RECONNAISSANCE/INVENTORY STUDY OF IRRIGATION SYSTEMS IN THE INDRAWATI BASIN OF NEPAL

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INTRODUCTION

The first official recognition and estimate of the extent of farmer-managed irrigation systems (FMIS) in Nepal was made by the Water and Energy Commission Secretariat (WECS) in 1981. The size of systems ranges from a single farmer's plot consisting of a fraction of a hectare (ha) to the federation of several organizations and diversions into a system which irrigates as much as 15,000 ha. However, it is the sheer number of systems rather than their size that makes the greatest impact on irrigated agriculture. Farmers in Nepal have been active for many generations in pushing the technology available to them to its limit. They have tapped all easily accessible water and land resources to develop irrigated agriculture.

Excluding the systems in the tarai, simple extrapolation of the results shown in this paper along with information from the Land Resource Mapping Project (1986), indicates that there may be well over 17,000 farmer-managed systems in the hills of Nepal. The impact of FMIS in terms of subsistence living and hence the national economy has not been carefully studied. Martin (1986) and Yoder (1986) present data from several communities with perennial irrigation at elevations below 1,000 meters (m) which produce three crops per year. The net annual increase in cereal production with irrigation over that of nearby unirrigated land was found to be well over 6,000 kilograms per hectare (kg/ha). As a conservative estimate one can assume an average increase in production of at least 2,000 kg/ha through FMIS. Using this estimate of yield increase and the WECS estimate that roughly 390,000 ha are irrigated by such systems in all of Nepal, one can show that the incremental increase in production due to **FMIS** is providing the total subsistence level cereal production for at least 30 percent of Nepal's population. This calculation is based on the average cereal consumption of 164 kg/person/yr (Khadka and Gautam 1981). WECS is presently conducting a water-use inventory in the tarai districts which will give a better estimate of irrigated land area. Preliminary analysis indicates that the area irrigated by FMIS may be as much as double the earlier estimates. In this case the dependency upon FMIS for food production may be much higher than the above analysis indicates.

INTERVENTION IN FMIS

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The appearance of most FMIS belies their potential performance. Brush/stone diversions and earth-lined canals leak and require frequent maintenance. This has led development agencies, and engineers in particular, to assume that structural improvements in the water acquisition and delivery system will improve the system efficiency. Further, that efficient operation will allow for more reliable, intensive irrigation of the existing command area, and expansion of the irrigated area where land is available.

Past efforts of intervention in FMIS to improve their agricultural performance have not been highly successful, This is partially due to misdiagnosing the cause of the shortcomings. FMIS are generally built with local materials that decay quickly when not in use. Inspection of systems by technicians responsible for intervention usually takes place in the winter and dry season. At that time many systems do not have water available in their source and farmers do not waste effort in trying to maintain a system that cannot be used for a season. Technicians often declare such systems to be in total disrepair without the understanding that they will be transformed into viable systems by the beneficiaries as soon as water is available. In some cases farmers are willing to invest as much as 50 person-days/ha/year in maintaining their systems (Yoder 1986).

Physical improvements in a system may be a necessary condition for better performance but making structural improvements alone seldom brings the desired results. The strength of an irrigation system with scarce resources that performs well, is its management. Improving the management capability of poorly performing systems may be equally important to making improvements to its physical system. In some cases assistance from outside the community has eroded local management and resource mobilization capability.

The magnitude and impact of resource mobilization by the beneficiaries is not well known or understood. The high performance of some FMIS is attributed to the capability to mobilize tremendous labor and cash resources for operation and maintenance (Yoder 1986). One system in Gulmi, two in Palpa and one in the Nawalparasi hills were intensively monitored for 18 months in 1982-83. In systems where the water source was adequate, all were producing three irrigated crops each year. Using crop cuts to estimate the yield, the system with least water--producing two crops--had a total annual production of 5,200 kg/ha and those with three crops per year ranged from 7,500 to 9,000 kg/ha. Such examples of intensive agriculture production in FMIS are not isolated cases (Pradhan 1986).

However, some FMIS are operating far below the production level that they could potentially achieve with the available water and land resources (Pant 1985; Tiwari 1986). In many cases farmers have good cause for requesting and actively campaigning to attract outside assistance for structural improvements. In addition to more reliable and extensive irrigation, farmers are interested in reducing the effort--labor and in some cases, cash--that they need to invest in maintenance of their systems.

With increasing interest among agencies to target poorly performing systems for intervention, several practical questions emerge. It is clear that FMIS have been successful in increasing agriculture production. Some systems perform well and are close to achieving their potential. Others perform far below their potential. How does one distinguish between systems? What procedure can be used to quickly collect and analyze information for ranking systems in priority for assistance? How does one analyze the symptoms in order to diagnose the causes of low performance'? How does one intervene to improve the performance?

WECS has engaged in an action-research project to attempt to answer some of these questions.

THE WECS ACTION-RESEARCH PROJECT

The underlying rationale for the WECS action-research project is the hypothesis that farmers in the hills of Nepal have already, to some extent, developed most **of** the sites with potential land and water resources for irrigated agriculture. Few new systems will be built where there is not at least some existing irrigation activity. Where irrigated agriculture already exists, farmers have some irrigation management experience. They also have knowledge about the stream discharge, diversion and canal maintenance problems, soils, irrigated agriculture practices, and benefits of irrigated agriculture. It is expected that food production gains can best be made by examining the existing (running) systems to identify, and to the extent possible, release the constraints that farmers face in increasing agricultural production through intensification **or** expansion of their irrigation system.

The aim of the WECS project is to examine the physical, hydrologic, agronomic, economic, and social/organizational aspects of existing irrigation systems to first identify if there are water and land resources in a community that are not fully utilized, and then attempt to uncover the reason for less than full exploitation of the irrigation potential. Another aim is to develop and test processes to overcome the problems. Emphasis is placed on developing the necessary methods and tools for collecting useful information as quickly and cheaply as possible. After evaluating the alternatives, recommendations for upgrading and improving individual system operation will be made and carried out as a part of the project.

The intent is to carry out all activities in such a way as to enable the beneficiaries to continue to take full responsibility for the operation and maintenance of their irrigation system. This implies maximum participation by the farmers in the identification of the constraints, examination **of** alternatives, choice of the appropriate action, and implementation of the action. The action-research mode of carrying out the work allows specific problems to be addressed as they are identified. Recommended actions can be implemented immediately, offering an opportunity to further study the impact of these activities and to make additional recommendations and carry them out as necessary.

Objectives of the Project

The primary objective of this action-research project is to examine ways to assist farmer-managed systems that will allow them to overcome the constraints limiting intensification and expansion of irrigated agriculture. This includes testing lower-cost techniques and technologies and maximizing the participation and resource mobilization of the beneficiaries. It also includes developing and testing low-cost processes, procedures, methods, and technology for developing under-utilized human and physical resources. The maxim is to do this without shifting the responsibility for operation and maintenance to the government.

The WECS action-research project proposes to assist irrigation systems in the project area. However, success of the project will not be measured by the intensification or expansion of irrigated area, but by the degree to which the objectives of developing processes and procedures are accomplished.

The implementation of the project is being carried out in two phases. The first phase consists of information gathering, analysis, and recommendations of steps for initiating the second phase. The second phase will involve intervention in irrigation systems selected as a part of the first-phase activity. Monitoring and evaluating the intervention will be an integral part of the activity.

The chronological steps taken to carry out the first phase include:

1. Project site selection.

2. Development of the terms of reference for a reconnaissance/inventory and rapid appraisal study of the project area.

3. Selection of a local consulting firm to carry out the first phase field studies.

4. Development of a procedure for the reconnaissance/inventory study and carrying out the field work and report writing associated with it.

5. Selection of micro areas for further investigation by rapid appraisal techniques based on the reconnaissance/inventory study report.

6. Development of a procedure for the rapid appraisal study and carrying out the field work and report writing associated with it.

7. Development of a work plan for the second phase based on the reconnaissance/inventory and rapid appraisal reports by the consultants, and additional field reconnaissance by WECS staff.

With the exception of developing a work plan in the last step, the first phase is complete. The remainder of this paper will examine and analyze the procedure and results of the reconnaissance/inventory step of this activity.

Methodology and Field Procedures

The project site was envisioned to encompass a large river basin and include all of its numerous minor tributaries. The criteria for selecting the site were: accessibility from Kathmandu for supervision and representativeness of the hill areas of Nepal. The Indrawati River basin in Sindhupalchok fit these criteria. To further define the boundaries of the project, only the area above Sipa Ghat, extending four kilometers (km) on each side of the Indrawati River, was included. This excluded the Melaunche River, a major tributary, but included almost all of the remaining irrigated area in the basin.

The consultants were given background materials, including check-lists and write-up guides developed in different parts of the world, and available materials from Nepal. From this material they developed their own lists and guides for both the reconnaissance/inventory and rapid appraisal study.

To carry out the field work the consultants were to use an interdisciplinary team consisting of at least an engineer, a social scientist, and an agriculturalist. However, the nature of consulting firms does not lend itself to fielding such a team. Few persons can be employed full time by consulting firms, therefore individuals who can take leave from their regular jobs are recruited. Frequently the best-qualified persons on the roster are not available and others must be substituted. This allows little flexibility in selecting disciplines.

The reconnaissance/inventory field work was carried out by a civil engineer, an agriculture specialist, one junior hydrologist and two helpers. Some assistance was provided for part of the time in the field by an IIMI social scientist.

The reconnaissance/inventory team visited each irrigation system in the basin. The most important activity was to walk along the length of the canal from the intake to the command area. One or a group of farmers was invited to accompany the team. While walking along the canal the farmers were questioned about the operation and maintenance of the system and the organization that was in place to carry out the various irrigation activities. Problems with the diversion and along the canal were discussed while making this inspection.

Water in the source was estimated while inspecting the intake. Farmers were also asked to estimate the discharge in the stream and relate the observed discharge to that in each irrigation season. In addition to the consultant's estimate of discharge by visual inspection, he asked the farmers to make their own estimate by asking them how they measure water. Usually the response was in <u>ghatta</u> of water (discharge required to drive a locally-built water-powered flour mill assumed to average about 28 liters per second {lps]) or & (water pot used for carrying domestic water holding about 20 liters) or <u>samaha</u> (water basin 5-10 liters). Water for driving a ghatta was further differentiated by asking if the water was sufficient for grinding all types of grain. If at some periods of the year it could only grind millet, the discharge was clearly lower than at other times. Half or one-fourth ghatta of water were also typical responses for discharge estimates. For lower discharges, farmers were asked how long it would take to fill a gagri or samaha. Since time is not generally measured in minutes and seconds by the farmers, they were asked how many times the gagri would fill in the time that it took to smoke a cigarette, which was estimated to be about four minutes.

The error in this type of estimate is high. A mill can grind grain with 0.25 - 1 kilowatt (kw) of power and power is a function of both the discharge and head (height the water is dropped) as well as the efficiency of the particular ghatta. However, it does give an idea of the relative discharge and of the variation over the year, Coupled with information from the farmers about the adequacy of the water supply for irrigating different crops and whether there was sufficient water to expand the area irrigated, the discharge information provided insight into the extent that the water resource had potential for further utilization.

To the extent possible the command area was also inspected. This was a difficult task among the many ridges and valleys and not always possible in the time available. The farmers were asked to estimate the area in the hydraulic command of the canal, how much of that area was actually irrigated, how much was cultivated but not irrigated, and the extent of the waste area. While examining the command area, farmers were also asked about their agricultural practices.

Estimates of land area were more difficult for farmers to make than estimates of water discharge. The cadastral survey of this area is complete and individuals have knowledge about their own holdings but not of the aggregate in the system. The most common measure of land area used by the farmers in this area is the volume of seed required to plant the area. A rough estimate for conversion is 20 patti of seed/ha (91 liters of seed/ha). Unlike most systems studied in western Nepal, few of these systems had quantified the resource mobilization or water allocation of the system on the basis of land area. Therefore, farmers have not needed to compute the total land area or seed required for a system and found it difficult to do so. The accuracy of the land area information could be improved with good quality air photos.

Since maps of a suitable scale are not available, the consultants were asked to make a sketch map of the area showing the irrigation water source, rough alignment of the canal, and layout of the command area. The map included the names and relative locations of the intake, canal, and command area of each system from that particular water source.

RESULTS AND ANALYSIS OF THE RECONNAISSANCE/INVENTORY WORK

The project area covers about 200 square kilometers (km^2). The Indrawati River cannot be used extensively for irrigation because it is deeply incised, and is large, with violent floods. Almost all of the irrigated fields in the project area receive their water from the 25 tributary streams. Most of these streams are steep-sloped having highly destructive, short-duration floods during the rainy season and very little water in the dry season.

The reconnaissance/inventory study identified 119 irrigation systems in the project area with canals longer than 0.5 km. These systems irrigate about 2,100 ha of land and were found to benefit approximately 10,100 households. In addition there are many systems with shorter canals and small command areas in the valley bottoms which have easy access to the available water. These were not included in the inventory because they have little potential for intensification or expansion.

The longest canal was found to be 5.5 km from the source to the command area. On the average the canals are 1.9 km long and serve 100 households. Several systems irrigate over 100 ha. Up to 800 households own portions of land in the larger systems. The average land area served by the systems in the study area is 18 ha. However, the median area covered by a system is about 10 ha.

Of the approximately 3,800 ha within the boundaries that can be irrigated by gravity (hydraulic or gross command area) from the canals, 30 percent is too steep or rocky for cultivation. Of the gross area, 56 percent is irrigated and about 14 percent is cultivated but not irrigated because of insufficient water in the source or inability to deliver the water to the land.

The area irrigated represents about 11 percent of the total 200 km^2 project area. Although the project area is small and no claim can be made that it is average for the hills, this is possibly the best data presently available for estimating the area irrigated by FMIS in the hills and for estimating the total number of such systems. Extrapolation of the number of systems and percentage of area covered by FMIS in the project, to all of the hills and mountains of Nepal, yields an estimate of at least 17,000 systems covering 300,000 ha. The basis for land area in this calculation is taken from the Land

Resource Mapping Project (1986) and only Class I, II, and III land (land classified as supporting cultivation) from the siwaliks, mid-mountains, and high mountains was included.

Out of the 119 systems identified, 25 have received some form of outside assistance in the past 20 years. For some the assistance was a certain tonnage of grain for working on the improvement or rehabilitation of an existing canal. In such cases the beneficiaries did most or all of the work themselves. Eleven systems in the study area have been built (about half are still under construction) by the Department of Irrigation, Hydrology, and Meteorology.

A major accomplishment of the reconnaissance/inventory work is a detailed listing of the potential for either intensifying the cropping pattern or expanding the area irrigated by each system. Out of the 25 basins of the minor streams tapped for irrigation in the study area, only 11 basins with 21 different irrigation systems were identified by the consultant as having land and water resources with potential for expansion of the irrigated area. A more reliable water supply would allow more intensive cropping in many systems beyond these 21 and improvements in both the management and physical system would assist in making this possible. However, assisting the 21 systems identified by the reconnaissance/inventory study is likely to lead to the largest gain in food production.

In addition to the physical resources, the study examined operation and maintenance (O&M) activities of the irrigation systems and agricultural practices. Even by spending very little extra time in each system the team collected valuable information about the historical development of the system, the current organization for O&M, and the capability for resource mobilization. This information was considered along with information about the physical system in determining the potential for expanding water and land resource utilization.

A summary of the effort that went into carrying out the reconnaissance/inventory work is presented in Table 1. Here it is seen that the report writing was more time consuming than the field work. Attention should be given to making the report writing simpler without compromising content and also to making it more readable than the present two volumes totaling 500 pages.

Table 1. Resources expended in carrying out the reconnaissance/inventory work (person-days).

Activity	Office	Field
Preparatory Work[1]	12	2
Field Work	-	50[2]
Report Writing	73	-

[1]This included map collection and study, preparation of question-guide and write-up format, pretesting, etc.

[2]Twenty-one calendar days were spent in the field by the team.

By making a comparison of river basins it is estimated that the same level of intensive field work to cover the entire Sindhupalchok District would require one team to spend about 18 weeks in the field.

DISCUSSION AND CONCLUSIONS

Although the estimates of water discharge and land area are not accurate in absolute terms, the reconnaissance/inventory work is extremely valuable in determining the irrigation development potential in a relative sense. The study has successfully identified the existing irrigated land resource. It has also successfully captured farmer input in identifying under-utilized resources. Finally, it has allowed the identification of systems with obvious potential for intensification or expansion from among those with little or no potential. Through systematic examination, attention is focussed on 21 of the 119 systems. The study provides a combination of information on the agriculture system, management practices, and physical system, giving an insight into the constraints that must be overcome to make the systems more productive.

If this type of study were to be carried out on a district-wide basis it would allow planners and policy makers to set priorities that would maximize returns on investment in development. The cost for completing the reconnaissance/inventory study in Sindhupalchok would be approximately six times what has been invested in studying the Indrawati basin.

Two limitations of the present study should be addressed in future work. The land area estimates need to be improved and potential areas where farmers have not been able to develop irrigation should also be examined. Both of these could best be addressed by using good quality, large-scale air photos in the field. The possibility of using existing air photos by enlarging relevant areas should be examined. By tracing the boundaries of the irrigated area on the air photo, more accurate estimates of area could be calculated. Some effort would need to go into determining the scale of each photo segment by making measurements on the ground or using the cadastral map, if identifiable features can be found on both the photo and map.

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