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IRRIGATION MANAGEMENT NETWORK

EQUITY CONSIDERATIONS IN THE MODERNIZATION OF IRRIGATION SYSTEMS

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ODI/IIMI Irrigation Management Network Paper 89/2b December 198[illegible]

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EQUITY CONSIDERATIONS **IN** THE **MODERNIZATION** OF IRRIGATION SYSTEMS

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1. INTRODUCTION

The failure of many irrigation systems in developing countries to achieve expected levels of performance, coupled with the relatively deteriorated state of many others, and the increasingly higher unit area cost of new systems, has prompted greater emphasis on the rehabilitation and modernization of existing irrigation systems. Illustrative of this is India's Seventh Five-year Plan[1] which indicates that a major objective of the plan will be "... to give the highest priority to the utilisation of the existing irrigation potential for optimising production by constructing field channels, land leveling and introduction of warabandi[2]."

This statement, which is typical of current views in a number of developing countries, incorporates both production and efficiency objectives. Other statements clearly identify social goals, e.g. "... giving "priority to projects benefitting the tribal areas, drought-prone areas and areas with a sizeable scheduled caste population"[3]. Thus, we have a triumvirate of basic objectives for many current irrigation programs to increase production, efficiency and equity. The mechanisms usually identified to accomplish this are the assignment of priority to specific systems, improvement of the physical infrastructure of those systems, and the modification of their water allocation procedures.

In general, in system modernization agricultural production is the primary objective, system efficiency measures are the indices most frequently used to determine the degree to which success has been achieved, and equity or fairness of economic and/or social impact on the 'beneficiaries' is assumed to occur if the system functions as designed.. The rationale for this perspective is relatively clear. Production is the operative mechanism for improvement in economic output of the system (and presumably for improvement in the economic well-being of the farmers). However, it is difficult to isolate the production effect of irrigation improvement from the effects of other components of the agricultural system, availability of inputs, market prices, etc. Thus, system efficiency measures, either on the input side (e.g. degree to which planned areas are actually served), or on the output side (e.g. system water efficiency[4] or crop water efficiency[5]), which are relatively easy to determine, have become widely accepted indices of system performance. Equity, however, remains an elusive parameter.

The equity identified as an objective in the Indian Five-Year Plan is a regional or class equity, which is anticipated to be met when a system is constructed and/or made to function in the region of its location. Within the irrigation professional community there also is a recognition of the need for 'head/tail' equity, usually cast in terms of equalizing the delivery of water between the extremities of the system. In the modernization of irrigation systems, especially where external donors or lenders are involved, the equity 'rule' that underlies system modernization is 'equality' in meeting crop-water-needs, usually with some specific crop or cropping pattern specified. But there are other views of equity that can be held by water users which have validity in specific situations[6]. Unfortunately, in systems operated by the state, equity from the perspective of the farmers is rarely explicitly recognized or considered in the planning, design, implementation, operation or maintenance of the system. It is the thesis of this paper that the failure to consider equity (fairness) from the farmers' points of view is a major cause of much of the relatively poor performance associated with system rehabilitation and modernization. This is not to argue that the farmers' perspectives always must be accepted in designing and implementing changes in the systems; there may be good reasons for wanting to change the current pattern of social relationships.

The role of equity in relation to the design process for system rehabilitation and improvement will be explored in the following sections: equity principles in water allocation; modernization interventions; and application of equity considerations in design decisions.

2. EQUITY PRINCIPLES IN WATER ALLOCATION

It is a truism that irrigation systems reflect their site specific characteristics, exhibit sensitive dependence upon the initial conditions of their formation, and thus are unique in many ways . Some aspects of site specificity are-relatively static, (e.g. those directly constrained by the physical aspects of the site) , but others are more dynamic, responding, with varying degrees of speed, to changes in economic and social conditions. Where the rate of adaptation in the system fails to keep pace with the needs associated with the changing environment there is increased pressure for rehabilitation. While much of the argument for rehabilitation is expressed in terms of the need to address the physical deterioration of the systems, the frequent . inclusion of significant system modifications is recognition of the need for "improvement /betterment/ modernization"[7]. It is in the context of the need for improvement (change) that the requirement for explicit consideration of equity is most critical. Unfortunately, planners and system designers usually give major attention to the production and efficiency goals, and minimal attention to the prevailing equity situation in the system or to that which will result following the changes.

Water users perceive a pattern of water allocation as equitable if claims to water are based on some social principles that are accepted as fair or right. Such principles are found in most

irrigation systems, e.g. that some users have priority because of seniority in the system or that crops suffering from water stress have priority over those not suffering, etc. These principles may, or may not, suggest the desirability of equal allocations of water to all users. There are differences in definitions of equity as seen in the variety of rules for water allocation that can be found in irrigation systems, both farmer-managed and governmental, around the world. Among the least equal are those that allocate the resource on the basis of priority in time, the first user has the first rights. This is typical of many systems in the western United States, as well as between systems in Asia that share a common water source. Examples include the irrigation associations in Taiwan drawing water from the Cho Shui River where there are time-priority differential rights to the water, as well as some tank-based systems in Sri Lanka, where villages with time priority pass "excess" water to a downstream village. In both examples, the inequality in access is not considered unfair. This uni-factor rule is the simplest and least efficient in technical and economic terms, in that it may not even consider the size of land holding, yet the allocations typically are in the form of rights which are very resistant to change[8].

More typical in Asia are systems that allocate water proportionally on the basis of land area[9,10]. These may be of a very simple type, in which the available supply is proportionately distributed solely on the basis of the proportion of the commanded area farmed by the water user; or it may be based on the level of contribution the user made to the construction of the system (in the case of farmer-developed systems). In this latter case, the contribution usually is related to the size of the individual's land holding, thereby reinforcing the strength of the proportional equity rule. In some cases, however, the level of contribution and resultant sharing in allocation are independent of the size of the irrigated holding. This is illustrated in some systems in Sri Lanka[11], where labor contribution to construction of the canal entitled the farmers to a share of the canal supply and the water could then be used on as much area as the farmer could develop. It is also illustrated in Nepal[12], where farmers purchased water shares based upon construction cost and these shares are independent of the area of land to be irrigated. This type of proportional sharing of the. supply does not differentiate on the basis of topography, soil type, crops grown or other factors, consideration of which presumably would lead to increased water efficiency and/or economic efficiency.

However, many systems do explicitly recognize such factors and modify the area/construction-input proportionality rule to consider them. This represents a different definition of equity, one in which the sharing is of the utility of the water resource rather than of the volume of the resource alone. This, in general, is the rule implicit in modern design procedure that starts with climatic, soil and crop water characteristics in determining the 'irrigation requirement'. In some systems with a resource sharing definition of equity there is a formal shift to the utility sharing rule under conditions of water stress. Illustrative of this pattern are the systems of Taiwan[13], where the normal rules of water allocation (based on time priorities and area) that differentiate between sub-systems are utilized until there is a significant shortfall in the water supply (usually about 30%). At that time, and with the acknowledgement of the shortfall by the system members, there is- a shift to "technical rules" by which the traditional rules are temporarily "abrogated and sharing is based on the needs of each irrigation small group. Even systems based on very simple resource-sharing rules frequently modify the rule informally during periods of stress to consider differential needs resulting from physical differences in the local environments[14]. This may be done through personal arrangements between individual farmers, as in Baluchistan, or through delegation to 'elders' of authority to make adjustments in flow delivery to meet critical needs of those in difficulty.

This utility concept of equity is advanced in some systems to include economic productive potential, in which the allocation rule considers not only physical differences in different parts of the system, but also differences in economic opportunity[15]. For example, in some systems in Indonesia a specified fraction of a village area must be devoted to production of government controlled crops; these crops yield lower economic returns than paddy rice. Decisions about allocation of guaranteed water for paddy rice production include consideration of the cropping history of individual farmers, particularly the time since they grew the mandated crops[16]. A different principle is illustrated by the Pani Panchayat systems in India, where water is allocated on the basis of family size, with water for one-half acre/person up to a maximum of 5 persons[17]; this defines economic equity in absolute, rather than relative terms.

Many examples exist where water charges are varied to reflect differences in potential economic return from the irrigation. These may be associated with different crops, with higher value crops being charged higher fees, as in a number of systems in India; they may relate to differential availability of water supply, illustrated in Taiwan where different fees are associated with "two crop rice areas" in comparison to "one-crop" areas.

Thus, we can find in irrigation systems a wide range of water allocation rules or policies, with very different implications for technical and economic efficiency, as well as for the amount of water received by each user. In their individual settings, each may be perceived as fair or unfair by a majority of the water users; changes toward other equity rules, including equality based on technical determinants nay be resisted strongly, enthusiastically endorsed, or both. This has clear implications for the process of rehabilitation/bettermen

3. MODERNIZATION INTERVENTIONS

The 'improvement' or 'modernization' of irrigation systems in developing countries usually envisions some combination of the following: extension of system control further into the farming areas; increased use of concrete and steel in channels and control structures; increased capability by system managers to measure and adjust water flows; revisions in water schedules to permit more flexibility in responding to production opportunities; and development of water user organizations. In certain situations, changes in the irrigation system will include some degree of land consolidation. Thus, improvement anticipates significant changes in the ability to control and distribute water, and potentially important changes in the rules for that allocation. Occasionally, but not universally, there will be increases in the basic supply. There frequently is an expectation that after improvement there will be an increase in the area irrigated, especially when the basic water supply has been increased.

3.1 Extension of System Control

The extension of system control usually takes two forms: (a) physical, in terms of increased density of channels and control structures; (b) managerial, either by the government irrigation department or by some type of water user group. This latter is gaining significant favour, for economic and political reasons.

Fundamental to the judgement that irrigation distribution systems should be extended is the view that each farming unit should be served directly from an irrigation channel. The benefits from individual delivery are clear in the case of non-flooded crops, but may exist to a lesser degree for paddy rice where, under reasonably reliable supply conditions, field to field distribution can be as effective and efficient as individual field outlets[18]. Notwithstanding the potential benefits from increased density of delivery channels, these changes frequently

affect both absolute and relative amounts of water among the water users, and may affect timing. In addition, there may be significant problems in obtaining rights of way, and maintenance responsibilities for the extended channels may devolve disproportionately to the tail end water users.

These problems are frequently exacerbated by the inability of many governments to design and construct effective channels, hampered by the demanding requirements for topographic precision, inadequate numbers of qualified surveyors, inexperienced construction firms, major problems of construction supervision and a failure to utilize farmer knowledge appropriately. This has been the case in the Upper Pampanga River Irrigation System in the Philippines[19], where 40 percent of the turnout structures were determined to be inappropriately located or inadequately constructed, in the 'dykes and ditches' project of the Central Plain of Thailand, in the Tertiary Development Projects in Indonesia and in the Mahaweli Project in Sri Lanka. Physical extensions that do not serve as intended introduce new stresses among the water users, as well as between the users and the irrigation departments.

In areas where fields are not served individually flow proceeds from field to field, often involving a number of different landowners. The downstream users usually are at a disadvantage - with respect to timing and amount of water, but generally have worked out accommodations with the upstream owners which they may consider reasonably fair (or unfair). Extension of channels to serve individual owners (or smaller groups) has the potential to improve the timing and amount of water received by the downstream users, changing the pattern of relationships with the upstream users. In some situations, this change will be resisted by the upstream water users, and specific efforts would be necessary to avoid conflict among the water users and between the users and the irrigation department. These efforts frequently involve an accompanying extension of control, either by the farmers in a group mode or by the government, through its irrigation agency.

In some instances, for example in the Sirsia-Dudehra system in Nepal, upper-farmers have been adversely affected by the lack of adequate field channels when downstream farmers have moved water over fields near harvest or being prepared for planting, In this type of situation there is benefit to all the users and acceptance of this type of change is more rapid.

3.2 Changed Construction Practice

Around the world, many irrigation channels and structures are constructed of locally available materials. In the case of channels this usually means unlined earth; weirs, dividers and other distribution control structures may be of wood, as is customary in farmer-developed systems, or of concrete and steel as in newer government systems. The emphasis on more durable structures is a result, of pressure tp reduce maintenance costs - pressure from external sources, as illustrated in a recent report of the U.S. Government which recommends "... stronger project design and construction criteria to reduce recurrent "costs."[20], as well as from water users themselves. The pressure from this latter group often results from increasing difficulty in obtaining the necessary local materials or mobilizing the required labor. In Thailand, for example, the increased policing of public forests as well as increasing scarcity of bamboo and various types of wood products for small dam repair has resulted in petitions for concrete structures.

While concrete and steel (well constructed) can reduce the frequency of repair (though not necessarily the cost), usually it also will reduce the ability of the farmers to effect those repairs since materials and necessary skills may not be locally available. However, the glue that binds many water user groups and provides the incentive for upstream or more powerful members to accommodate to the needs of their disadvantaged coworkers is the need to unite for maintenance activities, as is the case in many systems in Nepal and Northern Thailand. A reduction in this need can have serious effects on the viability of the water user organization, and on the maintenance of operational equity.

3.3 Water Control Capability

With few exceptions, farmers in developing country irrigation systems use forms of distribution control that are simple, but effective in implementing the operational rules. Where the allocation rule is a sharing of time, as in Warabandi, only on/off control is necessary and very simple gates are used; where the allocation rule is proportional sharing of the resource (as in many rice-based systems), fixed proportional dividers (preferably rectangular openings) coupled with on/off capability are sufficient. Openings from field channels usually are specified as to size and elevation, and thus determine the flows. The introduction of variable opening gates is necessary only when there is a potential benefit from being able to modify water deliveries to more nearly coincide with 'crop water requirements'. This benefit might come from saved water (utilizable elsewhere), from increased yield or improved, product quality. Thus, the introduction of increased control capacity of this type into an irrigation system implies a change in the **equity rule** from one of sharing the resource to one based upon sharing of the economic potential of the water. . This, then implies a need to explicitly foster acceptance of this altered view.

3.4 Water Measurement Capability

The ability to measure flows is generally considered essential to the operation of modern irrigation systems. However, different levels of measurement capability imply different types of distribution patterns (and their related equity). At the present time, even in systems where significant measurement capability exists, it is used infrequently (usually at the beginning of the irrigating season, or in unusual drought situations) and the data often are inaccurate. Lack of calibration and recalibration, failures in monitoring and inappropriate information processing combine to lower the management utility of measurement capability. The introduction of tertiary water measurement into irrigation system operation, therefore, usually implies the need for improvement of the entire information handling system and decision-making structure, as well as the potential changes in equity.

The relationship between a particular water distribution pattern (with its implied equity definition), and the level of water measurement capability necessary to implement it, can be illustrated by two types of water distribution rules. The Warabandi system of India and Pakistan, is based on the proportionate sharing of time of channel access (it does not guarantee a specific amount of water, though there is an implication of an amount sufficient to irrigate similar proportions of each farmer's holding). If the system is in reasonable repair, the distributary channels are designed to provide a specified amount of water/unit land when operated at full supply level. Two measurements, water elevation at the head and tail of the channel (relatively simple measurements), define full supply level. Periodic observations to identify discharge problems would then be the only other regular measurement required.

The **Demand** system, in which individual farmers can request water at times and in amounts convenient for their operations (frequently subject to specific system constraints, but with an implied objective of providing the best operating conditions for all the users) generally requires flow measurement, and information handling capability at least to the level where the requesting water user can control the entire flow, frequently to the individual farm, but at least to the field channel.

3.5 Operating Schedules

Equity rules are implemented, deliberately or de facto, by the schedules for water delivery. Where the schedules are predetermined or established prior to the start of the season, and consist of time of flow and/or fixed outlets, the system basically is an administered system, and a proportional sharing of the resource is implicit. When the associated water supply is severely limited, as in the original Warabandi systems, this type of operating rule can be efficient in physical and economic terms.

Where there are more abundant water supplies and the operating schedule is varied in response to information from the field, the system is a managed one and the implicit equity rule is one of . sharing the utility of the resource. Modern demand systems are designed to permit individual farmers to make their own farming , decisions, usually in the context of relatively large quantities of water, adequate channel capacities and a responsive organization. Technical efficiency can be achieved in demand systems, but effective control of demand is required. Design decisions about operating schedules, therefore, essentially determine the equity rules under which the system will function, as well as the physical and organizational infrastructures necessary for effective implementation.

3.6 Water User Organizations

Water user organizations are being fostered for a number of reasons, among them better operation, improved communication and the desire to shift operating and maintenance responsibilities (including costs) to the users. The techniques used to organize user groups can have a marked effect on the resulting allocation of water and maintenance responsibilities [22]. The groups may reinforce and/or expand existing disparities in service or act to reduce them, depending upon how power is shared in the group. Organizations established by fiat from above, with leadership vested in existing authority frequently reinforce existing disparities. In addition, experience has shown that unless these organizations are reasonably equitable they are ineffective in achieving the stated objectives. Organizations do not occur automatically, but reasonable groups with effective input from the disadvantaged can be organized in many situations. While obtaining an effective role for the disadvantaged is not easy or cost-free, experience in the Philippines, Sri Lanka and Nepal indicates that it can be done.

4. EQUITY CONSIDERATIONS IN DESIGN

The interactions between physical infrastructure, the roles of the irrigation bureaucracy and the water user organizations, and the rules which order those relationships, including rules related to equity, are rarely considered explicitly in planning, design and implementation of new systems, or in the rehabilitation of existing ones. In part, this omission occurs because irrigation systems are usually viewed as technical facilities, a predictable consequence of the dominance of engineers in irrigation bureaucracies. In addition, this oversight is sustained by the complexity of the interrelationships. Finally, it also is a result of the absence of a methodology for incorporating consideration of these complex relationships in the design process. Yet, failure to recognize and address the potential problems resulting from inappropriate relationships is, in our view, a major cause of irrigation system. operation and maintenance problems.

It is not possible, at this time, to suggest a methodology which would consider all the important relationships. However, we propose the use of equity considerations as a basis for such a methodology, and one which should have a significant beneficial effect on system improvement decisions and subsequent performance.

In reviewing a number of examples of farmer-managed and government-managed systems in **a** range of agro-ecologic regions, we have seen that those systems which appear to be successful. in technical and economic terms as well as from a social point of view, **have** clear **equity** rules, **appropriate** physical **structures and organizational** procedures **that permit effective implementation of those rules.** Examples include the Yun Lin Irrigation Association in Taiwan, some farmer managed systems in Nepal and some of the Warabandi-based systems in northwest India. The definitions of equity vary among the systems, as suggested earlier in this paper, but it is clear that a concern for equity is a driving force in all the systems.

A methodology for incorporating equity considerations in design decisions for governmentally-supported irrigation systems is outlined below, and briefly explained in succeeding sections. (This procedure is intended primarily for the government staff involved in design activities.) The steps in the methodology are specified in some detail, and may give the impression of adding significant time and expense to the overall design process; we do not believe this to be, the case. By comparison with the - efforts made to obtain and utilize basic physical information relating to climate, hydrology, topography and soils, and even to the effort associated with the economic analyses, this methodology would represent a small additional effort, with a number of the steps being carried out concurrently or in close sequence.

1. For existing systems, especially those with a relatively long life, identify the rules and operational procedures for water allocation and distribution in actual use and their implicit (or explicit) equity basis. For new systems, state explicitly the planned operating rules and procedures, and their equity basis.

2. Determine the key features of the definitions of equity in Water allocation and distribution held by the water users, including attention to variations in important sub-groups.

3. Evaluate the congruence and differences between the existing (or proposed, in the case of new systems) rules and operational procedures and the local views of equity.

4. Evaluate the appropriateness of the system rules and Operational procedures, both farmer preferences and system realities, for the system's external environment of relative values of water, land and capital resources.

5. If necessary, propose new rules and/or operating procedures that would be appropriate for the external environment anticipated for the next 10 to 20 years.

6. Evaluate the proposed rules and procedures through discussions with the water users.

7. Identify the changes, physical and/or organizational, which Would be supportive of the implementation of the new rules and operational procedures.

8. In making specific design decisions, evaluate the alternatives from the perspective of potential impact on the ability to implement the equity rules and procedures.

4.1 Rules and Operational Procedures

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In government administered systems one can conceptualize four sets of equity rules that coexist: (1) the nominal rules and procedures incorporated in the system design and intended operation; (2) those that reflect actual operation of that portion of the system under control of the operating bureaucracy; (3) those that are operative in the part of the system under the

control of the users; and, (4) the 'ideal' rules and procedures in the minds of the users.

The equity basis for the nominal rules and operating procedures may not be explicitly stated, but usually are relatively easily inferred. Actual operation is more difficult to determine since operational monitoring is not common, and special studies usually will be necessary to obtain the information. Studies during water stress periods should reveal the relevant rules and operating procedures and the implications for equity or inequity.

4.2 Farmers' Definition of Equity

Few irrigation systems serving small-holders in developing countries are controlled to the parcel outlet by the operating bureaucracy. Along field channels, and frequently to significant levels above the field channel, farmers control the functioning of the system. This is true, even with the relatively rigidly controlled warabandi systems of the Indian and Pakistan Punjab provinces. The ways in which the farmers, exercise this control reflect their perceptions of equity, as well as the degree of power they can exercise, either as individuals or in groups.

Water user perceptions of equity can be understood through in depth interviews with farmers with different size holdings and in various parts of the system. They can also be inferred from actual user practice and the type and extent of irrigation conflicts. It is probable that a number (perhaps many) views of the existing situation will be forthcoming, since the farmers in different parts of the systems and with different land resources frequently will have contrasting perceptions of system operation. Similarly, it is likely that more than one view of the desired rules and operating procedures will be proposed.

4.3 Evaluate the Agreement Between Existing Actual Rules and Procedures and User Views of Equity

A comparison of the equity implicit in system rules and operations with fanner definitions of equity should reveal the extent of agreement and disagreement. This comparison, coupled with information about types and extent of problems in the system, should suggest the importance of the disagreements. When there are significant disagreements, the design of rehabilitation should explicitly attempt to reconcile the differences between preferred and actual equity.

4.4 Evaluate Appropriateness of Existing Rules

The appropriateness of the existing rules and operational procedures is related both to the degree of fit between the current equity situation and the definitions of equity held by the farmers, as suggested in the preceding section, and the fit with the needs shaped by the **external environment.**

In section 2, we suggested that systems operate within a relatively dynamic external environment in which the relative **values** of factors important for system operation and utility change over time. To a major extent, these changes in relative values reflect changes in the economic and political environments beyond the system itself. The economic environment determines the absolute and relative values of the land and water resources, with obvious implications for the appropriateness of different rules relating to their use, as well as for the appropriate level of investment for increasing their use efficiency. The extent to which existing or proposed rules and procedures move the system toward increasing efficiency of the scarcer resources is a second measure of the appropriateness of those rules.

The development of new systems, or the rehabilitation of existing ones, is frequently associated with contemporary government views of economic and/or social objectives. The shift from

'protective' to 'productive' systems, in Pakistan, is illustrative of changed economic and social objectives. This is a major change, from equity as the proportional sharing of a limited, critical resource among the widest number of people, to a definition that emphasizes the right to maximum economic return for a limited number of farmers. By contrast, the increasing demands for water (industrial and municipal) and, thus, the increasing value of water in Taiwan were accommodated through the substitution of technical rules of water allocation and distribution for customary rights, while maintaining the basic equity objective of equal opportunity for productive rice production by each farmer.

The emphasis on greater farmer participation in system operation and maintenance, evident in a number of countries in Asia, is a reflection of both financial and social equity considerations, fostered by major political decisions. The appropriateness of new or revised rules and operating procedures, therefore, must be evaluated on the basis of their agreement with these political directives.

4.5 Propose Revisions or New Rules

The evaluation of the relative values of the factors associated with irrigated agriculture should permit the identification of rules and operational procedures that would accomplish efficient utilization of these resources, and which are considered equitable (at least by the planners). If these proposed rules and procedures differ significantly from either the actual rules, or those desired by the farmers, difficulties in implementing and sustaining the changes can be anticipated. A pattern of water allocation and delivery that persists over time (sometimes as short as two years) can be perceived as a right, and a change in this pattern perceived as an unwarranted taxing **away** of this right. If the pattern has persisted for a relatively long time, this may have established a right that has de facto legal status. If new rules effectively take away 'rights' they are likely to be resisted, sometimes in the courts, more often through unsanctioned acts. Thus, rules that significantly change amounts or patterns of water delivery must be weighed in terms of the benefits to be obtained and the costs, including political, associated with their implementation.

4.6 Involve the Farmers

If the government planners decide that the 'more efficient' rules and procedures should be implemented, careful consideration must be given to the process of implementation. Rarely is it possible to introduce effectively significant changes by fiat. Therefore, the change process must provide the conditions that will generate understanding, acceptance and approval by the water users. At the least, this means effective participation by the users in the entire process, including the identification of problems and the need for change. To the extent that the farmers can be productively involved in the actual implementation of the changes, the changes are more likely to be adopted and maintained. In some cases, implementation may require substantive quid pro quo if the farmers are being asked to give up perceived water rights.

4.7 Identify Supportive Changes

In design of new systems, initial emphasis is laid on the physical system necessary to capture and distribute the water, and in rehabilitation to repair deteriorated physical works. To implement new rules and operational procedures, however, it probably will be necessary to make changes from the existing physical and organizational structures. The design process for both the physical and organizational changes should start with tentative decisions about the equity objectives and the related patterns of operation and maintenance, working back to the physical and organizational structures required to achieve these. A deliberate effort should be made to consider a wider range of options for operation and maintenance patterns and for specific

techniques than is usual, to permit identification of the most economical and efficient practices and facilities.

4.8 Make Design Decisions

Each specific decision about necessary infrastructure should be judged on whether the proposed decision will enhance or impede the probability of achievement of the desired equity and associated operation and maintenance plans. For example, if the rule is one of strict proportionality in sharing the water (or its proxy, time of channel access), variable turnout gates are unnecessary and may impede effective implementation. Simple on/off gates would be much more appropriate forms of outlet control. By contrast, if the rule is one of sharing the utility of the resource among the widest number of users, with an expectation of significant taxation (fee payment) from individual profits, then adjustable gates would be appropriate, but only if accompanied by effective monitoring and response procedures. The decisions should be based upon the probabilities of effective implementation, and not on possibilities, modern irrigation experience has-more than its share of systems designed on the - basts of possibilities that were not realized. _ .

5. CONCLUSIONS

The dynamic nature of the context within which irrigation occurs frequently necessitates changes in physical infrastructure and organizational arrangements, including those which determine system operation and maintenance. For effective operation, these changes must fit with farmers' definitions of what is fair or induce modifications in those definitions.

Rules and operating procedures are implemented by use of the physical works as well as by the actions of the controlling agency and the farmers. Thus, decisions about the physical structures, the procedures of the operating agency, and the roles of the water users must be made with explicit consideration of their interacting nature. Consideration of these interactions is facilitated by using the impact of proposed changes on the probability of achieving the desired equity in the system as a performance measure.

fair by most farmers is more likely to be productive and efficient than one that the State has designed on the basis of productivity and efficiency, but which is considered unfair by the users. Experience suggests that individual self-interest, in many instances, is not so narrowly defined or so rigidly held that changes in water sharing cannot be effected with cooperation and success.

NOTES

1. As reported in the Economic Times, India, 10 November 1985.

2. Warabandi is a form of timed rotation of irrigation characteristic of the Punjab in India. See Malhotra, S.P. 1982 The Warabandi System and Its Infrastructure, Central Board of Irrigation and Power Publication No. 157, New Delhi, for a complete description.

3. Economic Times, India 10 November 1985.

4. Ratio of the amount of water utilized by the crop to amount diverted into the system (System Water Efficiency), or at specific points in the system.

5. Kilograms of crop/unit water, or similar water-based crop output indicator.

6. This view has also been expressed by Sampath [Sampath, R K (1988) "Some Comments On Measures of Inequity in Irrigation Distribution", ODI-IIMI Irrigation Management Network 88/2f], who proposes a methodology for characterizing inequity in terms of rich/poor and head/tail in the context of different cropping pattern demands.

7. For a fuller discussion of the rehabilitation/betterment issues, see, Levine G. The Challenge of Rehabilitation and Betterment, in Fowler, D. A. (ed) The International Conference on Irrigation System Rehabilitation and Betterment, Volume 2: Papers. Water Management Synthesis II Project. Jan 1987.

8.- For an example of a system with a mechanism for change, see: Levine,G. Irrigation Association Response to. Severe Water Shortage; The Case of the Yun Lin Irrigation Association, Taiwan, in Rural Development and Local Organization in Asia, Vol.2 East. Asia. N.Uphoff,ed. MacMillan, N.Delhi 1983.

9. For interesting accounts of farmer-managed systems with this allocation rule see: Tanabe,S. 1981. Peasant Farming Systems in Thailand: A Comparative Study of Rice Cultivation and Agricultural Technology in Chiengmai and Ayutthaya. PhD dissertation, The School of Oriental and African Studies, Univ. of London.; Martin, E. and Yoder,R. 1983. Water allocation and resource mobilization for irrigation: a comparison of two systems in Nepal. Paper presented at Annual Meeting, Nepal Studies Association, Twelfth Annual Conference on south Asia, Univ. of Wisconsin, Madison.

10. For a few descriptions of government-managed systems with this proportional allocation rule see: Malhotra,S.P. 1982. The Warabandi System and its Infrastructure. Central Board on Irrigation and Power, Publication NO. 157. New Delhi.;

11. See, Leach,E.R.,1961. Pul Eliya: A Village in Ceylon. Cambridge University Press.

12. Martin,E. and Y.oder,R. 1983. Water Allocation and Resource Mobilization for Irrigation: A Comparison of Two Systems in Nepal. Paper presented at Annual Meeting, Nepal Studies Association, Twelfth Annual Conference on South Asia, University of Wisconsin, Madison,

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