1	3	35	39	2	37
	Middle	1	3	17	18	39	11	15	13	39						
	Tail	1	3	2	23	39	8	15	16	39						
	Sub-total	**4**	**21**	**38**	**54**	**117**	**29**	**40**	**48**	**117**	**1**	**3**	**35**	**39**	**2**	**37**
2	Highway South (n=48)															
	Head	2	18	15	13	48	22	23	3	48	4	10	34	48	3	45
	Middle	1	8	21	18	48	26	19	3	48						
	Tail	3	11	19	15	48	22	21	5	48						
	Sub-total	**6**	**37**	**55**	**46**	**144**	**70**	**63**	**11**	**144**	**4**	**10**	**34**	**48**	**3**	**45**
	Grand total	**10**	**58**	**93**	**100**	**261**	**99**	**103**	**59**	**261**	**5**	**13**	**69**	**87**	**5**	**83**
	Percent	3.9	22.2	35.6	38.3	100	37.9	39.5	22.6	100	5.8	14.9	79.3	100	5.7	94.3

Vcs = Gravelly to very coarses and, Cos = Sand to coarse loam, Cml = Coarse to medium loam, Flc = Fine loam and some clayey, G = Good, M1 = Moderate, P = Poor, I = Improved, M2 = Maintained, D = Deteriorated

In almost all of the irrigation systems the resources for repair and maintenance were found to be mobilized from within the system which included cash and labor resources mobilized by the beneficiaries and no perennial external sources were observed. The basis for cash and labor resource mobilization was found to be differing for intake structure, main and secondary canals and for emergency repair and maintenance. For headworks the cash and labor resources were found to be mobilized on the basis of household (53 per cent of systems) and landholding (58 per cent of systems). For main canal however, it was landholding, the basis for cash and labor resource mobilization in most irrigation systems. In emergency repair and maintenance it was household, the basis for resource mobilization.

The characteristics of resource mobilization in the irrigation systems were found to be changing. In several of the irrigation systems it was observed that the water users send hired wage laborers or pay equivalent amount of money to the water users committee, instead of contributing labor by themselves at the time of annual repair and maintenance. An assessment of this trend in the irrigation systems by management types is presented in Table 14. This trend was observed in 65 irrigation systems out of which in 27 of the irrigation systems it was found increasing, in 4 of the systems this trend was found to be decreasing and it was found to be unchanged in 34 of the systems. The frequency of water users using hired labors for repair and maintenance was found to be higher in PCMIS (32 per cent of systems) as compared to TCMIS (15 per cent of systems).

Table 14. Trends of Water Users not Contributing Own Labor During Annual Repair and Maintenance by Management Types.

Trend	Management Types			Total
	TCMIS	PCMIS	MCMIS	
Water Users not Contributing Own Labor :				
Increasing	9	12	6	27
Decreasing	0	2	2	4
Not changed	6	18	10	34
Water Users Contributing Own Labor :	5	13	5	23
TOTAL	20	45	23	88

In TCMIS, the users reported that earlier " Jharahi" was the usual way of labor mobilization wherin all able men in the household used to contribute labor at the time of repair and maintenance. Resource mobilization pattern on the basis of household or land holding size was introduced to the area by migrant pahadiya community which are now prevailing basis for resource mobilization in most irrigation systems in the study area.

Conclusion and Implications

East Chitwan has a larger concentration of community managed irrigation resources initiated at different phases of times, mutually different in size and physical characteristics and operated and managed by different mixes of communities. Unprecedented increase in the population, rapid deforestation and associated land use changes, reduced soil fertility, occurrence of floods in rivers and streams and reduction in the dependability of dry season flow are some of the major environmental changes posing stresses on the irrigation resources of the area. The local communities have with time developed some stress coping mechanism either by formulating more restrictive set of rules for operation and management or by bringing about physical and structural changes in the system. Some of the outstanding conclusions that can be made on this study are:

i. The users have made substantial investments in the irrigation resource development in the study area. There is also some assistance provided by the government but such assistance is usually much smaller as compared to the resources mobilized by the local communities.

ii. Many irrigation systems in the study area were found hydrologically linked illustrating complex water rights. Due to this complex hydrologic linkage, any change in the physical or structural characteristics of one system could have linked effect on the functioning of other systems.

iii. There have already been several visible ecological and hydrologic changes which are posing stresses on the water resources and irrigation systems of the study area. The sustained productivity of these systems could be ensured by checking deforestation, river training works in Rapti river and balanced exploitation of land and water resources.

iv. Depletion of soil fertility, acidification and soil salinity are the emerging issues of farmers concern which are associated to irrigated farming of the study area. These problems need immediate attention as they will have a multiplicative effect in future.

v. The East Rapti Irrigation Project (ERIP) is presently underway in the study area, taking up rehabilitation and improvements of existing irrigation resources. One of the major challenge for the project is ensuring and protecting the water rights of the users since the existing irrigation resources illustrate diverse physical, hydrologic, social and institutional characteristics.

References

Ansari, N. and P. Pradhan, 1991. Assistance to Farmer Managed Irrigation Systems: Experience from Nepal. Ministry of Water Resources, Department of Irrigation, Nepal.

APROSC, 1982. Farm Economics Survey of Selected Public Sector Intensive Irrigation Development Projects. Agricultural Project Services Centre, Kathmandu, Nepal.

CBS, 1981. Statistical Year Book of Nepal - 1981. Central Bureau of Statistics, Kathmandu.

CBS, 1982. Statistical Year Book of Nepal - 1982. Central Bureau of Statistics, Kathmandu.

CBS, 1992. Statistical Pocket Book of Nepal. Central Bureau of Statistics, Kathmandu.

Elder J.W. et al. 1976. Planned Settlement in Nepal Terai: A Social Analysis of Khajura/Bardia Punarvas Project. CEDA, Kathmandu, Nepal.

Hagan Tony, 1961. Nepal: The Kingdom in the Himalayas. Kummerly and Fry, Berne, Switzerland.

IUCN, 1990. Developing a National System for Environmental Impact Assessment. Proceeding of First National Workshop, Kathmandu, Nepal. National Planning Commission, HMG-Nepal and IUCN - The World Conservation Union.

Joshi, J.R. 1981. Chemical and Mineralogical Analysis of Some Soils of Chitwan Valley, Nepal. Unpublished M.S. Thesis. University of Wisconsin-Madison.

Khatri-Chhetri, T.B. 1982. Assessment of Soil Test Procedures for Available Boron and Zinc in the Soils of Chitwan Valley, Nepal. Unpublished Ph.D Thesis, University of Wisconsin, Madison, USA.

Ostrom, E., P. Benjamin and G. Shivakoti, 1992. Institutions, Incentives and Irrigation in Nepal. Nepal Irrigation Institutions and Systems Project. Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, USA.

Parajuli, U. 1993. East Rapti Irrigation Project. A Discussion Paper presented in workshop on " From Farmers Field to Data Field and Back: A Synthesis of Participatory Approaches to Resource Information Systems", held at IAAS, Rampur, Chitwan, Nepal.

Pradhan, P. 1986. A Comparative Analysis of 21 Farmer Managed Irrigation Systems in Nepal, IIMI, Sri Lanka.

Pradhan, P. 1989. Increasing Agricultural Production in Nepal: Role of Low Cost Irrigation Development through Farmer Participation Country Paper. Nepal No. 2, IIMI, Sri Lanka.

Shrestha, G.R., 1990. Small Farmer Community Irrigation Project in Nepal. In Design Issues in Farmer Managed Irrigation Systems Proceeding of an International Workshop of the Farmer - Managed Irrigation Systems Network, Chiang Mai, Thailand.

WECS. 1981. Irrigation Sector Review. Report No. 312/190981/1/1. HMGN. Water and Energy Commission Planning Unit, Nepal.

Yoder, R. and S.B. Upadhayay, 1987. "Reconnaissance/Inventory Study of Irrigation Systems in the Indrawati Basin of Nepal" in Irrigation Management in Nepal: Research Papers from a National Seminar. IAAS/IIMI/Winrock International, Bharatpur, Nepal.

Spring	Jiundi or Mool
An outlet or water course serving as a common conveyance for more than one user	Phadki
A measuring stick usually 7 to 9 hat (1 hat = 1.5 ft) long used for demarcating the length of canal to be cleaned by individual user on unit area basis.	Laggi
Reinforced cement concrete aqueduct	Tarki
Wooden Flume	Dund
Protection of main canal dike at the intake	Peton
Drop structure	Chhango
Group of villages	Mauja

Appendix - II

Irrigation Systems of East Chitwan

S.No	Name of System	Source(s)	Code
1	Mahadev Tar kulo	Lothar	L1
2	Dubichaur kulo	Lothar	L2
3	Rapti Pratappur kulo	Rapti	R1
4	Mahadev Kulo	Rapti	R2
5	Sishabas Kulo	Rapti	R3
6	Parsa Padariya	Rapti	R4
7	Maduwabhar	Rapti	R5A
8	Kusuhana Kulo	Rapti	R5B
9	Janakalyan "Ka" (Thapakaji Kulo)	Rapti	R6A
10	Janakalyan "Ka" (Kathar VDC ward no. 1, 2, 8)	Rapti	R6B
11	JanaKalyan "Kha"	Rapti	R7
12	Chhatiwan Gaindadhap Kulo	Drainage of R1	R1A
13	Dadhuwa Kulo	Martal	M1
14	Martal Dhamili ko Kulo (Hawaldar Kulo)	Martal	M2
15	Beluwa Martal Kulo	Martal	M3
16	Beldiha Kulo	Dhongre	D1A
17	Dhamaura Kulo	Dhongre	D1B
18	Mahal Kulo	Dhongre	D1C
19	Phulauria Kulo	Dhongre	D1D
20	Rampur Kulo	Dhongre	D2
21	Hardi Mathillo Kulo	Dhongre	D3
22	Beldiha Bagar Kulo	Dhongre	D4
23	Hardi Sisanghari Kulo	Dhongre	D5
24	Laugain Kulo	Dhongre	D6

25	Dhongre Kathar Kulo	Dhongre	D7
26	Purwari Majuwa Bich Ko Kulo	Dhongre	D8
27	Purwari Majuwa Tallo Kulo (Bagar Kulo)	Dhongre	D9
28	Majhuwi Kulo	Dhongre	D10
29	Surtana Kulo	Dhongre	D11
30	Badgaon Kulo	Dhongre	D12
31	Tadauli Kulo	Dhongre	D13
32	Jhuwani Kulo	Dhongre	D14
33	Bachhauli Tesro Samuhik Sinchai Yojana	Dhongre	D15
34	Gathauli Kulo (Chuhadi Kulo)	Budhi Rapti	B1
35	Kathar Kulo	Budhi Rapti	B2
36	Khairghari Kulo	Budhi Rapti	B3
37	Kharkhutte Tallo Kulo	Budhi Rapti	B4
38	Jeevanpur Kulo	Budhi Rapti	B5
39	Janakpur Kulo	Budhi Rapti	B6
40	Kapiya Kulo	Budhi Rapti	B7
41	Tin Manje Kulo (Budhi Rapti Chautho Samuhik Sinchai Yojana), Kumroj	Budhi Rapti	B8
42	Naya Simalghari Kulo (Budhi Rapti Pahilo Samuhik Sinchai Yojana)	Budhi Rapti	B9
43	Budhi Rapti Dosro Samuhik Sinchai Yojana	Budhi Rapti	B10
44	Pumpa Kulo	Pumpa Khola	P1
45	Chipleti Kulo	Pumpa Khola	P2
46	Campa Kulo	Pumpa Khola	P3
47	Khurkhure Kulo	Pumpa Khola	P4A
48	Baireni Pakadibas Kulo	Pumpa Khola	P4B
49	Chautara Kulo	Pumpa Khola	P5
50	Baireni Kulo	Pumpa Khola	P6
51	Surtani Kulo	Pumpa Khola	P7
52	Khairahani Parsa Jamauli Kulo	Pumpa Khola	P8

53	Tanahi Kulo	Tanhi Khola	T1
54	Fasera Faserni Kulo	Tanhi Khola	T2
55	Padaria Kulo	Tanhi Khola	T3
56	Mainaha Kulo	Tanhi Khola	T4
57	Chyatrang Kulo	Chatra Khola	C1
58	Pakadibas Chatra Kulo	Chatra Khola	C2
59	Pipra Kulo	Chatra Khola	C3
60	Karaiya Kulo	Chatra Khola	C4
61	Baseuli Kulo	Chatra Khola	C5
62	Rangawa Kulo	Chatra Khola	C6
63	Naya Kulo	Dudh Koshi Khola	Dk1
64	Dudh Koshi Kulo (Sukkha Khola Kulo / Chalis Bighe Kulo)	Dudh Koshi Khola	DK2
65	Sukkha Kulo	Dudh Koshi Khola	DK3
66	Unan Tol Ko Kulo	Dudh Koshi Khola	DK4
67	Patiani Kulo	Patiani Khola	PT
68	Kalika Kulo	Kair Khola	K1
69	Bhateni Ko Kulo	Kair Khola	K2
70	Pithuwa Irrigation Scheme	Kair Khola	K3
71	Chainpur Kulo (Bhutiya Kulo)	Kair Khola	K4
72	Jyamire Kulo	Kair Khola	K5
73	Baheri Paschim Ko Kulo	Kair Khola	K6
74	Belsi Ko Kulo	Kair Khola	K7
75	Chana Pokhari Ko Kulo	Kair Khola	K8
76	Khaireti Kulo	Budhi Khola	BK1
77	Amaliya Madhavpur Kulo	Budhi Khola	BK2
78	Madhavpur Budhi Kulo	Budhi Khola	BK3
79	Madhavpur Upallo "Ka" Kulo	Budhi Khola	BK4
80	Madhavpur Tallo "Kha" Kulo	Budhi Khola	BK5

81	Bakulahar Budhi Kulo	Budhi Khola	BK6
82	Debauli Budhi Kulo	Budhi Khola	BK7
83	Thangkhola-Bungkhola Ko Kulo	Thangkhola Bungkhola	BT
84	Panchkanya Irrigation Scheme	Panchkanya Nadi (Khageri Khola)	PK
85	Pindarahani Ko Purano Kulo	Kuchkuchhe Mool	KM
86	Chiuri Ghol Ko Kulo	Chiuri Ghol	CG
87	Dhusari Mool Ko Kulo	Dhusari Mool	DS
88	Laurighol Ko Kulo	Lauri Ghol	LG