FARMER-MANAGED IRRIGATION SYSTEMS: HOW SUSTAINABLE ARE THEY?

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Robert Yoder
Visiting Professor
Iowa State University

INTRODUCTION

The heavy investments in irrigation development in developing countries in the 1960s and 1970s have in many cases not yielded benefits on the scale anticipated. One result of this realization has been a closer examination of irrigation systems that are sometimes called farmer-managed irrigation systems. Several important features distinguish farmer systems from those managed by a government-appointed agency. They tend to be under the control of the user from the point of water abstraction from a surface or groundwater source and most decisions, including those about the water distribution among users, are made by users themselves.

Research has shown that though the physical infrastructure of most farmer systems is weak, a strong organization of users can partially compensate this deficit with capacity for rapid response in emergencies and massive mobilization of labor for routine maintenance. A strong organization for system maintenance also tends to enable more equitable water distribution (Martin and Yoder 1987). However, farmer systems are faced with problems that some feel threatens their survival.

Problems Farmer Systems Face

Lift irrigation systems face problems that range from inaccessibility of spare parts for pumps and increases in the cost of fuel, to draw-down of the aquifer by over pumping. Continually deferred maintenance of pumps and canals reduces delivery to a fraction of the design capacity.

Gravity schemes that previously depended upon forest products for maintenance of their diversion and canals are finding access to forests restricted and supplies diminished. In mountainous countries like Nepal, the population increase has necessitated a search for additional land to cultivate and farmers have pushed into previously forested areas of upper watersheds. Irrigators in the lower watershed claim this has reduced the base flow of streams during dry periods and caused more frequent and severe flooding during the rainy season. These are arguments farmers use to urge governmental assistance for physical improvements in their systems.

In most areas in the Hindu Kush-Himalaya Region, with possible exceptions such as Bhutan where population density is still low, the best land for cultivation has been developed and easily available water tapped for irrigation. Farmers opening new areas must negotiate access to water for irrigation with those holding prior rights. Government irrigation developers, however, frequently view water resources as a public good that they are mandated to allocate efficiently and they sometimes overlook or disregard existing use and local rights in order to expand irrigated area. This has resulted in many conflicts between farmers and government staff and the demise of some systems where the existing canal alignment was destroyed or the water diverted to new areas.

Maintaining farmer systems that are largely constructed using earth, stone, and branches is a continual task that is not only arduous but dangerous. In areas of Nepal where access to education has enabled young people to escape from the farm, systems are said to be falling into disrepair due to labor shortages. This is similar to a larger problem that has been evident in northern Pakistan and India for several decades. Male family members seeking better employment opportunities temporarily migrate to the cities and industrial areas leaving the farm enterprise to women, elderly men, and children. Organized collective maintenance necessary to keep systems operating is not always possible due to labor and skill unavailability.

Importance of Farmer Systems

One result of the attention to farmer systems is a better understanding of the substantial contribution to food security they make in some countries. This can be viewed from several perspectives. In Nepal, for example, survival for many families in densely populated hill areas depends on the increased production made possible by their irrigation system. At the national level, at least 45 percent of the nations subsistence cereal requirement is met by the increase in food production made possible by irrigation from farmer-managed systems (WECS/IIMI 1990). Throughout the world, many countries have a significant population whose economic and food security is dependent upon irrigation systems that they manage.

Experimentation is also underway to create a whole new group of farmer-managed irrigation systems. As a mechanism for shifting the operation and maintenance cost to irrigation users and with expectation that productivity will increase, a number of irrigation agencies are experimenting with "turn-over" of management to farmers. In some cases, ownership of the irrigation property is also being shifted from the agency to farmers.

Recognition of the importance of farmer systems, reduced opportunities for expanding irrigated area with new irrigation systems, and "turnover" activities to move systems from agency to farmer management has focussed the attention of irrigation agencies in developing countries on issues related to long-term sustainability of these systems. Agency engineers, government planners, politicians, and researchers tend to have different perspectives of the potential and future viability of farmer systems. Researchers have tended to study systems that are well managed. They suggest that evidence of sustainability of these systems can be found in 1) the very large number of systems that are in operation today, 2) the fact that many farmer systems have survived decades, even centuries, with little assistance from outside the community of users, and 3) that research evidence shows many systems have over time become stronger rather than weaker as portrayed by engineers in many irrigation agencies.

However, some staff from irrigation agencies remain skeptical. They must respond to frequent requests for assistance from farmers and politicians to improve farmer systems that are struggling for survival. When they examine systems they often find that they are in poor condition with even the best far below the design standards they have been taught is essential for reliable operation. They suggest that only a few systems, the ones researchers have tended to highlight, are well organized and functioning adequately for long-term sustainability.

How sustainable are farmer systems in the changing environment of population expansion, reduced availability of materials traditionally used for maintenance, more accessible markets, and opportunities for employment away from the farm? Is there a way to quantify or at least determine the long-term trend in productive output from a system? Is there a way that sustainability can be tested to provide input for appropriate policy decisions? Who should initiate the work necessary to answer these questions?

The purpose for examining sustainability of farmer-managed irrigation systems is to develop appropriate government policy and adjust agency irrigation implementation programs accordingly. Sustainability questions could be addressed from a research perspective but experience has shown that presentation of research results to an implementation agency does not always translate to the desired program modification. This paper explores options for monitoring sustainability from the viewpoint that if an agency can generate the information and carry out analysis with its own staff and resources, the results will be more credible and program adjustment, if necessary, accepted more readily.

FRAMEWORK FOR SUSTAINABILITY ANALYSIS

Concern for the environment, human welfare, and the world food balance has developed from indications that the agricultural resource base, particularly in the tropics, is being over exploited. Examining agricultural systems from the perspective of their long term sustainability has become an important policy consideration in choosing among development options. While it is easy to agree that sustainability is a concern for the future and that it carries an imperative to plan more thoughtfully, a great deal of ambiguity still exists over the definition of sustainability.

Some argue that the ecological term stability (see Dover and Talbot 1987) comes close to describing what is meant by sustainability while others suggest (TAC 1988) that the definition must go beyond stability. Conway (1985) suggested that: "sustainability is the ability of a system to maintain productivity in spite of a major disturbance, such as is caused by intensive stress or a large perturbation." Lyman and Herdt (1988) used Conway's definition and added emphasis on the time dimension. They conclude that, "sustainability is the capacity of a system to maintain output at a level approximately equal to or greater than its historical average, with the approximation determined by its historic level of variability" (Lyman and Herdt 1988). This definition suggests that a sustainable system is one with a non-negative trend in measured output. This differs from the concept of stability, which is considered to be the variation in output measured about the trend line.

In order to use this definition of sustainability as an evaluation criterion, it must be possible to empirically monitor an output trend over time. Such a test requires that at a minimum one be able to specify the system, determine a suitable time period, and measure the output.

Time Period

Determination of the time period for analysis depends largely on the purpose behind the analysis. Assuming that the most important questions to be answered relate to the necessity and value of outside assistance to farmer systems, the time period must look forward far enough to span the adjustments and learning by experience that accompany changes in a system. It must also look backward as far as possible to identify the past trend in output to determine if the direction and relative magnitude changes in the future. This suggests that two distinct activities should be performed; assessment of past changes in output, and implementation of a means for recording future changes.

There must be an adequate period to project system output into the future with sufficiently low probability of error while consideration for the cost mandates keeping it as short as possible. Given that learning by experience and associated adjustments are a slow process, a period of five cropping years beyond any major changes in a system would probably be the minimum over which to observe a trend in output and ten years give a more reliable indication. Consideration will need to be made for the ability to monitor output consistently for such a period.

System Boundaries and Output

Setting the boundary for level of analysis within the system determines the output that must be measured. The most important objective of an irrigation system is to deliver water in the right quantity at the right time to the root zone of plants. It follows that the lowest level of meaningful analysis of irrigation system sustainability is water delivery.

At a higher level, the boundary of analysis could also be set to monitor the effect of water delivery with crop production measured as the output. However, this requires consideration of numerous external factors that influence production. The boundary of analysis could be set at the farming system level but this is considered too far removed from the irrigation system to provide meaningful insight on its sustainability.

Water delivery level. Reliable water discharge data rarely exist even in systems operated by agency engineers where water measurement devices were constructed as part of the system infrastructure. In farmer systems, with the exception of a few case studies where discharge data of up to a year are available, records of water delivery do not exist.

Determination of the adequacy of the water delivery by comparing crop water requirements to the availability of water would improve the analysis by explaining the systems ability to adjust to new crops with different water demands. However, this would add a level of complexity that would make information collection unmanageable except in a research setting. Simply monitoring actual changes in water delivery over time would provide sufficient information to establish a trend in a system's performance. If changes in water delivery were detected, inquiry would need to be made to determine if the cause is due to the supply and delivery or demand side of the system.

Measurement of water delivery requires careful installation of equipment and periodic calibration by skilled technicians if reasonable accuracy is expected. Even if one ignores spacial variation of delivery and concentrates on measurement at a single location in the main canal, frequent measurements may be required since farmer systems diverting water from a stream often have extremely high daily discharge fluctuations. In addition, delivery must be known for the entire period in the cropping season for which irrigation is essential. After adding the cost of human resources necessary for field readings and data analysis to the cost of installation of equipment, measurement of water delivery is expensive and not likely to be possible by available staff and resources in the irrigation department of most countries.

Production level. Most farmers have good information about their total production. Although this may only be in relative terms, such as, the extent their storage bins were filled compared to previous years or how many baskets of grain were put into storage and how many kilos of crop were sold, this information can be used to develop the output trend.

The major difficulty with monitoring the production level is determination of which part of the production can be attributed to irrigation. In many cases at least part of a household's production comes from non-irrigated fields. Farmers usually do not have any means of distinguishing between the two sources of production. Crop cuts done in sample fields would be a method for overcoming this difficulty. However, crops tend to be ready for harvest in different systems in a country at about the same time and a large staff with appropriate training would be required to make timely measurements. As with water delivery measurements, sample crop cuts as a means to estimated production attributable to irrigation, can likely only be done in a research setting.

Other factors of production such as new varieties, fertilizer use, rainfall, availability and cost of seed, market prices, changes in labor supply, credit, etc., all have bearing on production. Lyman and Herdt (1988) suggest that in such a situation the total factor productivity should be used to compute the output trend. They define this as the total value of all output produced by the system over one cycle divided by the total value of all inputs used by the system over the same period. A sustainable system would have a non-negative trend in total factor productivity. Given the extensive data collection this would entail and problems of standardizing prices where much of the production is consumed by the farm family rather than marketed, total factor productivity is too complex and expensive to be conducted by most agency staff. It would possibly be the procedure of choice in a research setting.

<u>A less quantitative strategy</u>. Irrigation departments and their associated ministries seldom have capacity to conduct more than rudimentary research let alone research that must be sustained over a number of years. Many, however, have a monitoring and evaluation unit. Frequently they do not have adequate staff or necessary resources to conduct elaborate field measurements. Assuming that such a unit would be assigned the task of conducting sustainability studies, a method is needed that does not require expensive field measurements but will give a reliable indication of an irrigation system's output over time. It is proposed that this can be accomplished by using information supplied by the farmers. The following paragraphs outline a procedure for establishing detailed information about the

total production output of a system during a base year that can be added to in subsequent annual one-day visits to establish an output trend line. The main level of analysis is the estimated total production but farmer information about the adequacy of water delivery needs to be checked to determine if irrigation supply was perceived by the farmers as the limitation causing a change in production.

Using techniques developed for rapid rural appraisal, it is possible for a team of several experienced persons to quickly establish the basic information of a system's past history and current production status. This requires one to several days depending on the size of the system. Basic information must include a history of the system that identifies changes over time in water delivery, area irrigated, cropping pattern and intensity, inputs other than water, and the yield of each crop. The year when more comprehensive information collection is done is the base year against which to compare past production and the future trend.

Information being collected in the base year will be current in the farmers' minds and quite reliable. Information from the more distant past will be less reliable but when groups of farmers compare it to the current status, the relative change should be clear. A graph can be prepared that presents an estimate of production changes from the beginning of the system or at least for the past few decades when recall is readily available.

In each subsequent year there will need to be a follow-up visit to the system. Open-ended questioning can be used with several small groups of farmers and the organization leaders to determine changes that have taken place since the past year. By using a standard format for handling the information, raw data values such as increase or decrease in water delivery, estimated yield and area for each crop, fertilizer use, market prices, etc., can be compared to past years while in the field for immediate identification of changes. Identification of change should direct questioning into determination of the cause of change. Plotting total production on the graph will make analysis of the trend immediate and easily continued if data is collected in future years. In addition to the graph there needs to be a report several paragraphs long based on the interviews with the farmers that explains the probable cause of the change in total production.

EXAMPLE CASES FROM NEPAL

To show information and analysis that would be available after the base year investigation, two cases from Nepal are presented. Neither of these cases were prepared from information collected by rapid appraisal. In the case of the Chherlung Tulo Kulo extensive research has been carried out with frequent visits to the system over the past nine years. The Majh Kulo was one of nineteen systems that received assistance in an action research project implemented by the Water and Energy Commission Secretariat of His Majesty's Government of Nepal with assistance from the International Irrigation Management Institute and the Ford Foundation. Similar information could be collected by rapid appraisal techniques and presentation made in the same way.

Tulo Kulo of Chherlung, Palpa

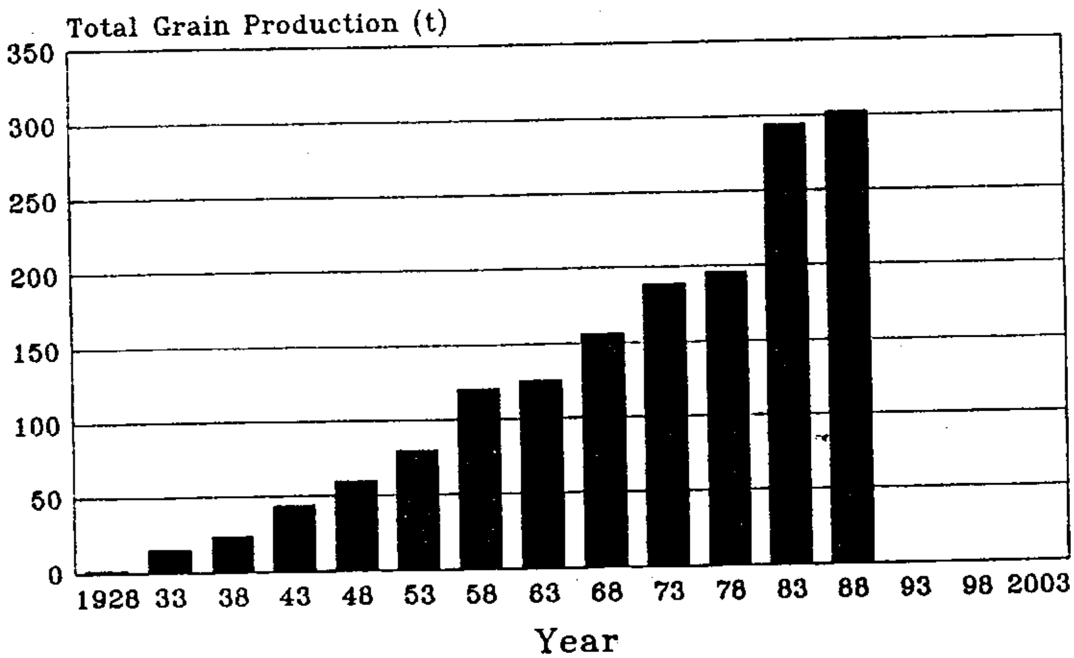
Construction of the Tulo Kulo of Chherlung in Palpa district was completed in 1932. The canal was constructed under the direction of several village elite with resources mobilized by the community. Since its completion there has been continuous investment by the farmers for improving the canal and expanding the irrigated area. Information from research conducted in the system in 1982 and 1983, including crop cuts (see Yoder 1986), was used to establish the total production for 1983 and is quite accurate. An estimate based on farmer information about system expansion and relative yields was used for all other years. The area irrigated by the canal in 1983 was about 34 ha and had expanded by a few hectares in 1988.

Farmers stated that the major reason for production increase from 1933 to 1960 was due to improved water delivery that allowed expansion of the command area. The improvements also made the canal more reliable giving some increased yield. In the mid 1960s fertilizer was introduced. This supplement to the compost already used by farmers brought significant increases in yield by 1978. In 1977 a group of farmers who had previously not had access to the system bought water rights from the Tulo Kulo organization and the money was used to enlarge the canal for additional water delivery. This allowed a 25 per cent increase in the irrigated area and a major increase in total production between 1978 and 1983.

In 1989 the Department of Irrigation made a large grant to the Tulo Kulo for improvement of their system. The money was used for lining segments of the canal where it frequently failed because of seepage. Immediately after the improvement there was a dramatic reduction in maintenance from an annual average of 2400 to 800 person days of labor. The farmers expect that the five hectares remaining to be irrigated for rice will be terraced within the next few years.

A one-time annual collection of information to extend the production graph would take one person about one day in this system not counting travel time. Given the system's record over the past sixty years and the improvements that have been made recently it is reasonable to expect the production trend to continue to increase until all the available land is irrigated. The decrease in maintenance cost will enable farmers of the Tulo Kulo to keep their system operating for the foreseeable future.

CHHERLUNG TULO KULO
Palpa, Nepal

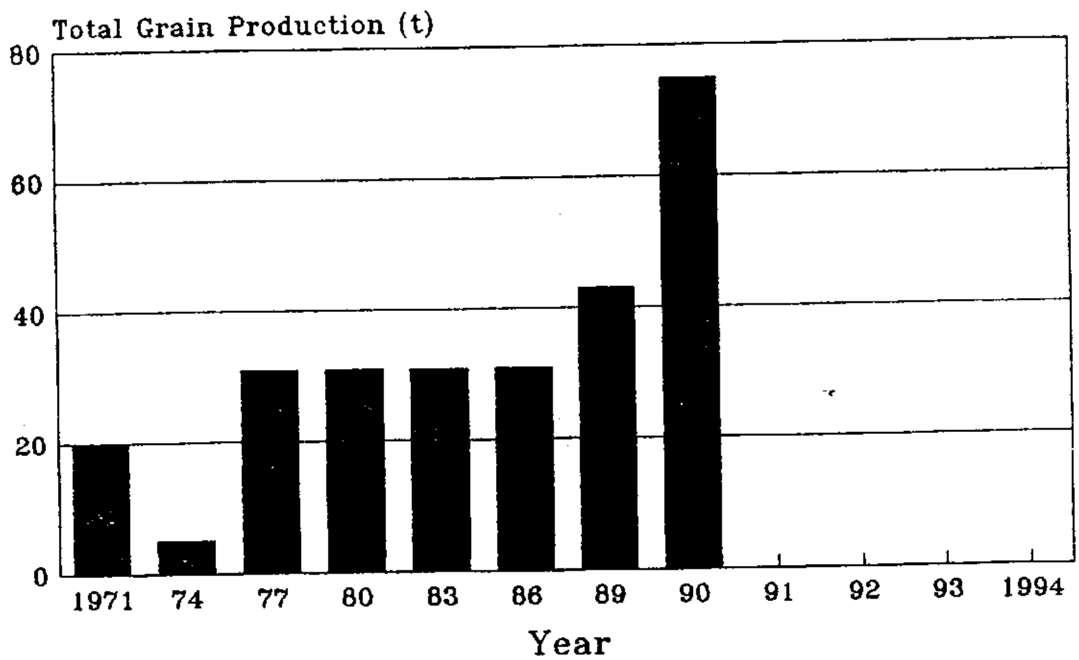


Majh Ko Kulo, Baguwa

The Majh Ko Kulo was built in 1971 primarily to irrigate wheat and maize. The farmers were not organized for maintaining the system and for the first several years struggled individually to keep the system operating. In 1974 they received assistance to improve the canal and about 13 of the potential 20 ha command area received some irrigation. In the period from 1986 through 1989 the system again received assistance from an action research project (see WECS/IIMI 1990). Area expansion and addition of rice to the cropping pattern resulted in a significant increase in production in 1990.

This would be an excellent case to follow for the next five years to see if the total production trend continues upward. From the expectations of the recently completed assistance project, production should reach nearly 100 ton per year after all the irrigable land is fully developed. Substantial investment was made by the recent assistance project to introduce better organization and management for this system. If the organization is not successful in continuing maintenance of the system and devising equitable water distribution, it is likely that production will decline sharply.

MAJH KO KULO, BAGUWA
Sindhupalchok, Nepal



CONCLUSION

In the Tulo Kulo case, evidence points to a likely continuation in the non-negative trend in production. Indication that production increased when improvements were made in the physical system is encouraging. Additional evidence that maintenance time and material costs were reduced after the recent assistance by the government suggests that it should now be easier for farmers to continue to operate and maintain the system.

The Majh Ko Kulo is perhaps a better example of the value of monitoring the production trend. The system is not as well established as the Tulo Kulo and it is not certain that production will continue to increase even though the land and water resources are available. The farmers' ability to manage this system with moderate to difficult maintenance requirements is still in question. With the information that is already available, one short visit each year will allow analysis of the trend in total production.

By administering the same series of questions on each annual visit, it will be possible to determine while in the field what has changed in the system's environment. Through group discussion, a quick probe into the reasons for change would provide valuable insight for policy and program adjustment.

In the past few years, expectations have been raised for increasing food production by assisting and expanding farmer irrigation systems. This has also raised concerns that many systems will not survive even if given assistance and there have been suggestions that the assistance money would be more productive if used for building new systems to replace those operated by farmers. To determine if farmer-managed systems are sustainable and to assist in developing appropriate policies and strategies for assisting farmer systems, field based information of the nature demonstrated in this paper is needed from many systems.

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