DESIGNING IRRIGATION FOR FARMER MANAGEMENT: ON THE PRIMACY OF PROCESS OVER CRITERIA[1]

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INTRODUCTION

The sustainability of irrigation systems is of current widespread concern. (Easter, 1986) Farmer management in irrigation systems is recognized as a vital factor in sustainability. (See Lowdermilk, 1986; Coward and Levine, 1986; Uphoff, 1986) The appropriate design of irrigation for farmer management (both new and rehabilitated) is a crucial element. If designed 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 unmanageable, irrelevant or extravagant.

Irrigation design is usually conceived and implemented as a discrete task, rather than an incremental process. But it is a task which sets long-term management parameters. In essence, irrigation design anticipates future management modes, intensities and efficiencies (Levine and Coward,1985) and it establishes parameters for system performance. (Abernethy,1988)

As such, it must be highly comprehensive and futuristic. Yet in practice, designs are often substantially assumptive and highly dependent upon a limited set of technical design criteria. The criteria are typically "satisfied" by the application of hydraulic and structure theory to collectable information. When designing specifically for farmer management, it becomes even more difficult to predict design-management criteria, without direct interactions with farmers in the design process.

Irrigation design conventionally has three basic steps: 1) collecting information specified by the design criteria, 2) analyzing this information against the design criteria, and 3) deriving the appropriate structure and layout. The criteria themselves are usually predetermined (relative to a given setting). In information theory (cybernetics) this is known as a "single-loop learning process", 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, unquestioned operating norms (technical design criteria). (See Morgan,1986,p.84-95)

This works fine 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

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design a given network. Unfortunately these two conditions are not often realized in dynamic sociotechnical environments, where system objectives and O&M needs may change over time. A rehabilitation may reorient O&M needs in such a way as to require additional future design changes.

For example, in 1981 in the Solok district of West Sumatra an enlarged cement weir was constructed to replace a brush and stone gabion weir. This increased water levels in channels which then stimulated a crop planting schedule with a significantly higher water demand. However, the added flows also caused much 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 rights-of-way issues to be settled between farmers.

In such cases, the information theorists tell us, a "double-loop learning process" is needed which permits the questioning and potential revising--in process--of "operating norms" (ie, design criteria). (See Figure 1, based on Morgan, ibid,p.88) This is also referred to as a management capacity for "learning to learn" and "self-organizing." We posit that 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) The sociology of knowledge tells us that a given paradigm (in this case, irrigation design criteria) will not be transcended soley on the basis of encountering discrepancies with reality. Alternative paradigms (explanations and operating norms) need to be brought forward. (Kuhn,1970) Hence, it is only through dialogue between design teams and water users that alternative criteria, and possibly operating norms, can be integrated into the design process.

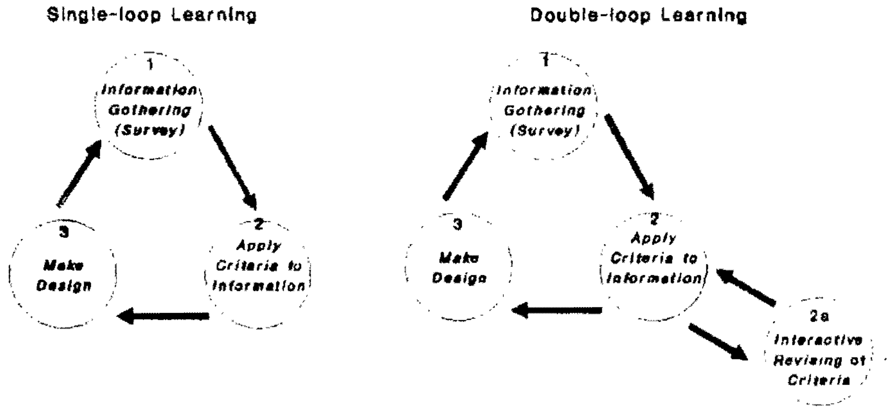

Figure 1. Alternative Irrigation Design Learning Processes

This paper has three objectives: 1) to demonstrate the broad kind of socio-technical criteria which farmers can contribute to the design process, 2) to illustrate the need for designing irrigation systems in an incremental way rather than as a discrete event attempting to produce a definitive product, and 3) most importantly, to show that the design process is more important than the design criteria per se. Therefore the process should be given the most attention. This is so because often relevant design criteria can only be identified in the process of designing itself (such as field-checking the layout or inviting farmers to respond to proposed layouts). Only the right kind of process can permit this kind of adaptive, or double-loop learning. This is much like what this author was recently told by a traditional orthopedic healer, who said that one researches the causes of the problem gradually by first applying solutions and then seeing what changes occur (in this case, in one's back).

The cases referred to in this paper are instances where farmers revised 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 1980's. The Dumoga valley is the site of several transmigration projects for Javanese, Balinese, and Minahasan settlers. The valley is about five to seven kilometers wide and has about 30,000 farmable hectares. Numerous streams flow to the valley center from steep mountain sides along the north and south rims. The population expanded from approximately 8,000 in the early 1960's to over 50,000 by the mid 1980's. Many streams were checked to irrigate new padi fields by the settlers prior to the construction of the Kosinggolan main canal, which runs easterly along the southern rim of the valley.

In Indonesia, individual farm parcels are usually 0.3 hectares or less, systems often contain considerable micro-variation in soils, topography, cropping patterns, and planting dates. Systems also frequently have multiple water sources, interconnectedness (between fields, blocks, and systems), and return flow. All these factors make Indonesia a formidable place to design and manage irrigation systems. 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 is done by multiple consultants and contractors.

Through interviewing village heads, farmer group leaders, and farmers involved in the farmer design alterations, the author attempted to identify as many cases as possible where alterations in the design had been made, or were in the process of being made, by farmers. The farmers' own rationale or criteria for making the changes was elicited, as were reports of any reactions by farmers effected. This was done along a major secondary canal, within all tertiary blocks in Ihwan village (in the upper part of the system), and at tertiary blocks seventeen, eighteen, and twenty-four (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. Tertiary blocks generally were between 50 and 150 hectares in size.

It should be noted that this was a context where farmers had had prior experience irrigating padi and many farmer-built structures where 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 hectares of the scheme, due to their own efforts. By 1983 approximately 3,000 hectares 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.

Farmers interviewed frequently reported approaching 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 according to their own design criteria. Altogether 27 case locations of design alterations were identified in the sample blocks. Many cases involved multiple alterations which were interconnected.

The most common kinds of alterations observed were relocated channels (involved in 11 of the cases), ponding and stream diversion (in 8 cases), abolishing or not using project channels (7 cases), new or relocated channel offtakes (6 cases). Other actions included redirecting project channels into drains or streams, making new channels, adjusting division box gates to "permanently" alter water divisions, making new flumes, destroying project flumes and lining channels. Only a few cases will be described briefly in this paper. A summary analysis of farmer design criteria is included below.

DYNAMIC SOCIOTECHNICAL CONTEXTS

The more a design process relies on dialogues with the users about anticipated outcomes, the less it will have to make the dubious attempt of specifying all relevant design criteria at the outset. Generally it will not be possible to specify all relevant design criteria prior to interacting with the water users. Unanticipated but crucial criteria may only become apparent in field meetings with farmers.

Farmer knowledge has four characteristics which make it a distinct and essential asset for the design process. It is: 1) sociotechnical or holistic, 2) experience-based, 3) historical and dynamic, 4) sensitive to microlevel contextual diversity. This is not to say that these characteristics are only positive. Sensitivity to the microlevel context may include vested factional interests or preclude a system-wide perspective. However, a design process which is interactive, admits "double loop learning", and has system-wide performance objectives should be structured to incorporate the positive aspects of local knowledge at the system level.

Before the Kosinggolan main canal was built, a farmer-built channel came down a slight ridge (See Figure 2). Although the channel passed through the middle of three landholdings, the farmers recognized it was necessary to do this at the time. However, besides not wanting the channel passing through their own land, the farmers did not want "their" channel first going through the middle of their neighbor's fields above them. As they said, this made it too easy for the neighbor to tamper with the channel and to steal water. So after several seasons of land preparation and gradually cutting away at the slight ridge, the padi terraces were lengthened and the ridge was levelled. After this gradual levelling process was completed in all three landholdings the channel was filled in and relocated along the boundaries. In this case new, gradual terracing changed topography enough to prompt a later relocating of channels and intakes. In this case, the social and the technical components were inextricable, neither being dominant. And the context was dynamic in that the original design intervention influenced water theft practices and the farmers' terracing strategy. These in turn prompted the later relocation of the channels.

Farmers in Block 18 were disatisfied with three tertiary division boxes. They complained that some channels with high gradient were getting too much flow, others were getting too little (with two cases were back flow occurred at low water periods). Some areas of sandier soils were getting inadequate deliveries while other fields with better water retention were getting too much water. Farmers owning parcels with lighter soils and inadequate water supply would attempt to compensate for this by frequently borrowing water. My observation of this block over two planting seasons supported these assertions about the maldistribution caused by the division boxes. (See Vermillion,1986) The farmers spoke to project personnel a number of times about this and were told that the design had been prepared after making careful calculations of the areas and slopes. A farmer noted that the theory and analysis probably was right. But in their experience the allocations were actually unfair. The farmers were reluctant to alter the division boxes because they considered them to be government property, since, as they said, the government had built them, using its own materials.

However, after waiting several seasons the farmers reluctantly decided to alter the division boxes themselves. After one harvest in 1983 the water users association finally altered the relative heights of the bases of the offtake gates of the three division boxes to make the allocations more equitable. In each case the locations with the scarcest water supplies were getting their division enlarged. This was done by the agreement of the entire group. It cost them only about US $24 for the cost of labor and two sacks of cement and about US $2.40 for sand to do all three alterations.

Although farmers' microlevel knowledge about topographic and soil variations was important in this case, it was their trial-and-error experience that caused them eventually to change the relative heights of the gates. Although finally they overcame their reluctance to alter the division boxes, they were afraid to destroy and replace them with their traditional notched proportioning logs, which they were using elsewhere in the block. By contrast, farmers were not reluctant to move unlined project-built channels if deemed necessary, without consulting project officials beforehand, with the rationale that no agency-purchased materials had been used by the government.

SMALL SCALE MANAGEABILITY

In their need for small-scale manageability within tertiary blocks, numerous farmers demonstrated and described to this author three kinds of design criteria which were distinct from, and often incompatible with, project criteria. The first was the common tendency of farmers to tap multiple water sources as supplements to system channels, as a strategy for avoiding risk of water shortage. Such sources as small streams, springs, marshes, ponds and drains were prevalent throughout the command area. The project originally was designed without reference to such alternative sources, assuming that the Kosinggolan Weir would be the sole source. The second farmer criteria 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 minimize the number of channels. The project design required the separation of the two functions into different channels. The third criteria was the preference of farmers 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 quarternary channels.

In one block in the middle section of the system, two farmer actions were taken to alter project structures, and in a sense, to redefine their use. (Figure 3) Farmers built a very small brush weir over the small stream on the side of the landholding of farmer X. Water from fields and channels drained into the stream. This weir created a small pond and provided supplemental irrigation for several farmers below it. The second farmer action was the relocation of the project channel from its previous location (through the middle of farmer X's field) to its present location--following the top boundary line and then entering the stream just above the pond.

This relocation allowed Mr. X's plot to receive the same water at the top but also avoided having his land traversed by the channel. The results were that the farmers below still received water from the channel, but now it was rerouted via the pond and weir. There was another advantage for lower-enders which made them favorably disposed to the design change. Since the channel no longer went through the middle of X's land holding but went into the stream on the side, the water was now less susceptible to water theft by X and was more controllable by lower-enders. This arrangement also added to the storage capacity of the pond.

This case exemplified a common farmer strategy of draining water into small natural streamlets, which were checked by other small brush weirs and reused below. This practice, so prevalent in parts of the Dumoga valley where ponding is possible, tended to segment otherwise long channels into shorter, clearly-defined units more easily managed and maintained by small groups of neighboring farmers.

Such segmenting made it more obvious which group of farmers was responsible to clean portions of the channel and repair weirs. Farmer groups, often informal but hydraulically-based, were kept smaller, and hence more easily accountable, than was the case with longer project-built channels.

In the lower part of Block 18 (Figure 4) farmers advised contractors not to bother building a water flume over a small stream to convey water to the plots on the other side of stream. They told them that this stream flowed into another one and that the far side plots needed both water from the channel and the stream. They wanted the channel to enter the stream and then be directed out of it below to serve fields on the opposite side. In this way the farmers meant to take advantage of both sources, without disrupting the prior channel network. But the workers said that they had to complete the contract according to specifications. The farmers later moved the channel to direct the water into the upper stream, as their supplementary water source. The stream was tapped in four places downstream and served nine farm plots. The flume was never used.

Figure 5 shows the pattern in Blocks 7 and 8 where farmers repeatedly redirected project channels into streams which were checked to make collecting ponds. This maximized water reuse and redirected 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.

LOCALLY EVALUATED TRADEOFFS

Essentially a design layout is underdetermined by whatever set of criteria is used. There is virtually always a discretionary range which admits personal preferences. There are tradeoffs between criteria which may be best settled through trial periods and negotiation among users rather than through centralized agency decisions. Sometimes farmers intentionally allow silt to accumulate in certain places along channels where the channel bed is particularly sandy or porous. An outsider may consider siltation as prima facie evidence that the water users association doesn't function well. However farmers may evaluate the benefits and costs of permitting some selective silt accumulation to limit conveyance loss in certain places, as an alternative to lining the channel.

In Block 17 a quaternary channel branched off from the left-side tertiary canal and ran through the middle of one farmer's field. It then ran into a small stream which had been checked to form a pond. This channel was built by farmers. Without it they would have had no direct access to water from the project. Below, the water was drawn off to the other side of the pond, where it supplied eight fields downstream.

Originally, when these farmers requested that a channel be built from the tertiary channel to their fields, a farmer in the upper field offered right-of-way through the middle of his newly-terraced land. They agreed to try this. Eventually it became apparent to the farmers who had requested the channel that this farmer was able to take advantage of having the channel cut through his field. Although he had an official offtake, he frequently opened one to three additional offtakes from the new channel to add to his water supply. He had new terraces which soils were not yet compacted and the infiltration rate was still very high. The farmers below said he had done this as a "political trick" and that as long as the channel ran through the middle of his land, "the security of the water for downstream users could not be guaranteed".

At the end of one season of testing this arrangement, the lower-enders wanted the channel relocated to run along the top boundary of the upper field, before reaching the pond. This change, they said, would make the channel and its water supply more "public" and "official". It was too easy for a farmer to steal water and feel justified in doing so since the channel cut through the middle of his land. To the lower-enders, it had become an excuse to justify diverting more than a fair share. The lower-enders also mentioned feeling awkward inspecting the channel in the middle of another's landholding.

The farmer whose field was traversed by the channel found that the disadvantages of having a channel cut through his land were offset by the gains in access to additional water, which he needed while making new terraces. In this case it was the users downstream who wanted the channel moved to the boundaries, not the farmer whose land was being traversed. Hence, a design decision was made not to satisfy or optimize given criteria. Instead the trade-offs between various factors (security of delivery, land use, high water demand) were locally tested and "negotiated" after a trial use period.

In the example of Block 18 above, where farmers avoided using a project flume (and instead directed the channel into a ponded stream (Figure 4), four lower terraces (about twenty square meters) of a farmer's field became inundated with water. Farmer X demanded reimbursement for the value of the land inundated. The ponding helped irrigate 7.5 hectares. The seven users agreed to pay some amount (such as the cost of padi not planted) but refused to pay for the value of the land. One of the beneficiaries argued that if the ponds were abolished, other fields below would become inundated and they would have to demand reimbursement from farmer X. Farmer X occasionally chased away farmers using the pond if they tried to weed or repair the pond check structures while he was present in his field. However, he was not bold enough to destroy the structures. The controversy still had not been resolved during the time of this study. This area was outside of the formal boundaries of the water users association and so was in a weak position for reaching a corporate decision about the matter.

Sometimes farmers were reluctant to distinguish whether or not a given design modification would be permanent or temporary. There was an ambivalent, tentative attitude about it. This group decision to place a tertiary channel along farm boundaries versus following the exact topographic line was dependent upon a period for testing water adequacy from multiple sources, negotiated rights of access to alternative water sources and an evaluation of the tradoff between part of a parcel not getting irrigated versus having land traversed by the channel.

FARMER CRITERIA FOR DESIGN ALTERATIONS

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. Ten categories of criteria were derived and their frequencies of occurrence are displayed in Figure 6. The criteria are of three types: 1) farmer criteria which conceptually were also used by the project (although obviously were 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. 42% 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. (See Table 1)

Table 1. Frequency of Occurrence of Three Types of Criteria

Type of Criteria	Frequency
Compatible Criteria but Different Information Base	47 (42 %)
Additional Farmer Criteria	33 (29 %)
Incompatible Criteria Between Farmer and Engineers	33 (29 %)
Total Related Criteria	113 (100 %)

Regarding the first type of criteria, both farmers and project engineers accepted the rule that water head loss 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 microlevel, sociotechnical and grounded in local experience. Farmers have told this author about significant variations in soil textures (sandy to loam) within single padi 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.

Farmers added three criteria to those used by the project: 1) channels should follow farm boundaries whenever possible, 2) actual farmer land use preferences (such as planting tree crops) 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% of the total elicited criteria. Three types of criteria held by the farmers were incompatible with project criteria. These were: 1) the preferability of having multiple water sources available to one's field than being reliant only upon a system channel for one's supply, 2) the preferability of combing conveyance and drainage functions in single channels where possible and 3) the preferability of minimizing the number of division points and levels of network hierarchy (avoiding "too much dividing of the water", as the farmers put it).

Farmers did not like to have lower-order channels branching out from higher-order channels and running parallel to each other for "long" distances (>200 meters). 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 quarternary 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 consolidate flows into fewer channels.

The most frequent criteria reported by farmers as rationale for making design changes were 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%).

CONCLUSION

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 criteria which were either additional to or incompatible with project criteria accounted for 58% of the farmer criteria elicited. Hence the majority of redesign criteria were outside the scope of project criteria. 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 social. Design revision sometimes required negotiation and testing over several planting seasons.

However exhaustive, resilient, or flexible a set of design criteria may be, it can not substitute for the local knowledge obtained through dialogues with the farmers and the negotiated settlements of design tradeoffs. Farmers typically elucidated their design criteria not in the abstract but in the process of discussing irrigation structures. Most of the cases were rather ordinary and undramatic. Yet in their mundaneness we see how common and basic farmer design knowledge is and how inadequate is a process of designing irrigation for farmer management which relies more on pre-specified criteria than on interactions between design teams and water users.

Over the last decade the Indonesian Government together with the Ford Foundation, USAID and other donors, have supported several innovative pilot projects and studies to improve the design process with farmer participation. These include the use of institutional organizers (IOs) in the HPSIS Project (small-scale irrigation), rehabilitation of tertiary blocks in large systems in Madiun (using IOs), small-scale irrigation inventory and assistance studies in South and West Sumatra and most recently the national program to turn over O&M responsibility in small-scale systems to the water users.

From these experiences and others it is evident that a number of elements are needed in a successful process of designing irrigation for farmer management. Farmer knowledge needs to be made accessible to design teams. Both farmers and design teams need to meet together to discuss proposed designs, perhaps with the initial proposals coming from the farmers. In the Madiun project arrangements were made for farmers to prepare sketch maps and lists of proposed design improvements before a design team visited the block. In the Philippines and Indonesia "walk-throughs" of the system by design teams with farmers have been effective forums for more precise and clear two-way communications. In such agency-farmer meetings, discussions should not focus on criteria per se. This would likely stifle discussion which could uncover unanticipated criteria. (Smith,1988) Attention instead should be directed towards anticipated functional outcomes, performance expectations, local sustainability of new structures and water users association O&M workplans. (See Coward,et al,nd,p.IV-74)

Both sides must be flexible and willing to compromise. Arrangements should be made to support negotiation between design decision-takers and obtaining reactions. Ideally, systems should be improved incrementally, as they have developed traditionally in Southeast Asia. (Spencer,1974) Some irrigation departments in India do not permit newly-constructed channels to be lined until they have been tested for a few seasons. Designing irrigation improvements should be a step-wise or "staged modular development." (Turral,1989,p.93) Perhaps activities could be staggered according to network hierarchical levels; by first using temporary materials and after a trial period, using permanent materials; or by the agency incrementally responding to priorities suggested by the users.

Where agency staff or consultants are not trained or oriented to engage in such activities, the use of IOs 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 the IO model on a national scale. Nevertheless the Indonesian program to turn over small-scale irrigation O&M to the farmers is currently attempting to do just that, by using agency staff as IOs. (See Helmi and Vermillion,1989)

The fact remains that most of these intensive efforts at 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 things 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 staff 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, and
7) local WUA investment along with the agency assistance will be encouraged.

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

From a recent pilot project for assisting small-scale irrigation in Sindhupalchok, Nepal, researchers from the International Irrigation Management Institute concluded that four elements of agency management are essential in assisting farmer-managed irrigation systems: 1) openness of information with farmers about project budgets and accounts, work schedules, etc, 2) flexible work schedules, 3) accountability of contractors and farmer representatives to the water users association as a whole, and 4) intense on-site technical supervision. (Yoder and Pradhan,1989) Perhaps the more difficult issues ahead are what kinds of structural and operational changes be made in the agencies, ministries, and engineering firms in order to support such processes.

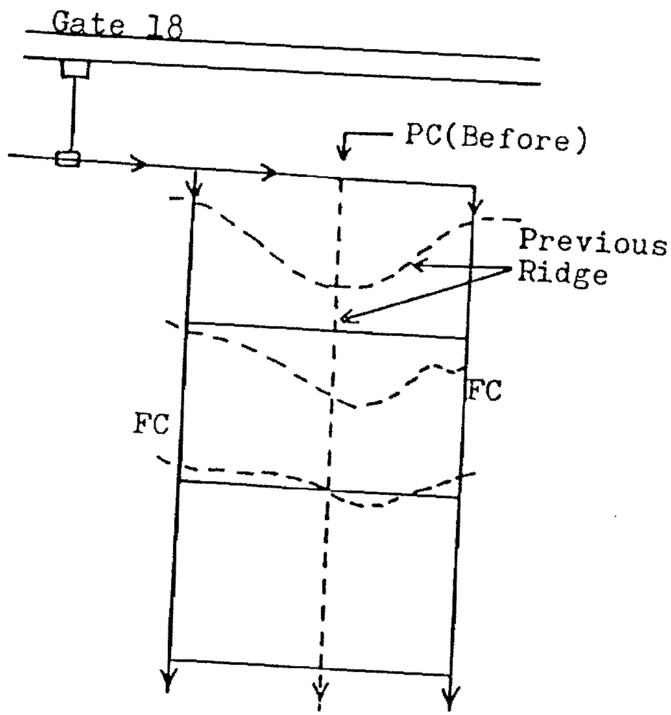

Figure 2

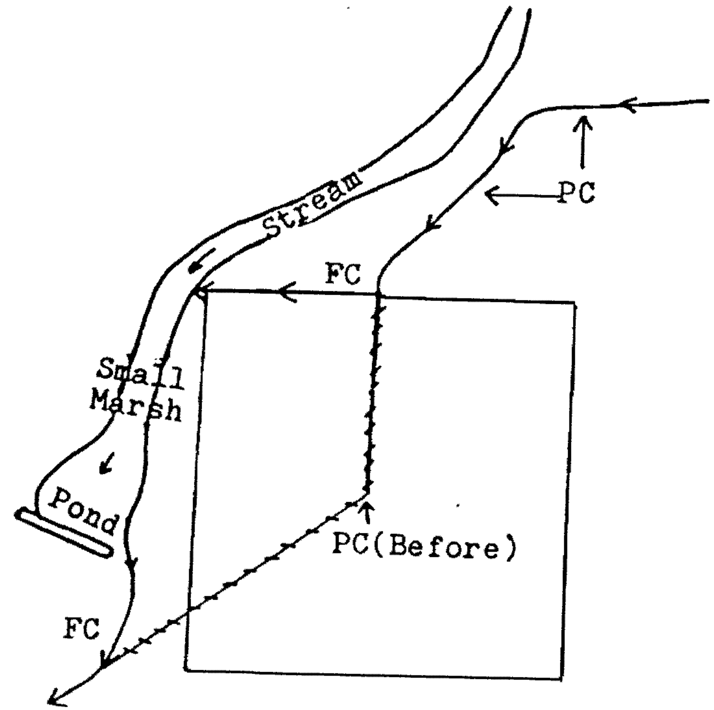

Figure 3

* PC = Project Channel
FC = Farmer Channel

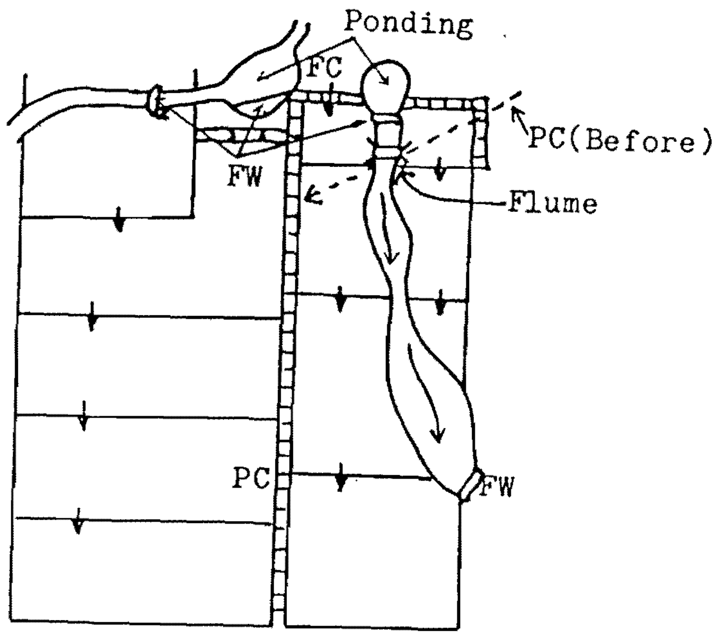

Figure 4

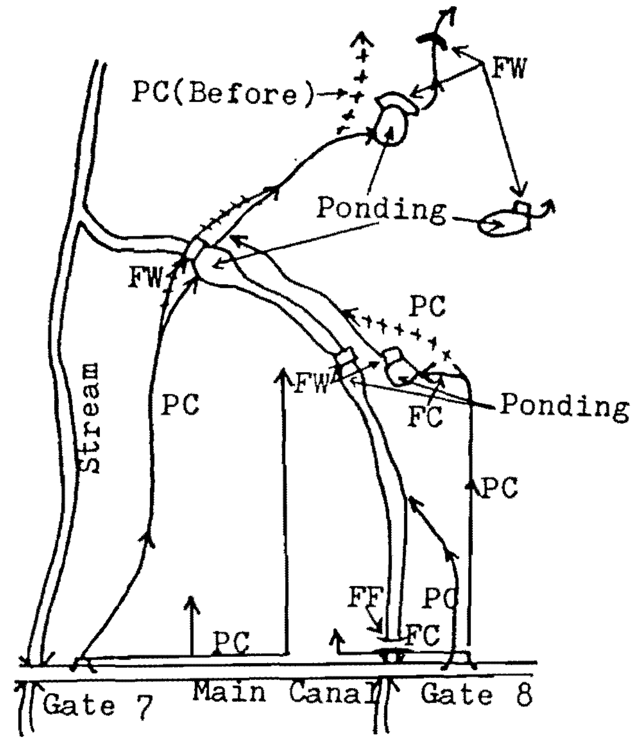

Figure 5

* FC = Farmer Channel; FF = Farmer Flume
PC = Project Channel; FW = Farmer Weir

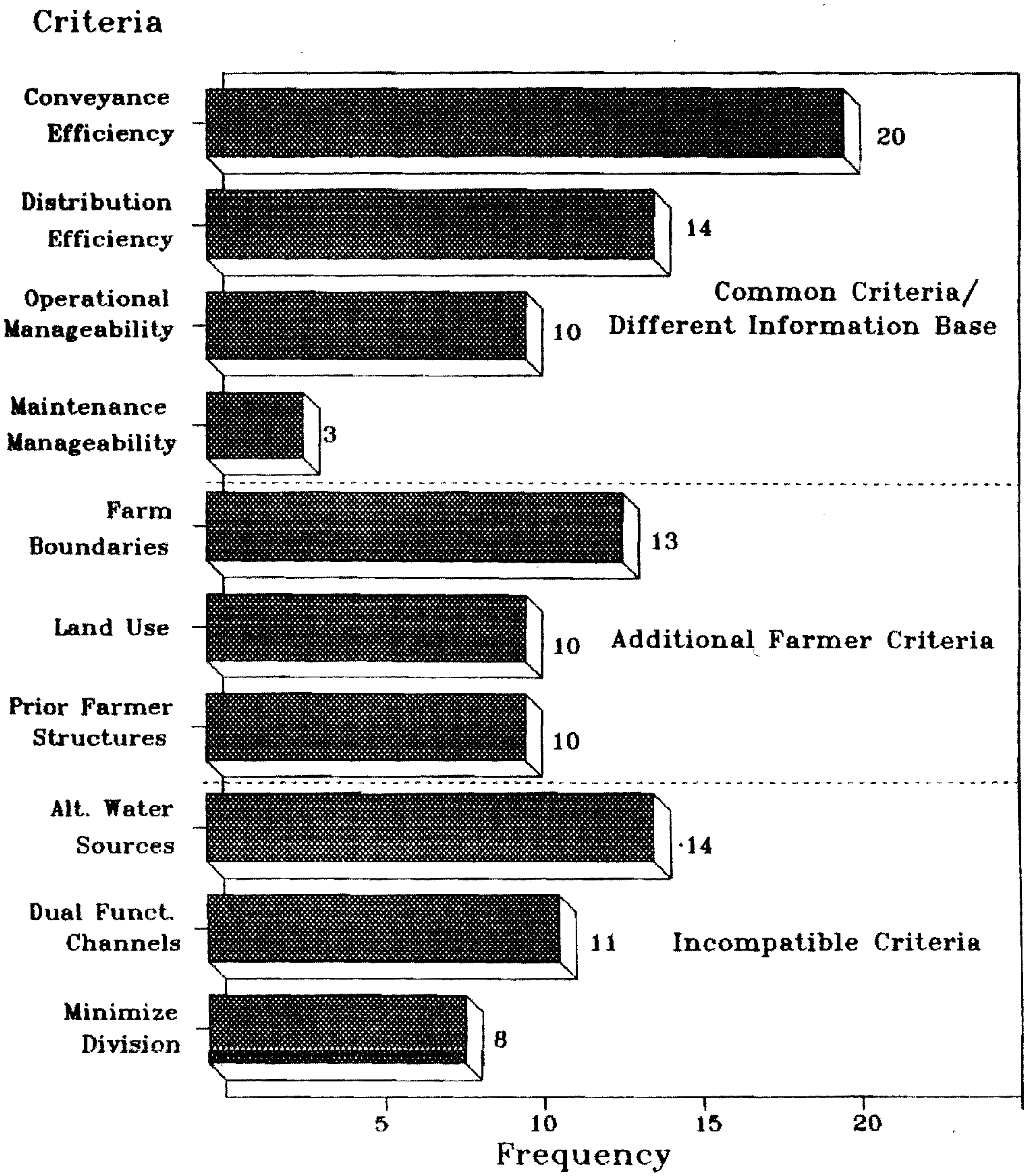

Figure 6. Frequency of Occurrence of Farmer Redesign Criteria
(27 Cases, 113 Total Frequency of Criteria)

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