Use of Inventory Methods for Policy Inputs: Experience from Irrigation Resource Inventory of East Chitwan

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BACKGROUND

Sound planning begins with an analysis of focused, realistic and systematic data of a given resource system. The data needed in the areas of rural resource development and management may range from purely technical information on biophysical characteristics of a resource base, to socio-economic structure of appropriators managing and utilizing the resource base. Biophysical data are usually generated through physical and biological experimentation, and measurements. For socioeconomic data collection, several techniques are employed ranging from conventional questionnaire-based socioeconomic surveys, to recent popular techniques of Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA). Geographical Information System (GIS), one of the most recent tools for information gathering and analysis, has the capability to relate both biophysical and socio-economic dimensions of data for meaningful inferences. While techniques like questionnaire-based information generating techniques are criticized for their biasness (Gill, 1992) and called "Survey Slavery" and "Long and Dirty" for their dependence on figures instead of facts (Chambers, 1983, Chambers, 1987), techniques like GIS require sophisticated, costly and largely inaccessible hardware and software.

Resource inventory techniques aim at collecting similar information in a systematic fashion from a resource system within the area of interest. It can be applied to a larger resource boundary such as a macro-watershed or a river basin or to an individual resource parcel within a larger resource boundary with the same strength, consistency and accuracy. RRA and PRA techniques on the other hand are said to be applied with greater success on relatively smaller resource boundaries for more appropriate resource planning and management (Messerschmidt, 1981; McCrackew et al., 1981).

The strengths of the inventory technique are its universal nature, multidisciplinary approach, versatility and quickness. It has been found to be applied to all types of resource bases (Messerschmidt, 1991) and to all sizes of resource bases (Tuladhar et al. 1992; Yoder 1987; Acharya, 1989) with a high degree of success. Inventory techniques involve both measurement and validation of biophysical variables, and collection of socio-economic information using either semi-structured group interviews or individual interaction with the users. Inventory techniques focus on collecting just enough information from the resource boundary to perform required analysis, derive meaningful inferences and develop realistic plans. This technique is quite different than questionnaire surveys which create a data-bunch, devoting more time and efforts for relatively less valuable outputs.

INVENTORY TECHNIQUE: CONTEXT OF RESOURCE FIELD TO DATA FIELD AND BACK

The objective of collection and management of resource information data is to develop a two way communication from the resource field, to the data field, and back. The ultimate goal is to deliver the information, inferences and the decisions based on the inferences, to the participants of resource development and management at all levels--the policy makers outside the resource boundary, the managers within and outside the resource boundary and the users. Within the resource boundary, Bryan (1992) points out that a major limitation of resource information systems is the policy makers' centered approach in information collection and management, neglecting those involved in the implementation of decisions, and more importantly, the users in the resource boundary who are going to be affected by the decisions.

In an irrigation system, for example, the users may be unaware of complex interrelationships between physical, hydrologic and social-institutional attributes determining performance. Presenting them cross comparison of these attributes and performance of several irrigation systems, existing in the same setting or from outside, could provide them information on several of the options available for any changes they are to make.

Further, the inventory of a resource base should be as *participatory* as possible rather than only verification or validation of the data with the users. The users, therefore, are involved or at least consulted at all stages of the inventory--from designing the inventory tool, to data collection. This captures the types of data and information essential to meet the objectives of the inventory. In conventional data collection techniques, the users of the resource base are considered as *objects* of data collection; they never see the outcome of collected information.

The Inventory technique is *innovative*; no single standardized format or approach for data collection is applied to all situations. Like RRA or PRA techniques it is *iterative* and the data collection format develops as the inventory proceeds. It also involves the process of *triangulation* wherein several different sources or means are used to collect information on the whole or part of the resource system. Contrary to RRA or PRA techniques, Inventory is *semi-informal* in the sense that only specific types of data are collected systematically and most of the information gathering is handled informally.

The inventory of a resource base is never complete since it is a dynamic unit and changes with time. The changes are both natural and human-induced. The Inventory technique has a built-in scope to capture the changes that have taken place over time, and incorporate the changes in the database.

A carefully designed inventory can be handled mechanically using micro-computers, which makes the data handling and analysis easier and flow of information from the datafield to the users, managers and policy makers more efficient. An example of this is the Nepal Irrigation Institutions and Systems Database (NIIS-Database) developed by Workshop in Political

Theory and Policy Analysis, Indiana University which includes computer-backed information on 127 farmer and agency managed irrigation systems from different parts of Nepal.

INVENTORY TECHNIQUE: APPLICATIONS IN IRRIGATION DEVELOPMENT AND MANAGEMENT

Inventory techniques have been used for a variety of purposes in irrigation development and management in Nepal and elsewhere. The purpose of inventory varies from provision of preliminary information on existing planned use of water for irrigation in an area or region, to project identification for development and rehabilitation. An example of such an inventory is the district-wise Water Resource Inventory of 59 districts in Nepal carried out by the Water and Energy Commission Secretariat (WECS), now being extended to cover other districts (Tuladhar et al., 1992). In several IIMI supported studies, inventory of farmer managed irrigation systems from different parts of the country have been collected (Pradhan et al. 1987, Shrestha, 1987, Khatri-Chhetri et al. 1987). A WECS-IIMI action research inventory of farmer managed irrigation systems in the Indrawati River Basin in Sindhupalchowk district, was used to identify projects for rehabilitation and improvement (Yoder and Upadhyay, 1987, WECS/IIMI, 1990). In a different inventory, the existing and potential usage of irrigation water in Dhading district has been collected under a WECS/GTZ-supported inventory study (Tuladhar et al. 1992). In the same district, an inventory of existing community managed irrigation system was used to select projects for rehabilitation and improvement.

Inventory techniques have also been used with equal success to document management information and institutional status of water users' associations (Yabes, 1992; Lauraya, 1992). Bruns (1992) have also identified potentials of the inventory technique to cross-compare physical, management and institutional variables and performance of irrigation resources.

IRRIGATION RESOURCE INVENTORY OF EAST CHITWAN

Rationale

The Irrigation Resource Inventory of East Chitwan was conducted by a multidisciplinary team of the Irrigation Management Systems Study Group (IMSSG) at the Institute of Agriculture and Animal Science (IAAS), Rampur. Funding for the study was made available from the Workshop in Political Theory and Policy Analysis, Indiana University, and United Nations Development Program (UNDP) Project On Supporting Decentralization in Nepal.

This study obtained a wide range of information from 88 mutually exclusive community managed irrigation systems in East Chitwan including: the history of irrigation system development, physical characteristics, operation and management, agricultural systems, nature and development of irrigation organization, and their social and institutional characteristics. The study focused on the following key questions: how are the irrigation systems in the study area operating? How effective they are in utilizing the local resources? How have the users developed irrigation organizations? What factors determine operational rules and management practices? How are the characteristics and performance of the agricultural systems? What are the potentials and constraints of each system? The study systematically documented information from a large number of irrigation systems found in the same physical and political locality. The systems were constructed at different times, have different physical characteristics and are operated and managed by different communities.

East Chitwan was selected as a study area for a number of reasons including: a) its high agricultural potential b) the existence of a large number of community managed irrigation systems constructed in different phases of time, and initiated and managed by different mixes of community. The information available on the irrigation resources of the study area, with respect to number and area covered were highly inconsistent. The Water Resource Inventory of Chitwan District (WECS/CEMAT, 1985) for example, reported a total of 35 farmer managed irrigation systems (FMIS) in East Chitwan irrigating 4,941 ha of land. On the other hand, a feasibility study of East Rapti Irrigation project (DIHM/ADB/Nippon Koei, 1986), estimated the total irrigated area under FMIS in the study area to be 4,000 ha during monsoon and about 1,300 ha during dry season. Yet another inventory of FMIS in the East Rapti Irrigation Project area--the majority of which falls within the study area--conducted by DOI/Nippon Koei/SILT Consultants (1990), reports the existence of 86 independent FMISs. The ground validation of the available information through a separate resource inventory was found essential. Further, IMSSG has planned long term irrigation studies through the Rural Resources Studies Program (RRESP) recently initiated at IAAS, Rampur. East Chitwan, being in the vicinity of IAAS, provides a good site and field laboratory for such studies. East Rapti Irrigation Project (ERIP) a large public sector irrigation development and rehabilitation program is underway in East Chitwan under credit assistance from Asian Development Bank (ADB). A major portion of the project activity includes rehabilitation and improvement of several FMISs in the project area. Results from the Resource Inventory of East Chitwan could be useful for the nature of works planned under ERIP. It would be extremely important to document the process and impact of rehabilitation under ERIP.

Methodology

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

An inventory checklist was prepared which was modified in several stages through pre-testing and experiences gathered from the field. The Nepali version of checklist was found useful in improving the communication between interviewer and the respondents. The terms for irrigation management activities used in local dialect (Tharu dialect) of the study area, commonly used by the respondents, were incorporated in the checklist to improve the efficiency of information gathering.

Group interviews were conducted in each of the irrigation systems in the study area using the inventory checklist. The respondents included water users, functionaries of water users' committee and local leaders. Elderly persons were consulted to collect and validate historical information. Attempts were made to make the group interviews as participatory and iterative as possible.

The study team walked with the beneficiaries of the system from the head to tail end of the system and recorded its physical characteristics. This activity cross-checked and validated information obtained from the respondents. The field information was then tabulated; coded information was entered in microcomputer and SPCC/PC Version- 4.0 was used for cross tabulation and frequency analysis for cross comparison of irrigation systems.

The Rapti river and its tributaries are major water resources in the study area. Among them, Lother, Dhongre khola, Martal khola, Budhi Rapti, Chatra khola, Tanhi khola, Kair khola, Pumpa khola, Dudh koshi khola, Budhi khola and Khageri river, are the major water resources supplying water to the community managed irrigation systems in the study area. Some irrigation systems also originate from springs and *Ghols* which are either perennial or seasonal in nature. The total area served through different irrigation systems, obtaining water from each of these sources, is presented in Table 1. The Rapti river flows from Northeast to Southwest. In 1982, the water released from Kulekhani No. 1 Power Plant also began supplementing the natural run off from the Rapti river. The river brings massive boulders and gravel during floods in monsoon, resulting in the constant rise of the river bed. Degradation of the upstream watershed has resulted in high peak floods and low dry season discharge. Serious inundation of prime agricultural land during the floods, and stream bank erosion along the north bank in Piple, Bhandara, Kathar, and Kumroj VDCs have been reported.

All the irrigation systems listed above are accessible by gravel roads linking their service area with Bharatpur-Hetauda Highway. The accessibility, however, becomes difficult during monsoon due to lack of bridges and culverts across many of the streams and canals. The number of irrigation systems in different VDCs in the study area is presented in Table 2. Among the 88 irrigation systems presented in this report, Bhandara (17), Kathar (11) and

TABLE 1. **Distribution of Irrigation Systems and Total Service Area by Sources**

Source	No. of irrigation systems served	Total service area (ha)
Lothar	2	294
Rapti	10	2506
Martal	3	134
Dhongre	18	2120
Budhi Rapti	10	1331
Pumpa	9	982
Tanahi	4	209
Kair	8	1772
Chatra	6	464
Bung khola		
Thang khola	1	120
Patlani khola	1	12
Budhi khola	7	505
Panch kanya nadi (Khageri)	1	268
Dudh koshi	4	90
Springs and Ghols	4	188
Total	88	10995

TABLE 2 **Location of Irrigation Systems by Village Development Committees (VDCs)**

Village Development Committee	No.of Irrigation Systems	Percent
Piple	05	5.7
Bhandara	17	19.3
Khairhani	08	9.1
Kathar	11	12.5
Kathar + Khairhani	01	1.1
Bachhauli	03	3.4
Khairhani + Bachhauli	03	3.4
Kumroj	05	5.7
Birendranagar	10	11.4
Khairhani + Birendranagar	02	2.3
Chainpur	06	6.8
Panchakanya	01	1.1
Ratnanagar	04	4.5
Panchakanya + Ratnanagar	01	1.1
Jutpani	03	3.4
Pithuwa	05	5.7
Kathar + Kumroj	01	1.1
Chainpur + Ratnanagar	01	1.1
Khairhani + Chainpur	01	1.1

Birendranagar (10) VDCs have the largest number of irrigation systems. Ten irrigation systems were located in more than one VDC.

Types of Irrigation Systems

Among the irrigation systems reported, four were found to have multiple sources of water. These are: Rapti Pratappur kulo (R1 => Rapti + Lothar), Badgaon kulo (D12 => Dhongre + Budhi Rapti), Bachhauli Tesro Samuhik Sinchai Yojana (D15 => Rapti + Budhi Rapti), and Unan Tol ko kulo (DK4 => Ladri + Dudh koshi). In Chhatiwan Gaindadhap (R1A), drainage water from Rapti Pratappur kulo (R1) is the supply source.

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 (55.7 percent) irrigation systems to be seasonal and 39 (44.3 percent) to be perennial in nature. The classification of perennial or seasonal irrigation systems was based on whether a system obtains water supply during spring (March-May) and Monsoon (June-September). A system was considered perennial if irrigation water was available in both spring and monsoon and considered seasonal if available only during monsoon. In the study area for the winter crops, either no irrigation is practiced or the area irrigated is too small. Another basis of this classification has been the number of rice crops grown per year. In perennial irrigation systems it is possible to grow two rice crops due to availability of irrigation water during spring season, while only one rice crop (monsoon rice) is grown in seasonal irrigation systems.

By sorting perennial and seasonal irrigation systems by source, a larger number of perennial irrigation systems were found in Dhongre, Budhi Rapti and Rapti rivers (Table 3). All the irrigation systems getting their supply from Rapti, Lothar and Budhi Rapti were found to be perennial while 15 of 16 irrigation systems in Dhongre khola were perennial. The only seasonal irrigation in Dhongre khola was found to be Purwari Majuwa Tallo kulo (D9) where spring season irrigation is impeded due to relatively higher elevation of service area in relation to the source. The head available at the intake is also inadequate to supply water to the service area during the spring.

TABLE 3 Number and Types of Irrigation Systems by Source

Source	Number of irrigation system Perennial	Seasonal	Total
Lothar river	2	0	2
Rapti	8	0	8
Lothar + Rapti	1	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
Pancha nadi (Khageri river)	1	0	1
Spring and ghol	2	2	4
Total	49	39	88

The average size of the irrigation systems in the study area was found to be 125 ha with the range varying 7 to 1005 ha. Rapti Pratappur kulo (R1) was found to be the largest irrigation system in terms of service area and Khairghari kulo (B3) was found to be the smallest irrigation system.

The total irrigated area under 88 irrigation systems included in this study accounted for 10,658 ha of which 6,580 ha of land was found to be irrigated under perennial and 4,078 ha irrigated under seasonal irrigation systems. Table 4 presents a summary of total irrigated area under all the irrigation systems reported in this study during monsoon, winter and spring season. The area irrigated during monsoon (10,658 ha) was found higher than winter (5,417 ha) and spring (5,556 ha) which is due to higher availability of water at the source during monsoon.

Inter-irrigation System Water Use

Inter-irrigation system water use was observed in several of the irrigation systems in the study area (Table 5). As many as 11 of the irrigation systems were found to be using water from other systems, and 12 were found to be providing water to other systems. Three out of nine irrigation systems were providing water to two 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 the initial construction. In some cases, the new system seeking access to water use was paying a fixed sum of money to the system that agreed to provide the access. This was observed in Beldiha kulo (D1A) and Dhamaura kulo (D1B) which paid Rs 5000.00 and Rs 400.00 respectively, for access to water use from Parsa Padariya kulo (R4). In addition, 9 systems were found to be using drainage water from other systems. Usually the drainage from upstream systems is recycled for irrigation on the downstream side.

Sub-surface formations in most parts of the Chitwan district are gravelly and porous (Khatri-Chhetri, 1982; Joshi, 1981). Due to porous subsoil, the water applied on the upstream side reappears and drains into the streams located downstream. Farmers reported that the water supply in Dhongre khola resumes after the farmers in Rapti Pratappur and Sisabas kulo begin irrigating their lands during spring. This shows hydrologic inter-linkages between the irrigation systems, particularly those on the south of Bharatpur-Hetauda Highway.

TABLE 4 **Irrigated Area under Perennial and Seasonal Irrigation Systems by Seasons**

System type	Perennial	Seasonal	Total
Service Area (ha.)	6626.0	4078.0	10,704.0
Irrigated Area by season (ha.)			
Monsoon	6580.0	4078.0	10,658.0
Winter	5294.0	123.0	5,417.0
Spring	5556.0	-	5,556.0

TABLE 5 **Inter Irrigation System Water Use**

Provision		Number	Percent	System Code
Use of water from other systems				
	From 1 system	11	7.30	R2,D1A,D1B,D1C, D1D,P3,P5, C5,BK4,BK5,BT
	From 2 systems	-	0	
	Drainage water	9	10.20	R3,R5B,R1A,P4B, P7,P8,T1,C4,DK4
	None	68	77.30	
	Total	88	100.00	
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	
	Total	88	100.00	

Multiple Usage of Irrigation Water

Multiple usage of irrigation water was observed in 6 irrigation systems. In Dadhuwa kulo (M1), Martal Dhamili ko kulo (M2), and Bhateni ko kulo (K2), water from the irrigation canal is used to operate water mills. Martal Dhamili ko kulo was, in fact, initially built for operating a water mill; the use of this system for irrigation began later. In Rampur kulo (D2), Fasera Faserni kulo (T2), and Panchkanya Irrigation Schemes (PK), water from the system was being used in fish ponds. Rampur kulo (D2) was built primarily to supply water to a Government Fishery Development Program at Bhandara.

TABLE 7 **Community Responsible for Initiation of the Irrigation System of the Study Area.**

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 community	40	45.45
Pahadiya	40	45.45
Agency initiated	2	2.27
DIHM	1	1.14
Govt. fishery	1	1.14
Total	88	100.00

Initiation of the Irrigation Systems

The irrigation systems' ages, based on year of initial construction, are given in Table 6. A majority of the irrigation systems (62 percent) were found to be at least 25 years old. Only 33 (38.37 percent) were found to be less than or equal to 25 years old. As much as 23 (26.74 percent) were constructed over 100 years ago.

Table 6 **Age of the Irrigation System in the Study Area.**

Age (Years)	No. of systems	Percent
Less than 25	33	38.37
25-50	18	20.93
51-75	10	11.63
76-100	2	2.32
More than 100	23	26.75
Total	86	100.00

Of the 88 irrigation systems reported, 46 (52.27 percent) were initiated by the original settlers in the Chitwan valley, and 40 (45.45 percent)were constructed under the initiation of migrant Pahadiya Community who migrated to the valley from different parts of the country in different time periods (Table 7). Among those initiated by the original settlers, 43 irrigation systems were found to be developed by the Tharu community, two by the Darai community, and one jointly by both communities. Two of the systems had been initiated by an external agency: the Pithuwa Irrigation Scheme (K3), initiated by DIHM, and Rampur kulo (D2), initiated by a Government Fishery Development Program at Bhandara.

The resettlement program in the Chitwan valley began in 1953 (2011 B.S) under the Rapti Valley Development Project. Among 41 irrigation systems constructed before 2011 B.S., 35 were found to be initiated by the original settlers, and 6 by the migrant Pahadiya Community. Contrarily, among 47 irrigation systems constructed after

2011 B.S., 34 were initiated by migrant Pahadiya Community and only 11 by the original settlers. This reflects a positive correlation between the migration and irrigation system development pattern in the study area. The Tharu are the pioneers of irrigation system development in the study area. After the resettlement program initiated in 2011 B.S., people from adjoining hill districts (Pahadiyas) migrated and settled in that area. Most of the recently constructed irrigation systems were found to be Pahadiya initiated, while the old systems were initiated by the original settlers.

Management of the Irrigation Systems

The population of Chitwan valley is multi-ethnic and made up of different castes who migrated in at different times. A broader classification of settlements in the valley can be conceptualized as: Tharu communities, Pahadiya communities, and mixed communities. It seemed essential to define and classify the irrigation systems according to community responsible for its management.

Table 8 presents the classification of irrigation systems based on the community responsible for management as: Tharu Community Managed Irrigation Systems (TCMIS), Pahadiya Community Managed Irrigation Systems (PCMIS) and Mixed Community Managed Irrigation Systems (MCMIS). Of the 88 reported irrigation systems, 20 are TCMIS, 45 are PCMIS and 23 are MCMIS. Of the 46 irrigation systems initiated by the original settlers, 20 are managed by the Tharu community, 6 by the Pahadiya and 17 by mixed communities. In 40 of the irrigation systems initiated by the migrant Pahadiya community, 35 were currently being managed by the Pahadiya community and 5 by the mixed community.

Among the 88 irrigation systems, the initial construction of only 5 (5.68 percent) was supported by external agencies, either fully or partially. One irrigation system was supported by the VDC, and the initial construction of two others was supported through Ex-Militarymen Funds. In 83 (94.32 percent) of the irrigation systems, the local community mobilized all the resources used in the initial construction including cash, labor, material and in kinds (e.g., food grains paid to laborers).

Since the irrigation systems were constructed at different times, the cash resources mobilized during initial construction was discounted for meaningful comparison. It was therefore not possible to perform cross comparison of amount of cash and labor resource mobilization in initial construction and relate it either to size or type of the irrigation systems. Considering further validation of information on resource mobilization in initial construction and the analysis to be done, the following initial observations can be made:

1. The users have made substantial investments for irrigation system development in the study area. Support from government agencies and local political institutions were

TABLE 8 Distribution of the Irrigation Systems by Initiators and Management Types

Initiator community	Types of system management			Total	
	TCMIS	PCMIS	MCMIS	Number	Percent
Original settlers	20	9	17	46	52.27
Tharu	20	6	14	43	48.86
Tharu+Darai	0	1	0	1	1.14
Darai	0	2	0	2	2.27
Migrant community	0	35	5	40	45.45
Pahadiya	0	35	5	40	45.45
Agency initiated	0	1	1	2	2.27
DIHM	0	1	0	1	1.14
Govt. fishery	0	0	1	1	1.14
Total	20	45	23	88	100.00

also observed in some systems, but such assistance is usually much smaller compared to resources mobilized by the local community.

2. Resources mobilized by the local community include primarily cash and labor, and in some cases, food grains--to pay for the hired laborers.

3. Cash and labor resources were mobilized on either a per household basis or in proportion to the size of land held in the irrigated area. Usually, cash resources at the time of initial construction was mobilized on the basis of landholding size (21 out of 25 systems), and labor resource on the basis of household (18 out of 24 systems).

4. In 51 out of 88 irrigation systems, no record of resources mobilized in initial construction could be obtained because either the systems are too old and no record could be obtained, or the respondents could not make any estimates.

TABLE 9 **Frequency of Rehabilitation and Improvement in the Irrigation Systems**

Frequency of rehabilitation and improvement	Types of system management			Total	Percent
	TCMIS	PCMIS	MCMIS		
0	3	15	6	24	27.30
1	13	24	13	50	56.80
2	4	5	3	12	13.60
3	0	1	1	2	2.30
Total	20	45	23	88	100

Rehabilitation and System Improvement

The rehabilitation and improvement works done on the irrigation systems were found to be of various types. These include construction of permanent or semi-permanent diversion structures, head regulators, provision of cross-drainage works, and the construction of water allocation and distribution structures. These also include improvement of canal carrying capacity, of their lengths, and of the acquisition of water from other irrigation systems in the neighboring areas.

Rehabilitation and improvement works were observed in 64 of the 88 irrigations systems. Of them, 24 had no rehabilitation or improvement schemes; in 14 systems, improvement and rehabilitation works had occurred more than once (Table 9).

The impact of rehabilitation and improvement in most cases was reflected in terms of reduced repair and maintenance needs of the system resulting in decreased labor and/or cash resource mobilization at the time of repair and annual maintenance. Increased areas under irrigation and more reliable water delivery were also observed in some irrigation systems following rehabilitation and system improvement.

Improvement and rehabilitation resources were mobilized from both internal and external sources. The internal resources include cash and labor contribution by the beneficiaries. In 27 of the 64 irrigation systems where rehabilitation and improvement works were done, all the resources were mobilized by the beneficiaries. In 37 systems, assistance came from external sources.

A number of agencies including DIO, FIWUD, SFDP of ADB\N, CIP, King Mahendra Trust for Nature Conservation (KMTNC), CARE-Nepal, Department of Roads (DOR) and VDCs had provided assistance in rehabilitation and improvement. Table 10 presents the number of irrigation systems which received assistance from each of these agencies.

TABLE 10 Distribution of Irrigation Systems by their Management Types and Agencies Providing Assistance in Rehabilitation and Improvement

Agencies	Types of system management			Total	Percent
	TCMIS	PCMIS	MCMIS		
DIO	2	6	3	11	29.73
FIWUD	2	1	2	5	13.51
SFDP	0	1		2	5.41
SFDP+CARE-Nepal	0	2	0	2	5.41
CIP	0	0	2	2	5.41
DDO	2	2	1	5	13.51
VDC	0	1	0	1	2.70
DOR	0	1	0	1	2.70
DDO+FIWUD	1	0	1	2	5.41
DIO+KMTNC	3	0	1	4	10.81
FIWUD+SFDP	1	0	0	1	2.70
VDC+DIO	1	0	0	1	2.70
Total	12	14	11	37	100.00

TABLE 11 Distribution of Irrigation Systems by the Types of Headwork

Original diversion structures	Present diversion structures				Total
	Brush-wood	Semi per-manent	Perma-nent	Water pond	
Brushwood	40	37	4	0	81
(92.0)					
Semi-permanent	0	3	1	0	4
(4.5)					
Permanent	0	0	2	0	2 (2.3)
Inundation type off-take	0	0	0	1	1 (1.1)
Total	40 (45.5)*	40 (45.5)	7 (8.0)	1 (1.1)	88 (100)

* Figures in the parenthesis indicate percentage

The District Irrigation Office (DIO) was the largest contributer, supporting 11 irrigation systems for rehabilitation and improvement. External assistance comprised 12 out of 20 TCMIS, while such assistance was mentioned in 14 out of 45 in PCMIS and 11 out of 23 in MCMIS. Assistance from more than one agency was noticed in ten of the systems.

Types of Headwork

The major types of headwork in the irrigation systems of the study area include temporary brushwood check dams, gabion boxes used as semi-permanent diversion structures, and permanent cement concrete gated diversion weirs. Some systems were also found to be using inverted siphoning systems 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 11. This table indicates that a total of 40 systems have brushwood, 40 systems have semi-permanent, and 7 systems have permanent diversion structures. Only one system was found to be using a direct offtake through inundation canals. Table 11 also indicates that at the time of original construction, a total of 81 systems had brushwood, 4 systems semi permanent and 2 systems had permanent diversion structures. Most of the systems with permanent diversion structures are of recent construction with external assistance.

The main and secondary canals in most of the irrigation systems reported are unlined. The average length of the main canal of all systems was 2.98 km (Table 12). Out of 87 systems, the main canal length in 8 systems is more than 5 km; 4.1 to 5 km in 11 systems; 3.1 to 4 km in 13 systems; 2.1 to 3 km in 18 systems; 1.1 to 2 km in 26 systems; and up to 1 km in 11 systems. The irrigation system with the longest main canal (10 km) was found to be Amiliya Madhavpur Kulo (BK2). The shortest (200 m) was observed in Rangawa Kulo (C6). The systems with relatively longer main canal include Pithuwa Irrigation Scheme, Jhuwani Kulo and Budhi Rapti Dosro Samuhik Sinchai Yojana. In almost all cases (94 percent), secondary canals for irrigation water distribution was noted (Table 13). Budhi Rapti Dosro Samuhik Sinchai Yojana had the most branches (17) followed by Pithuwa Irrigation scheme and Janakpur Kulo with 16 branches each. Most systems (42) had 1 to 3 branches, followed by 4 to 6 branches in 22 systems, and 7 to 9 branches in 13 irrigation systems.

TABLE 12 **Distribution of Irrigation Systems by Length of Main Canal**

Length of main canal (m)	Number of irrigation systems
Up to 1000	11
1100 - 2000	26
2100 - 3000	18
3100 - 4000	13
4100 - 5000	11
More than 5000	8
Total	87

Table 13 **Distribution of Irrigation Systems by Number of Secondary Canals**

Number of Branches	Number of Irrigation Systems
No branches	5
1 - 3	42
4 - 6	22
7 - 9	13
More than 9	5
Total	87

Structures for Cross-drainage Works

Piped culverts and flumes are the major types of cross drainage structures in many of the irrigation systems. These are mostly permanent in nature except in few cases where the users have designed and constructed wooden flumes/aqueducts and culverts with their indigenous knowledge and resources.

Structures for Water Allocation and Distribution

Cement, concrete, or wooden proportional weirs for water allocation were found in 17 irrigation systems. As many as four to five cement concrete proportional weirs were found in systems such as Sisabas Kulo (R3), Parsa Padariya (R4) and Dhamaura (D1B) Kulos. In the irrigation systems with no proportional weirs, gated outlets, piped outlets and temporary outlets of specific sizes were found. The size of these outlets were proportional to the area irrigated. The most (60) wooden check gates were found in Pampa Kulo (P1). The quantity of water allocated in each branch or outlet was proportional to the supply basis, or based on a time-area relationship. In the absence of permanent water allocation structures, farmers erect temporary checks of wooden stakes, bushes, stones and earthen materials across the main canal to ensure near proportional allocation of irrigation water.

Other Structures

In order to control and regulate the quantity of water in the canal during high floods, permanent and temporary head regulators were provided at the intake in some irrigation systems. The systems with permanent head regulators are Mahadevtar (L1), Majhuwi Kulo (D10), Pithuwa Irrigation Scheme (K3) and Khairahani Parsa Jamauli Kulo (P8). In Beluwa Mortal Kulo (M3), users have provided a wooden flume along the main canal at the intake to regulate the flow during high floods.

The original settlers include Tharus, Darais, Rais, Kumals and Bhotes. Among the original settlers, the Tharu community is in the largest, existing in 53 out of 65 systems. The migrant Pahadiyas have settled in 86 out of 88 systems. The Pahadiyas migrated mostly from the central and western hills of Nepal.

The average number of households in the study area was 140. The number of households ranged from 7 in Martal Dhamili ko Kulo to 1100 in the Pithuwa Irrigation Scheme. Land holding size of most farmers was less than one hectare. In most of the irrigation systems, the farmers were owner/operator though share cropping; lease holding was also found in some cases.

Nature of Organization

Nearly one-tenth of the systems had no formal users' organization (committees). Eighty five percent of the WUOs were meant only for the operation and management of the irrigation systems. Some organizations such as Badgaon (D12) and Rapti Pratappur (R1) were also responsible for social welfare such as school management. All the irrigation systems except Pithuwa Irrigation Scheme (K3) were unitary in nature with only one tier of irrigation organization. In the Pithuwa Irrigation Scheme, branch canal committees function at secondary canal level, and a federation of all branch committees functions at the main system level. No such federation was found in Beldiha (D1A), Dhamaura (D1B), Mahal (D1C) and Phularia (D1D) kulos despite the fact that they use water from the same intake. Although these four systems are commonly known as Char Mauje Kulo, they each have a separate organization without a formal linkage among themselves.

The committee members were selected by general consensus of the appropriators during the users' assembly (general body meetings). The tenure of the executive body members was not specifically mentioned in most (73 percent) systems. Members would not be changed or replaced unless their honesty and capability were no longer valued by the appropriators and/or the individuals no longer had an interest to remain on the committee. More specifically, the executive members or functionaries would be removed from their positions by the general body meetings only under the conditions that the functionaries misused the funds. The official term of the functionaries in one-tenth of the systems was one year, whereas in 4 out of 88 systems, the duration of the tenure is fixed up to five years. No ex-officio functionaries were observed except in Pithuwa Irrigation Scheme where the elected chairman of Pithuwa VDC was also the chairman of Water Users' Committee.

Selecting the functionaries was based on leadership quality, interest, experience, and involvement in social welfare activities. No formal discrimination against caste or sex was found, no female functionaries in Water Users' Committee were observed.

In 70 percent of the systems, the executive committee members were not given any additional facilities. Full exemption from cash or labor contribution for repair and maintenance was noticed in one-fourth of the systems. In only one system (Rapti Pratappur), the chairman and vice chairman receive the cash equivalent to 12 percent of the total funds raised by the committee.

Table 14 shows the distribution of committee functionaries by the management types of irrigation systems. A maximum number of systems (41%) had a total number of executive members ranging from one to five. Tharu managed systems have a smaller number of functionaries than Pahadiya managed systems. A higher number of executive committee members were found in Rapti Pratappur, Pithuwa Irrigation Scheme and Bachhauli Tesro Samuhik Sinchai Yojana.

The executive committees also show functionary hierarchies ranging from simplest to complex. As shown in Table 15 most systems had an organization consisting of chairman, vice chairman, secretary, treasurer and members followed by chairman, secretary, and members.

TABLE 14 **Distribution of Number of Executive Committee Functionaries by Management Types of Irrigation Systems**

Number of Executive s Members	Types of Irrigation Management TCMIS	PCMIS	MCMIS	Total
No Members	1	6	3	10
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

TABLE 15 **Distribution of Categories of Functionaries by Management Types of Irrigation Systems**

Categories of functionaries	Types of irrigation systems TCMIS	PCMIS	MCMIS	Total
1. Chairman	0	1	1	2
2. Chairman+Members	2	1	2	5
3. Chairman+Vice chairman	0	0	1	1
4. Chairman+secretory	1	0	0	1
5. Chairman+Vice chairman+ Members	0	3	1	4
6. Chairman+Secretary + Members	3	11	3	17
7. Chairman+ Secretary Treasurer+ Members	6	2	4	12
8. Chairman+Vice chairman+ Secretary+Members	4	5	5	14
9. Chairman+Vice chairman+ Treasurer+Members	0	1	0	1
8. Chairman+ Vice chairman+ Secretary+ Treasurer+ Members	3	14	3	20
9. Chairman+Vice chairman+ Secretary+Joint- secretary+ Members	0	1	0	1
No Functionaries	1	6	3	10
Total	20	45	23	48

Special Appointments

A quarter of all systems had no provision for any special appointments like a peon or Dhalpa, of which 60 percent were PCMIS. Of those with a provision, ninety percent, 66 percent and 78 percent of the TCMIS, PCMIS and MCMIS had appointed at least one peon or Dhalpa. Except in the case of Government assisted irrigation systems (Panchakanya Irrigation Scheme and Pithuwa Irrigation Scheme) the peons are selected/appointed from among the appropriators. The peons are responsible for informing the decisions made by executive committees especially Banwari to the appropriators. They are also responsible for checking the condition of the irrigation system and communicating with the chairman.

General body meetings are held at least twice a year in most systems (73%). Generally, the meetings are conducted during January to February (just before transplanting spring paddy) and/or May to June (before transplanting monsoon paddy). The purpose of the general body meetings mentioned were any one or more of the followings: a) deciding the date of repair and maintenance, b) amending rules regarding fines (kadarai) for absentees during repair and maintenance, c) amending the rules regarding the distribution of the irrigation water, d) amending rules related to penalties for defaulters, and e) forming or updating executive body members.

Executive Body and Emergency Meetings

Only one-fifth of the systems conduct executive body meetings. The agendas of such meetings are related to making decisions regarding repair and maintenance, and the improvement and rehabilitation of the systems. Emergency meetings were regarding repair and maintenance, and were occasionally conducted.

A majority of the systems (62.5 percent) had a provision for keeping records of general body meetings, executive body meetings or emergency meetings.

Inter-system Water Allocation

In most systems observed, inter-system water allocation at the source was based on mutual consensus among the water users of both the upstream and downstream irrigation systems. This is practiced particularly during the water deficit periods. Usually the users from the downstream systems approach the water users committee of the upstream systems through the functionaries of their committee, and make an informal request for their share of water. Cases of stealing water by breaking the diversion structure of the upstream system were also observed, often resulting in conflicts between the up- and downstream systems. Formal legal right of access to water at the source exists between Surtana (D11) and Badgaon kulo (D12), Tadauli (D13) and Jhuwani kulo (D14) and between Khurkhure kulo (P4A) and Baireni Pakadibas kulo (P4B).

Table 16 presents different water allocation patterns. During water adequate periods, most systems (38) adopt continuous supply methods. However, in order to meet the water demand within the system, about 12 systems allocate water to fields or users on genuine demand only. On the other hand, 31 systems were found to adopt a combination of continuous and demand-based supply by assessing the genuine demand of needy users. Few systems suffer from scarcity of water even during monsoon season due to the ephemeral nature of the streams as a source of water supply to the systems. Consequently, five systems have been compelled to adopt a more restrictive set of water allocation methods during monsoon season. Panchkanya Irrigation Scheme is one such example where water is allocated on the basis of type of land to be irrigated. Table 16 indicates that allocation of water based on number of secondary canals is the most practical method adopted in 24 irrigation systems. However, Time-Area relationships have become the most viable water allocation technique, adopted in 23 systems during water deficit periods.

Farmers have also developed allocation techniques by assessing the time required for a given stream size to saturate a given size of land. About seven systems have adopted this type of water allocation pattern in the study area. Rotation of water supply starting from head reach to tail reach of the irrigation system was the most common distribution schedule observed. Few systems, however, alternate between head reach and tail reach so as to ensure equitable distribution of water. In order to make the rotation of water supply more systematic, farmers have increased delivery time to the given supply moving towards the tail reach for the same size of

TABLE 16 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	-	2
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 (ie. 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 (ie.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

land taking into consideration the time elapsed and losses in conveyance of water. Other prevailing distribution schedules include time slot allotment to individual user, distribution from one field to another, and delivery of water to the tail and head end, during the day and night time respectively.

In systems where water is distributed by share or time rotation, based on the proportion of land in the irrigated area, there are wooden or concrete proportional weirs (*jhyal*), piped outlets, and gated outlets, in the canals, which help users monitor the flow of water. Without permanent water distribution structures, users utilize locally available materials like wooden stakes, bushes and soil slices in order to maintain constant depth of flow in branch bifurcation points, in the main canal, for proportionate release of water in different branches. The width of outlets directly connected to the main canal are inspected and adjusted by the WUO functionaries or water monitors to allow a definite release of water supply.

In some systems, particularly those adopting rotational allocation, water supply turns ranged from once in 8 hours, to once in 6 days. These turns were fixed, based on the size of irrigation system, nature of the source, canal network, type of land and topography.

Annual Repair and Maintenance

Annual repair and maintenance of the irrigation systems includes desilting of the main and major branch canals, repair of intake structures and strengthening of canal dikes. Most of the perennial irrigation systems desilting was conducted twice a year; once before spring rice season during Feb - March, and before monsoon rice season during May-June. In seasonal irrigation systems, however, desilting of the canal network is done only once before the start of monsoon season during April-May. Some irrigation systems, particularly those tapping water from the Rapti river, also repair approach canals from the Rapti river at the same time.

Emergency Repair and Maintenance

Repair of the diversion structure and main canal embankment are the primary forms of emergency repair and maintenance. The brushwood type diversion structure must be repaired every time it floods. Diversion structures in systems receiving water from the Rapti and Lather rivers, are repaired most frequently. Dhongre and Budhi Rapti are perennial streams with steady flows from their sources; they have a lower incidence of high flood and subsequently have lower maintenance requirements. Due to a high incidence of floods during the monsoon season, the irrigation systems dependent on seasonal streams like Pumpa khola, Tanhi khola, Chatra khola, Budhi khola and Dudh koshi khola have a higher rate of diversion structure repair. Cash and labor are mobilized by the water users to carry out repair of intake structures and desilting of the canals; almost no resources were solicited from outside the system. For Pithuwa (K3) and Panchkanya (PK) irrigation schemes, a budget is allocated from DIO annually to meet the repair and maintenance expenditure. The farmers from Pithuwa Irrigation Scheme reported last year, that the amount of Rs. 70,000.00, allocated by DIO, was inadequate. They, therefore, had to raise the remainder of expenses from among the users.

The basis for cash or labor resource mobilization was different for intake structure, main and secondary canals and for emergency repair and maintenance (Table 17). For headworks in most irrigation systems, cash and labor resources were mobilized based on household (53) and landholding (58), respectively. For main canal, it was based on land holding. For emergency

TABLE 17 **Distribution of Irrigation Systems for Cash and Labor Resources Mobilization Under Different Management Types**

Basis	Management types						Total	
	TCMIS		PCMIS		MCMIS			
	Cash	Labor	Cash	Labor	Cash	Labor	Cash	Labor
Headwork								
None	3	0	17	5	8	4	28	9
Household	0	11	2	30	0	12	2	53
Landholding	17	8	26	10	15	7	58	25
Jharahi	0	1	0	0	0	0	-	1
Main canal								
None	3	0	13	6	8	4	24	10
Household	0	0	1	23	0	8	1	3
Landholding	17	19	31	16	15	11	63	46
Jharahi	-	1	-	0	-	0	-	1
Secondary canal								
None	19	2	37	4	21	3	77	9
Household	0	0	0	23	0	9	-	23
Landholding	1	17	8	18	2	11	11	46
Jharahi	0	0	0	0	0	0	-	-
Emergency repair								
None	19	3	40	13	20	8	79	24
Household	0	11	0	26	0	13	0	50
Landholding	1	4	5	4	3	2	9	10
Jharahi	0	2	0	2	0	0	0	4

repair, household was found to be the basis for cash and labor resource mobilization. *Jharahi*, wherein all able men in the household contribute labor at the time of repair and maintenance, was observed in TCMIS only for headworks and main canal.

Methods of resource mobilization are changing. In several of the irrigation systems, water users send hired wage laborers, or pay the equivalent amount of money, to the water users committee instead of personally contributing to the annual repair and maintenance schedule. This trend is presented in Table 18. This trend was observed in 65 irrigation systems. In 27 of the irrigation systems, the trend was increasing; in 4, it was decreasing, and in 34 systems it remained unchanged over time. The frequency of water users using hired labors for repair and maintenance was found to be higher in PCMIS (32) as compared to TCMIS (15).

In TCMIS, the users used to practice *Jharahi* to mobilize labor resource. They learned their current pattern of resource mobilization based on household per landholding size from the migrant Pahadiya community.

Some water users raise funds from their community to contract out the annual repair and maintenance works.

The rules and regulations in all the systems were related to the allocation and distribution of water, resource mobilization for repair and maintenance, charging fines for being absent during repair and maintenance (Kadarai), and penalties for the defaulters of the rules and regulations. Three quarters of the systems (60 percent) have written rule, but 70 percent of TCMIS have no written rules. However, the information on extent of rule follow reveal that it is high in 75 percent, 64 percent and 60 percent in TCMIS, PCMIS and MCMIS respectively. Rule violators face a variety of sanctions. If someone violates the labor obligation rule or is absent during annual repair and maintenance work, monetary fines are imposed. The amount of the fine (*Kadarai*), in most cases, is equivalent to the daily labor wage rate in the particular area. In some systems, where the availability of labor

TABLE 18 **Trends of Water Users not Contributing Labor During Annual Repair and Maintenance Under Different Management Types**

Trend	Management types			Total
	TCMIS	PCMIS	MCMIS	
Water users not contributing labor	15	32	18	65
Increasing	9	12	6	27
Decreasing	0	2	2	4
Not changed	6	18	10	34
Water users contributing labor by themselves	5	13	5	23
Total	20	45	23	88

TABLE 19 **Distribution of Irrigation Systems by Types of Fines Imposed on Defaulters and Management Types**

Nature of fine	Management types			Total
	TCMIS	PCMIS	MCMIS	
No fine	4	9	6	19
Monitory Fine	8	13	9	30
Cessation of water turn	0	3	1	4
Monitory fine + cessation of water turn	8	17	2	27
Monitory fine + cessation of water turn + removal from water users	0	3	5	8
Total	20	45	23	88

is scarce the defaulters must pay slightly more (NRs 5 to 10) than the daily labor wage. Fines and sanctions imposed by different communities are presented in Table 19.

If someone violates the water allocation rule, the defaulters are required to pay a monetary fine and/or receive social sanctions. The sanctions are graded according to the severity of the violation. Graduated sanctions are present in 40 percent, 44 percent and 26 percent of TCMIS, PCMIS and MCMIS respectively.

CHARACTERISTICS AND PERFORMANCE OF AGRICULTURAL SYSTEMS

Prevailing cropping patterns in the study area are presented in Table 20. They were categorized by either perennial or seasonal irrigation systems. To obtain more specifics, the perennial irrigation systems were further categorized as water adequate and water deficit. Perennial irrigation systems are defined as water adequate, if irrigation is possible year round, and water deficit, if irrigation is not possible during any seasons. In most cases, however, winter season irrigation was impossible in the water deficit perennial systems.

The most widely propagated crop sequences in the perennial/adequate, perennial/deficit and seasonal irrigation systems were spring-paddy/monsoon-paddy-mustard, spring paddy-maize/monsoon paddy-mustard, and spring-maize/monsoon-paddy-mustard respectively. Other crop sequences observed consisted of lentil, wheat, winter maize, mustard plus lentil, and lentil relayed with monsoon paddy. The cropping intensity, in general, was 300 percent in perennial irrigation systems, and about 200 percent in seasonal irrigation systems.

Among the paddy cultivators, CH-45 and mansuli are the single most popular varieties of spring and monsoon. Rampur composite and

TABLE 20 **Cropping Pattern Under Perennial and Seasonal Irrigation Systems in the Study Area**

Perennial System Code	Cropping Pattern	Seasonal System Code	Cropping Pattern
1 Water Adequate Systems			
R1 R2 R3 R4	Sp-Mp-Wm	M1 M3 T3 T4	Mp-Mu-Sm
R5A R5B R6A	Sp-Mp-Wh	P8 C1 C2 C3	Mp-Lt-Sm
R7 KM B1 Bk1	Sp-Mp-Mu	C4 C5 C6 P2	Mp-Mu+Lt-Sm
D1A D1B D1D	Sp-Mp-Lt	P3 P4A P4B P5	Mp-Mu+Lt-Fa
D3 D4 D5 D6	Sp-Mp-Mu+Lt	P1 PT BK2 BK3	Mp-Wh-Fa
Sp-Mp/Lt	BK4 BK5 BK6 BK7	Mp-Wm-Sm	
K1 K2 K3 K4 K5	Mp-Fa-Sm		
		K6 K7 K8 T2 CG	Mp-Po+Wh/Sm
		BT DK1 DK2 DK3	Mp-Fa-Fa
		DK4 DS	Mp/Lt-Fa
2 Water Deficit Systems			
L1 L2 R1A R6B	Sp & Sm-Mp-Lt		
M2 D1C D7 D8	Sp & Sm-Mp-Mu		
D9 D10 D11 D12	Sp & Sm-Mp-Wm		
D13 D14 D15 P6	Sp & Sm-Mp-Wh		
P7 B2 B3 B4 B5	Sp & Sm-Mp-Mu+Lt		
B6 B7 B8 B9	Sp & Sm-Mp/Lt		
B10 PK T1 LG			

Sp=Spring Paddy; Mp=Monsoon Paddy; Mu=Mustard; Sm=Spring Maize; Wm=Winter Maize; Po=Potato; Lt=Lentil; Wh=Wheat; F=Fallow

Arun-2 are the popular maize varieties, whereas UP-262 and RR-21 are the popular wheat varieties. Chitwan local is the only mustard variety available.

Crop Area and Productivity

The area and productivity of major crops in seasonal and perennial irrigation systems is presented in Table 21. During the monsoon, most of the area under seasonal (4,078 ha) and perennial (6,577 ha) irrigation was paddy. Crop diversification and their area coverage was observed during winter and spring both in perennial and seasonal irrigation systems. During spring season, more spring paddy and less spring maize was observed in perennial irrigation systems. Contrarily, spring maize was more abundant than spring paddy in the seasonal irrigation systems.

Table 21compares area and productivity of major crops in seasonal and perennial irrigation systems. The productivity of all crops in general was higher under perennial irrigation systems than seasonal irrigation systems, except winter maize. The productivity of spring paddy under both the perennial and seasonal systems was distinctly higher than the productivity of monsoon paddy. The higher productivity of spring paddy is attributed to the cool nights, longer day length, and bright sunshine.

TABLE 21 Area and Productivity of Major Crops Under Seasonal and Perennial Irrigation Systems.

Season/crop	Type of irrigation system				Total
	Perennial		*Seasonal*		
	Area (ha)	Productivity (qtl/ha)	Area (ha)	Productivity (qtl/ha)	
Monsoon					
Paddy	6577	36.9	4078	30.3	10,655
Winter					
Wheat	597	27.3	516	14.0	1,113
Mustard	4113	6.6	1924	4.0	6,037
Lentil	1224	7.6	868	6.5	2,092
Maize	136	17.6	72	1.2	208
Spring					
Paddy	4684	45.9	34	43.8	4,718
Maize	1349	19.6	1565	12.5	2,9914

SUMMARY, CONCLUSION AND IMPLICATIONS:

The ultimate goal of resource inventory is to deliver the information, inferences and the decisions based on the inferences, to the participants of resource development and management at all levels: the policy makers outside the resource boundary, the managers within and outside the resource boundary, and the users. In an irrigation system, for example, the users may be unaware of complex interrelationship among physical, hydrologic and social institutional attributes determining performance. Presenting them with a cross comparison of these attributes and performance of several irrigation systems, existing in the same setting or from outside, might provide them information on several options for possible changes.

The inventory of a resource base should be as *participatory* as possible rather than used only to verify data with the users. The users, therefore, must be involved or at least consulted at all stages of an inventory from designing the inventory tool to collecting data, in order to capture reliable and useful data. Conventional data collection techniques view users of the resource base as *objects*. Likewise, the users never see the outcome of this collected information.

The inventory technique is *innovative*, and no single standardized format or approach for data collection can be applied to all situations. Like RRA and PRA techniques, it is *iterative*; the data collection format develops as the inventory proceeds. It also involves the process of ***triangulation***, wherein several different sources or means are used to collect the information. Contrary to RRA/PRA, inventories are *semi-informal* in the sense that only specific types of data are collected systematically, while most of the information gathering is handled informally.

Inventory of a resource base is never complete because of its dynamic quality. Inventories in a database, have an inherent ability to capture and incorporate changes over time. A carefully designed inventory on micro-computer makes the data handling and analysis easier, and flow of information from the datafield to the users, managers and policy makers more efficient. The Nepal Irrigation Institutions and Systems Database (NIIS-Database) developed by the Workshop in Political Theory and Policy Analysis, Indiana University, is a good example, which includes computer-backed information on 127 farmer and agency managed irrigation systems in Nepal.

Inventories are useful for a variety of purposes in irrigation development and management. Inventories can be used to acquire preliminary information on existing or planned use of water for irrigation in a specific area or region. They can also be used to identify projects for development and rehabilitation. Inventories have also been used with equal success to document management information and institutional status of water users' associations.

The present study used an inventory technique to document the history, physical characteristics, operation and management, agricultural systems related to, and the social and institutional characteristics of 88 mutually exclusive community managed irrigation systems in East Chitwan. The output of the Resource Inventory of East Chitwan can be used to convey information from the farmers back to policy level. Additionally, with the collected base line information, follow-up inventories by IMSSG will be able to document the process and impact of the rehabilitation program planned under ERIP (see introduction).

Notes

[1] Other members of the Irrigation Management Systems Study Group include K.R. Adhikary, N. P. Joshi, K.N. Pandit, Rabi Poudel, S.M. Shakya, A.P. Shrestha, T.B. Thapa, and D.N. Yadav. The Irrigation Management Systems Study Group (IMSSG) is a professional group of faculty involved in the study of issues related to irrigation development and management at the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal.

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