Second Approximations: Unplanned Farmer Contributions to Irrigation Design

Douglas L. Vermillion[§]

INTRODUCTION

As PEOPLE DESIGN irrigation systems they either explicitly or implicitly predict future cropping patterns, irrigation-demand requirements, water supplies and use efficiencies, probability of drought or flooding, and command-area boundaries. In essence, irrigation design has to anticipate a mode of management (Levine and Coward 1985). This includes conceptions of whether management will be demand or supply-driven, what kinds of information will guide management decisions, what operation and maintenance tasks will be handled at what levels of the system, whether by the agency or farmers, and what performance standards will be acceptable by future managers -- including equity, distributional efficiency, adequacy, timeliness, reliability, and sustainability (Abernethy 1988:5-7).

In the design process, often the assumptions are more imposing than the amount of actual local information utilized. The reasons design so often does not adequately reflect management tend to be the following:

1. The range and intensity of relevant information are inadequate.
2. In rehabilitation or upgrading, technical design criteria are usually "satisfied" solely by the application of hydrologic and structure theory to "collectable" information (i.e., design often is not aided by any transfer of knowledge based on local management experience).
3. Design engineers may assume too narrow a definition of management (e.g., it may include demand/supply parameters but not account for expected rotational practices, timing constraints, or adaptability of distributional procedures to changes in crop patterns such as

[§]Douglas L. Vermillion is an Irrigation Specialist with the International Irrigation Management Institute.

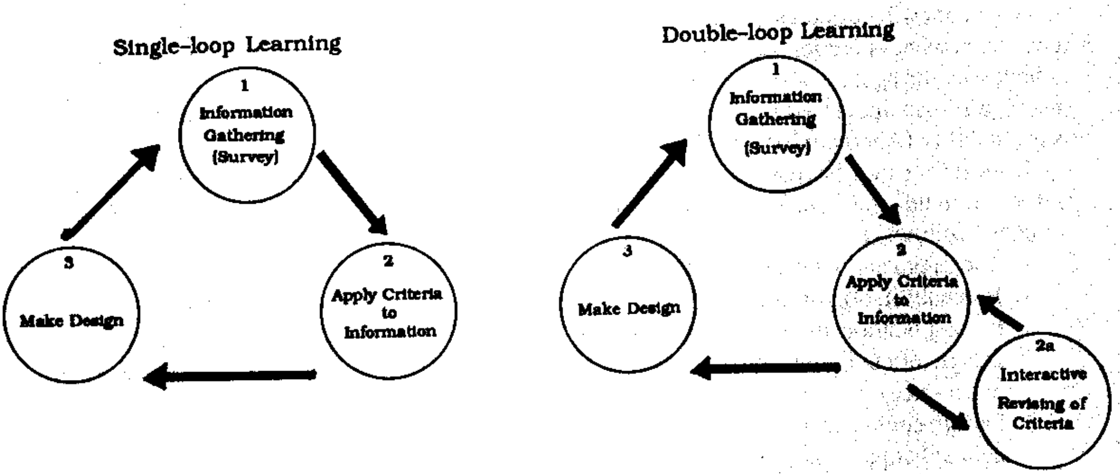
a trend toward crop diversification).

4. Design is conceived and implemented as if it were a single task which produces a definitive product (a project mode precludes a phased trial-and-error approach).
5. Design and construction are done by multiple parties who are not accountable either to one another or to the future users and managers of the system.

The physical, institutional, and financial sustainability of irrigation systems has become one of the most important indicators of management performance success (Easter 1986:245-255). If done properly, especially with farmer involvement and investment, the design process can be the cornerstone of system sustainability. If done improperly, structures tend to get damaged or to deteriorate quickly, management is hampered, and farmers are less inclined to pay irrigation-service fees when they perceive structures as being faulty, unmanageable, or extravagant.

In information theory (cybernetics) conventional irrigation-design processes can be depicted as "single-loop learning processes," where the actor (design engineer) learns about what action to take (design layout) on the basis of selective information (survey) which is obtained and evaluated solely in reference to given, operating norms (technical design criteria). (Figure 1; also Morgan 1986:84-95.) By design criteria, we mean principles specified by designers by which the existence, type, location, shape, size, materials or function of a given physical irrigation structure can be determined for a given location.

Figure 1. Alternative irrigation design learning processes.



This approach would be acceptable as long as two conditions are met: 1) information utilized reflects the relevant complexities of the environment, and 2) design criteria adequately determine what aspects of the environment are relevant to successfully design a given network. Unfortunately, these two conditions are not often realized in dynamic socio-technical environments where system objectives and needs may change over time and where design problems may wax and wane and require locally evaluated trade-offs against competing criteria.

For example, an enlarged cement weir was constructed in Solok, West Sumatra, in 1981, to replace a brush and stone gabion weir. This increased water levels in channels which then stimulated a crop-planting schedule with a higher water demand. However, the added flows also caused higher conveyance losses. These two factors prompted subsequent demands for lining. Eventually, much of the main canal was lined which in turn restricted the number of direct farm offtakes permissible from the canal. This created the need for additional field channels which then gave rise to land use and right-of-way issues to be settled between farmers.

The study referred to herein was an exploration of the nature and range of socio-technical criteria and knowledge farmers may use in evaluating irrigation-design options. Field observations and interviews were conducted with farmers in order to identify instances where farmers revised, or were revising, what had been designed and built by engineers in the tertiary network development of the Kosinggolan Scheme of the Dumoga Irrigation Project in North Sulawesi, Indonesia, in the early and mid-1980s. This study was done while the author was doing field research for his Ph.D. dissertation (Vermillion 1986).

Criteria used by farmers to make the design changes were identified to demonstrate both the nature, range, and relevance of knowledge inherent in the farmers' experience, as well as the kinds of information which tend not to be available to engineers. Farmer-redesign cases were identified along a major secondary canal, within all tertiary blocks in Ihwan village (in the upper part of the system) and at tertiary blocks 17, 18, and 24 (in the middle part of the system). Tertiary network construction had not yet been completed or used long enough by farmers in lower blocks of the system (i.e., for at least three seasons) to be represented in this sample.

Farmers interviewed frequently reported that they had approached construction laborers or supervisors in the field to suggest changes and were usually told that the design had been established by the government and could not be changed. Often farmers relocated the construction markers when the crews had left. Others waited until construction was finished and the contractors had moved on before altering the structures. Altogether, 27 case locations of design alterations were identified in the sample blocks. Many cases involved multiple alterations which were interconnected.

The Dumoga valley has about 30,000 farmable hectares (ha) surrounded by steep mountains originating many streams which snake onto the plain, many of which were checked for irrigation prior to the irrigation project. The valley has had a rapid expansion of population mainly due to immigration growing from about 8,000 in the early 1960s to over 50,000 by the mid-1980s. In the area studied, single landholdings were one hectare for transmigrant land allotments and less for non-transmigrant land allotments. Blocks often contain considerable micro-variation in soils, topography, cropping patterns, and planting dates. Also, they frequently have multiple water sources, interconnectedness (between fields, blocks, and even systems), and return flow from drainage or seepage into lower areas. Hence, this was a formidable place to design an irrigation system.

The Dumoga Irrigation Project was designed utilizing topographic surveys which focused primarily on information about landform, soils, and natural waterways. Local information on prior use of natural waterways, farmer-built structures, landholding boundaries, and land use was not integrated into the design. Tertiary layouts were based on topographic surveys using a 1:2000 scale and one-half meter elevation interval lines. Design and construction were done by multiple consultants and contractors. Tertiary blocks generally were between 50 and 150 ha in size.

Farmers had prior experience irrigating rice fields and many farmer-built structures were in use in the area prior to the project. Before the project weir was completed in 1976 farmers were already irrigating 2,000 of the planned 5,500 ha of the scheme by their own efforts. By 1983, approximately 3,000 ha were being irrigated. Hence, generalizations herein may be less applicable in other settings where farmers have had no prior experience with irrigation or where new irrigation is introduced.

FARMER DESIGN ALTERATIONS

The most common kinds of alterations observed were channels being relocated (involved in 11 of the cases), streams being diverted or ponded (8 cases), project channels being abolished or not used (7 cases), and channel offtakes or division points being relocated (6 cases). Other actions included redirecting project channels into drains or streams, making new channels, adjusting division box gates to alter water divisions, making new flumes, destroying project flumes and lining channels. Several cases involved relocating channels to follow farm boundaries, to accommodate low water requirement crops or to continue to make use of preexisting structures built by farmers such as small weirs, channels, and ponds.

In their need for small-scale manageability within tertiary blocks farmers often mentioned reasons for making design changes which were different from and incompatible with project criteria. One type of rationale was the wisdom of diversifying one's water sources wherever possible as a strategy for avoiding the risk of dependency upon only project channels. Farmers frequently tapped multiple water sources as supplements to system channels or individual fields. Such sources as small streams, springs, marshes, ponds, and drains were prevalent throughout the command area and were commonly exploited by farmers as water sources additional to the project. The project was originally designed without reference to such alternative sources, assuming that the Kosinggolan weir would be the sole source.

Another strictly farmer criterion was that of, wherever possible, combining conveyance and drainage functions in the same channels so as to maximize reuse and the utility of the channels and to minimize the number of channels. The project design required the separation of the two functions into different channels. Farmers frequently redirected project channels into streams which were checked to make collecting ponds. This had the effect of maximizing water reuse and redirecting drainage water to add to the centralized supply being conveyed through project channels. Water was then diverted out of the ponds to downstream users. This common pattern helped ensure that the channel had value, at any given point, to both upper enders (for drainage) and to lower enders (for supply). Maintenance was more important to both upper and lower enders than was the case where supply and drainage functions were kept distinct in different channels. However, project design criteria separated supply from drainage channels. The project defined all natural streams as drainageways. Every six months it routinely destroyed farmer-built brush weirs along small streams and natural depressions within the command area with the intent of "normalizing the drainageways" to prevent obstruction of drainage.

Farmers were inclined to minimize both the number of channel divisions (especially at the upper ends of blocks) and the levels of network hierarchy. The project however, was based on a four-tier design, with the assumption that farm-level offtakes would be made only along quaternary channels. Farmers did not like to have lower-order channels branching out from higher-order channels and running parallel to each other for "long" distances (more than 200 m). Many farmers were convinced by experience that such "excessive dividing" (especially if done too far upstream) increased conveyance losses. Light-textured soils were especially prevalent in the upper sections of the tertiary units. Hence, many quaternary channels were abolished or not used by the farmers. Turnouts were relocated downstream to where they more directly branched away from mother canals. The effect was to tend to consolidate flows into fewer channels.

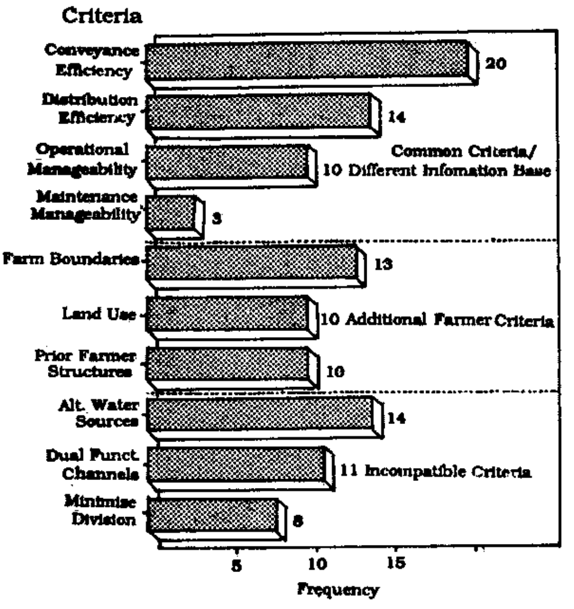
One example of how farmers altered the design in a step-wise, trial-and-error approach involving socially evaluated tradeoffs was in Block 18 where farmers chose to relocate a tertiary channel in accordance with farm boundaries rather than in strict accordance with topography. They knew this would make it difficult or impossible for at least one or two relatively high terraces on one farmer's landholding (A) to get water from the realigned channel. They also knew that having the channel follow the boundary was very important to the farmer's (A) productive capacity. And they knew that the field neighbor (B) always had more than adequate groundwater entering his field (as he was situated in a very slight basin) and that this water could be drained across the channel, via a small bamboo aqueduct, into the needy terraces of the other farmer (A). Both farmers were on good terms, so the local water users' association decided that the "receiving" farmer (A) would have an individual right to make private use of the neighbor's drainage (B) (which otherwise would have gone back into the public channel). Only he (A) could pull out the aqueduct as needed for drying.

Nevertheless, when the small aqueduct did dry up under conditions of water scarcity the needy farmer opened up a new, temporary intake in yet another location to direct water into the terrace. Ordinarily this would not be allowed. But the group recognized the farmer's right to make this alteration temporarily. This decision to relocate a tertiary channel along farm boundaries instead of following the exact topographic line was dependent upon a period for testing water adequacy from multiple sources, negotiating rights of access to alternative water sources, and evaluating the tradeoff between land served by the channel and part of a landholding not being served by the channel.

ANALYSIS OF FARMER-DESIGN CRITERIA

From the farmer interviews, criteria used by the farmers were elicited and categorized based upon the functional implications of the design alterations as expressed by the farmers. A total of 113 criteria were specified in the cases which represents an average of 4.2 related criteria per case. Criteria expressed or directly implied by the farmer-design changes were grouped into ten categories. Their frequencies of occurrence are displayed in Figure 2. The criteria are of three types: 1) farmer criteria which were also conceptually used by the project (although obviously quantified into hydraulic theory by the engineers), 2) farmer criteria which were additional to project criteria, and 3) farmer criteria which were incompatible with project criteria.

Figure 2. Frequency of occurrence of farmer-redesign criteria (27 cases, 113 total frequency of criteria).



Regarding the first order of criteria, both farmers and project engineers accepted the rule that water head should be relatively even and adequate to reach the intended service area. Both were in agreement that distribution should be equitable according to area served. Both agreed that the tertiary-level structures should be within the abilities of farmers to operate and maintain. The problem was in the different information base which the farmers brought to bear against the criteria. It was micro-level, socio-technical, and grounded in local experience. Farmers have told this author about significant variations in soil textures (sandy to loam) within single rice-field terraces of their parcels. The project's information was naturally survey-based, primarily limited to technical criteria (hydraulic, structural, agronomic, and meteorologic) and based on hydraulic theory. Forty-two percent of all redesign criteria elicited were cases where more detailed local knowledge prompted a different design although the criteria were not in dispute between the agency and farmers (Table 1).

The second order of criteria comprised those which were additional to, but not necessarily incompatible with those used by the project. Three types of these criteria were expressed by farmers: 1) channels should follow farm boundaries whenever possible, 2) actual farmer land use preferences (such as planting tree crops) needed to be considered, and 3) the design should incorporate prior farmer-built structures where these are still deemed useful by the users. These additional criteria accounted for 29 percent of the total elicited criteria.

Table 1. Frequency of occurrence of the three types of criteria.

Type of criteria	Frequency	
	Number of cases	Percent
Compatible criteria but different information base	47	42
Additional farmer criteria	33	29
Incompatible criteria between farmers and engineers	33	29
	---	---
Total related criteria	113	100

The third order of criteria comprised those which were incompatible with project criteria. These were: 1) the utility of using multiple water sources, 2) combining conveyance and drainage functions in the same channel, and 3) minimizing channel divisions and levels of network hierarchy. This type of criteria constituted another 29 percent of the total criteria identified.

The most frequent criteria reported by farmers as rationale for making design changes were on questions of conveyance and distribution efficiencies, farm boundaries, and the conjunctive use of alternative water sources. Together, these criteria accounted for 61 of 113 incidences of elicited criteria (54 percent). Farmer criteria which were either additional to or incompatible with project criteria accounted for 58 percent of the farmer criteria elicited. Hence, the majority of redesign criteria were outside the scope of the project criteria.

CONCLUSIONS

This paper has sought to demonstrate the nature of contributions farmers can make in the design process. It has not evaluated the actual performance effects of the farmer alterations although this should be a research priority. Farmer knowledge has five characteristics which make it a distinct and essential asset for the design process. Farmer knowledge is: 1) holistic (cutting across disciplines of expertise), 2) experimental, 3) historical and dynamic, 4) sensitive to micro-level contextual diversity, and 5) in part, derived from locally evaluated trade-offs and negotiations. This is not to say that these characteristics are only positive. Sensitivity to the micro-level context may include vested factional interests or preclude a system-wide perspective. However, a design process which is interactive and has system-wide performance objectives should be structured to incorporate the positive aspects of local knowledge at the system level.

Sometimes it is asserted that farmer participation is needed so that the "social aspects" of irrigation will not be left out implying that the technical aspects are the realm of the engineers. However, the cases observed contained aspects which were as much of a technical nature as of a social nature. Design revision sometimes required negotiation and testing over several planting seasons. However exhaustive, resilient, or flexible a set of design criteria may be it cannot substitute for the local knowledge obtained through dialogues with the farmers and the negotiated settlements of design trade-offs.

In settings such as this conventional system designs should be considered as only preliminary approximations. What is usually needed in the irrigation design process, particularly where farmers have prior irrigation experience and will be future managers, is a "double-loop learning process" which would permit the questioning and potential revising -- in process -- of "operating norms" (i.e., design criteria). (Refer to Figure 1.) This is also referred to as a management capacity for "learning to learn" and "self-organizing." Such a process requires two-way communication and mutual adjustment between design teams and the water users -- because part of the essential local knowledge and management criteria is only in the minds of the users (Smith 1988:93-107). In such agency-farmer meetings attention should be directed toward anticipated functional outcomes, performance expectations, local sustainability of new structures and water users' associations' operation and maintenance work plans (Coward et al.:IV-74).

Where agency staff or consultants are not trained or oriented to engage in such activities the use of institutional organizers has often proven to be effective in ensuring a more participatory process. There is evidence that this does effect better designs and system performance as well (see de los Reyes and Jopillo 1986). However, it has proven difficult to replicate this model on a national scale. Nevertheless, the Indonesian program to turn over small-scale irrigation operation and maintenance to the farmers is currently attempting to do just that by using agency staff as institutional organizers (Helmi and Vermillion 1989).

The fact remains that most of these intensive efforts for more participatory-design processes have been pilot projects, not routine national-operating procedures. However, largely as a result of lessons learned from such pilot studies, the Indonesian Directorate General for Water Resources Development has recently formulated national policy guidelines to support farmer participation in future small-scale irrigation development (DGWRD/LP3ES 1989). These guidelines include such propositions as:

1. The agency will react to farmer requests for assistance (rather than being the primary initiator).
2. Farmers will submit a list which ranks the priorities of proposed improvements.
3. Water users' association (WUA) participation is required in each stage of the assistance process.
4. An agency field person will function as a motivator, mediator, and facilitator for the WUA.
5. A simple farmer version of the design will be prepared with the assistance of an agency staff and will form the basis for preparation of a technical version.
6. The WUA will have a role in construction supervision.
7. Local WUA investment along with agency assistance will be encouraged.

It will be no small challenge for the Indonesian provincial irrigation services to reorient themselves toward implementing such progressive policies.

References

Abernethy, Charles L. 1988. Irrigation design for management: The Kandy symposium, guest editorial. Irrigation and drainage systems. 2(1):5-7.

Coward, E. Walter, Jr., Johnson, Robert L. and Walter, Michael F. (n.d.) Other channels: Improving public policies and programs for small-scale irrigation development in Asia. (Working paper). Irrigation Studies Group. Ithaca, New York: Cornell University.

de los Reyes, Romana P. and Jopillo, Sylvia Ma. G. 1986. An evaluation of the Philippine participatory communal irrigation program. Institute of Philippine Culture. Quezon City: Ateneo de Manila University.

Directorate General for Water Resources Development and Institute for Social and Economic Research, Education, and Information. 1989. National workshop for formulating procedures for developing village and tertiary irrigation and the turnover of small-scale irrigation to water users' associations, Jakarta, Indonesia, August 8-10.

Easter, K. William. 1986. Irrigation policies for future growth in agriculture. In Irrigation Investment, Technology and Management Strategies for Development. K. William Easter (ed.). Studies in water policy and management, No. 9. Boulder, Colorado: Westview Press.

Helmi and Vermillion, Douglas L. 1989. Using irrigation agency staff as institutional organizers: The small systems turnover program in Indonesia. Presented at IIMI Workshop on the Role of Social Organizers in Assisting Farmer-Managed Irrigation Systems, Khon Kaen, Thailand, May 15-20.

Levine, Gilbert and Coward, E. Walter, Jr. 1985. Irrigation water distribution: Implications for design and operation. Draft for the World Bank, April.

Morgan, Gareth. 1986. Images of organization. Beverly Hills, California: Sage Publications.

Smith, P. 1986. Design and management in rehabilitation: Understanding the other man's point of view. Irrigation and Drainage Systems. 2(1).

Vermillion, Douglas L. 1986. Rules and processes: Dividing water and negotiating order in two new irrigation systems in north Sulawesi, Indonesia. Unpublished Ph.D. dissertation. Ithaca, New York: Cornell University.