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Working Paper No. 8
Center For Resource Policy Studies

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THE ECONOMICS OF WATER REFORM:

INSTITUTIONAL DESIGN FOR IMPROVED WATER MANAGEMENT IN THE LDC'S

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PREFACE

We gratefully acknowledge research support from the U.S. Agency for International Development for a project entitled: Production Performance of Irrigation Systems in LDC's.

This research will comprise Mr. Parker's doctoral dissertation at the University of Wisconsin, with empirical work conducted in Pakistan during 1976 and 1977. Dr. Taylor was a Visiting Professor, Department of Agricultural Economics, University of Wisconsin, Madison.

We gratefully acknowledge the constructive criticisms on an earlier draft of Anthony Bottrall, Robert Chambers, E. Walter Coward, Jr., Thomas Dobbs, Peter Dorner, Brooke Green, John Harriss, Robert C. Hunt, Norman Nicholson, Effendi Pasandaran, Vernon W. Ruttan, William Staub, and Thomas Wickham.

I. INTRODUCTION

The political and economic pressure for increased food production in the LDC's is considerable, reflecting both the increased demand for food as population levels rise and as people become more affluent, and a political drive of individual countries to become more self-sufficient in the production of food. The latter received renewed emphasis during the early 1970's when the world experienced an absolute scarcity of food in international markets and a skyrocketing of food prices.

The political and economic pressures are not only for more production, but for production which brings benefits to a wider cross-section of the people involved in production. One need only review national planning documents in most LDC's and the pronouncements of most international lending agencies and foundations to see substantial evidence of concern for equity in development goals and objectives.

While this paper gives some attention to the productivity dimension of irrigated agriculture, its primary emphasis is on equity. This approach is followed because of the substantial gap between the stated ideal of achieving greater equity and what has actually been realized in most circumstances.[1/] More importantly, we believe that those concerned with equity-based reforms need to be more explicit in recognizing what will be required to achieve progress under the circumstances found in most irrigation systems.

One fundamental strategy for intensifying agricultural production involves irrigation. Irrigation potentials may be expanded through: (1) the construction of new projects, where decision variables are the size and location of potential projects and whether the projects are to involve river diversion,

ground water, or reservoir storage; (2) the rehabilitation and modification of the infrastructure in existing projects, where the key decision variables concern the timing and nature of the possible infrastructural changes; (3) the more intensive and perhaps modified operation and maintenance (O & M) of irrigation infrastructure, where key decision variables include the nature and relative intensity of O & M, the planning of cropping patterns, and the intergroup and intragroup allocation and scheduling of irrigation water deliveries; and (4) the fuller implementation and enforcement of, or possible changes in, the rules and regulations governing the use of irrigation facilities.

Here, we treat water reform encompassing the second, third, and fourth aspects listed above. Water management is defined to represent the making of decisions concerning these possible approaches. This purposely broad definition enables "water management" to encompass a full range of possible options available for enlarging and making more equitable the use of existing irrigation water supplies.[2/]

The paper deals with gravity-flow canal irrigation in which access to water within projects, in terms of the scheduling and allocation of water per unit of area irrigated (or in rare cases per irrigated farmer), is supposed to be -- but rarely is -- equal. It has primary reference to inequities which arise because larger and otherwise more powerful irrigators exert inordinate influence over decisions on water management. Illustrations are projects in which, for example, decisions are made to redesign infrastructure so as to: (1) serve most directly land owned by more powerful irrigators; (2) allocate larger and more regular water supplies

to more powerful irrigators; and (3) enforce less rigorously rules and regulations against more powerful irrigators. Alternatively, inequities may arise because the less powerful are unable and/or unwilling to press for decisions that would improve their relative access to irrigation water.[3/]

We readily acknowledge that the possibilities of achieving institutional reform under the above circumstances are much less than when: (1) the disparity of economic power and social status among irrigators within individual projects is relatively small [Freeman and Lowdermilk, 1976; Harriss, 1976; Lewis 1971; Mirza, 1975; RISS, 1975]; (2) the extent of intercommunity factionalism is small [Freeman and Lowdermilk, 1976; Kumar, 1974; Mirza, 1975]; and (3) institutions to deal with water arise simultaneously with the development of an area's water resources for irrigation [Hutapea, et al., 1976]. But it is precisely because these circumstances are more intractable, much more common, and the subject of little serious attention by scholars that we believe it important to attempt to deal with them. We do not provide final answers, but we do suggest alternative approaches that appear essential if the problems of achieving greater equity in water distribution are to be effectively addressed.

Before proceeding with the paper, two initial comments are necessary, with the first being definitional. We use <u>water reliability</u> or <u>water security</u> to embody both the quantity and timing of water availability. That is, these terms involve not just average amounts of available and needed irrigation water per unit of area but also the certainty of water being available when it is needed. The latter dimension takes account of varying

irrigation water requirements associated with different periods in land preparation-crop growth cycles and differing incidences of rainfall and cloud cover. In reporting on literature in the following section, however, we have generally retained the terminology used by individual authors.

Second, we are aware that necessary and feasible courses of action for improved water management are rather location-specific. That is, the circumstances surrounding individual irrigation projects importantly influence which approaches are most likely to be effective in improving the management of the projects. Examples include: (1) the source of water supply, size, topography, and climate of a project; (2) the organizational structure, density of infrastructure, and nature of the operation, maintenance and enforcement procedures of a project; and (3) the population density and existing institutions, social values, and cultural norms in a project area. Thus, we do not attempt to outline in the paper universally valid approaches for improving LDC irrigation water management. Indeed, the extent and nature of applicability of the various proposed approaches will have to be assessed project-by-project. However, there are some generally applicable conceptual issues which need to be recognized by researchers. It is this recognition which we hope to stimulate.

The format, then, is to turn to a review of the literature on the role of water management in agricultural development, and then to offer an explicit discussion of equity-based water reform. This discussion will include a set of general principles, some suggestions of organizational structure, a brief overview of the Philippine Irrigators' Service Associations, and some concluding comments about possibilities for implementation.

II. WATER MANAGEMENT AND THE DEVELOPMENT OF AGRICULTURE

In this section we deal with the relationship between water management and agricultural development.[4/] The existence of insecure water supplies to LDC irrigators is documented, and the implications of water insecurity to aggregate levels of agricultural production and the distribution of production and income among irrigators are examined.

Water Management and Productivity

In many canal irrigation systems, water supplies to some irrigators are extremely insecure. To the extent that this is so, farmers have an incentive to avert the risk of water shortage, thereby adversely affecting their production.[5/] Increasing the reliability of water supplies through improved water management could, therefore, be expected to enhance aggregate agricultural production. There is an extensive literature on this subject, some of which will be reviewed.

Lowdermilk, Clyma, and Early [1975] report that almost 70 percent of their sample of Pakistani farmers in the Punjab consider water supply as <u>the</u> most important factor in determining which crops and what areas to plant. Expected crop price becomes important only after water supply is settled. Moreover, the crops with high water demands are generally grown near the head of watercourses; this same land also has the highest cropping intensity.

In a more recent study of Pakistan, Freeman and Lowdermilk [1976] find that water supply looms larger in explaining yields than all other inputs combined. Lowdermilk [1972] also reports that Pakistani Punjab wheat farmers with a more secure water supply (tubewells) achieve statistically higher yields than farmers without tubewells. He also finds that water control, nitrogen, seeding rate, seed-bed preparation, and sowing method combined explain 91 percent of the variation in yield.

In a study on India, Hodgedon [1974] reports that water is the crucial ingredient precluding almost 75 percent of nonadopters from using new inputs. VanderVelde [1971] finds that water supply is the key factor in inhibiting irrigators in Haryana North India from using new high-yielding seeds, fertilizers, and other modern inputs. Kumar's [1974] study in Orissa of the contrast between areas where field channels are well maintained and where they are not shows that during the dry season the improved areas have higher cropping intensities, higher yields, and more area under irrigation.

Again in India, Moorti and Mellor [1972] report that secure water from tubewells results in average yields of 25 percent more than when water availability is less secure. Reidinger [1971] and Miglani, et al [1975] report similar tendencies in other studies of Indian irrigation. In a later article, Reidinger [1974] analyzes in some detail three sources of uncertainty faced by farmers in receiving assured irrigation supplies. He concludes that institutional changes to deal with these uncertainties would allow farmers to reduce risk adjustments, improve water and crop management, and thus increase yields and profits.

Literature reporting on the relationship between water security and productivity in Southeast Asia is less extensive than that for South Asia. Reports on the Philippines 6/ include a case study by Wickham [1970] of three provinces in which she reports that, below a certain level of water adequacy, yields are adversely affected. In a study of the Penaranda River Irrigation System, Valera, et al [1975] find negative effects of reduced water availability on yields, and on the area planted under irrigation.

Abel [1975] reports that a primary motivation for modifying the design and management of Taiwan irrigation systems in the 1950's was to reduce the variance in water received by farmers, and thus to achieve larger areas of irrigated cropland and expanded levels of production.

In the upper part of the Chao Phya project in Thailand, Small [1973] has evaluated the returns to water control facilities. He finds a return to the public investment in the control facilities of 6 to 9 percent. The gains are largely in the form of reduced risks of wet season paddy losses from inadequate water and excessive flooding. Also in Thailand, Tantigate [1976] has studied the impact of water conflict between upstream sugarcane producers and downstream rice producers in the Mae Klong irrigation project. She finds that the sugarcane farmers frequently interrupt the planned schedules of water delivery to rice farmers. This added uncertainty of water supply discourages the rice farmers from adopting modern transplanting techniques, reduces wet season rice yields, and precludes an assured second rice crop.

In conclusion, there is substantial evidence that steps taken to increase irrigation water security will improve the possibility of fuller adoption of modern technology, result in higher yields and cropping intensities, and permit greater production and income from irrigated agriculture.

Water Management and Equity

The distributional impacts of insecure irrigation water supplies are examined through studying different groups of farmers who have equal access to irrigation water in <u>theory</u>, but not in actuality. Specific attention is given to distinguishing the characteristics of those who are well served by irrigation from those who are not. Since inequities of distribution are frequently an underlying cause of conflict, literature dealing with irrigation conflicts is also covered. A basic presupposition of this section is that improved water management procedures, if they are designed to help assure greater equity of access to water supplies among irrigators, could contribute to achieving certain income redistributional objectives as well as productivity objectives.[7/]

Most large-scale canal irrigation systems in LDC's are planned to be egalitarian,[8] in that equal quantities of water are allocated per unit of land irrigated.[9] The Hunts [1976] document this as the basic allocation principle for Mexican irrigation, and Wade [1975a] does likewise for India; the authors are aware of few exceptions to this pattern in the developing world.

This issue, then, becomes one of practice; in reality, is water equitably distributed across all the land intended for irrigation? Empirical evidence in LDC's suggests many exceptions, particularly during periods of water scarcity when water supplies become potentially insecure--circumstances to which few irrigation systems are completely immune. The following illustrative studies deal sequentially with South Asia, Southeast and East Asia, and Central and Latin America.

South Asia

Wade [1975a] suggests that under common water-scarce conditions in Indian irrigation, certain categories of clients are likely to be more successful than others in presenting their water needs to the irrigation bureaucracy. Such farmers are those with large landholdings, more wealth and education, and greater influence. Further, he sees at least two causes for a growing inequality of distribution among irrigators over time. On the one hand, disadvantaged farmers with insecure water supplies adopt a variety of approaches to reduce adverse effects from possible water shortage, e.g., diversification into lower-profit (but more drought-resistant) crops and the use of lower levels of variable inputs. Secondly, although initially large farmers may be more or less randomly located within a project command area, over time it is highly likely that the larger and more powerful landowners will acquire more favorably located land and thereby reinforce their wealth and income position relative to that of others.

In the Sarda Canal System of Western Uttar Pradesh, India, Thorner [1962] has observed two standards of water service. A small minority of rich farmers obtain as much water as they want and are able to adopt profitable irrigated crops. The small farmers on the other hand must adopt a basically rain-fed cropping pattern, treating canal water as an intermittent blessing to be welcomed when it comes, but not to be relied upon.

Reidinger's [1971] study of irrigation in Hissar District, North India shows that water service is much more favorable at the head-end of watercourses. Head-end farmers are not subject to as great a loss from seepage and evaporation as tail-end farmers, and there are fewer opportunities for intervening farmers to steal water. A tail-ender's position is made even more precarious if the elevation of his land is relatively high.

An additional finding of Reidinger is that the holdings of larger and more powerful landlords are often closest to the head of the watercourse. In one watercourse he found topographic conditions such that the larger farmers with relatively low land were initially at the tail-end of the watercourse. It was not long, however, before the large and powerful farmers were able to bring pressures leading to the re-location of the watercourse outlet near to their farms.

In Poona District, West India, Orenstein [1965] finds water shortages to increase as the distance of farmers' fields from canals increases. He also finds a tendency over time for land to be sold by remotely located farmers with insecure water supplies to farmers located near canals. Human obstacles to the flow of water to distant lands are thereby removed, but in the process the advantaged became more advantaged and the disadvantaged more disadvantaged.

Chambers' [1974] study of South Indian tank irrigation shows considerable evidence of water being distributed inequitably, with farmers at the head-end of watercourses generally being more favored. In some cases, however, tail-enders have more adequate water supplies. For the latter, decisions had been taken to allow water distribution to tail-enders before head-enders, though the circumstances leading to the decision are not indicated. While this illustration pertains to rather small scale tank irrigation, it is included to highlight the importance of the sequential timing of discharges along watercourses to water receipts of various cultivators. Moreover, it suggests the possibility of revised operational procedures to deal with those otherwise disadvantaged.

A final aspect brought out in the Indian literature is the expected implication for the distribution of irrigation benefits from improving the security of water supplies to cultivators' fields. Wade [1975b] suggests several reasons for believing that increased water security will have positive redistribution effects. Part of his rationale is simply that small farmers currently bear the major brunt of water insecurity. Further, he sees the possibility for more amicable personal relationships between landlords and tenants or laborers from reduced uncertainty. Reidinger [1974] argues that allocating more water to small farmers would not only improve income distribution but probably also increase aggregate production. Miglani, et al [1975] provide empirical evidence of less dispersion in incomes among irrigators with more secure water supplies in the Indian Punjab.

Several recent studies in Pakistan document the inequitable access to water of various types of irrigators. Freeman and Lowdermilk [1976] find that power over water allocation varies directly with land ownership. When inducements to water masters are offered, large landowners enjoy scale economies; they are able to receive extra water at a lower per-unit cost than their less powerful neighbors.

The propensity to offer inducements is also an increasing function of the landowner's distance from the main water source, thereby implying that the greater the number of intervening cultivators, the greater the water insecurity.

Mirza's [1975] study of watercourse maintenance and operation shows evidence of tail-end farmers having less satisfactory access to water supplies. When representations are made to irrigation authorities, large landholders are more likely to produce favorable responses than small farmers.

Lowdermilk, Clyma, and Early [1975] indicate a discrepancy between actual and regulated rates of water discharged into farmers' fields, and a need to give special attention to the rights of smaller farmers in modifying water distribution procedures.

In Sri Lanka, Chambers [1974] finds evidence of head-end irrigators receiving disproportionately larger amounts of irrigation water. These farmers flood their paddies excessively, thereby insuring themselves against later water shortages. Additionally, greater water depth results in less weed growth thereby permitting a reduction in labor expenses for weeding. Farmers at the tail-end not only receive smaller quantities of water, but also experience delayed discharges; they are often precluded from growing the most productive varieties (which have more exacting water requirements) and their crops frequently suffer from inadequate soil moisture.

Harriss [1974] indicates that the rural power structure of Sri Lanka's Hambantota District has exercised a significant influence upon water management. Even with the agricultural productivity Law of 1972 which makes "...improving productivity and maintaining efficient standards of production..." a legal requirement on the owners or occupiers of agricultural land, it seems that the law has had no effect on creating a more equitable use of irrigation water. Poor

and marginal farmers remain as poor as ever. He points out, however, that power and wealth are not consistently related to water access and that plots near watercourses are not necessarily most desirable. Soil fertility, elevation, and drainage are complicating factors.

Southeast and East Asia

There has been substantial emphasis in the research on equity of water distribution in the Phillippines on identifying the location--within irrigation systems--of the most significant water distribution problems. The focus has been on two dimensions of location: (1) distance of fields along the main distribution canals from the canals' main turnouts;and (2) distance of individual fields from the turnouts which serve the fields. Since plot-to-plot movement of water to individual paddies is common in the Philippines, the former dimension largely involves water distribution within main irrigation systems and the latter concerns water distribution at the farm level. In summarizing the results of this research, Wickham and Valera [1976] conclude that the main shortcomings in water distribution are within the main system rather than at the farm level. They believe that the relatively efficient and equitable on-farm distribution of water reflects informed arrangements for water sharing worked out over many years.

Valera et al [1975] report the results of a pilot project in the Penaranda Irrigation System in which controls over the distribution of water were improved. This study shows improved water control leading to larger production and a more equitable distribution of production and income, largely because tail-enders received earlier and larger quantities of irrigation water.

In another Philippines' study, Cruz [1974] finds that larger and more powerful Iloilo landowners exert more control over irrigation than average irrigators.

Pasternak [1968] has undertaken a study of conflict and cooperation in Taiwanese irrigation. He finds the most important factor influencing cooperation in the P'u-Wei Irrigation System to be the location of fields relative to their water source. Further, he indicates that the introduction of pumps to reduce the insecurity of water supplies to irrigators' fields has significantly reduced conflict.

Vandermeer's [1968] study of Taiwan's Nan-Hung Irrigation System, following the introduction of improved water control measures, shows that field location no longer affects the availability of water to various irrigators. He [1971] also reports thirteen interrelated factors influencing conflict among irrigators and the resulting thievery of water, including inequities in water supply, water rights, and water control. Contiguous farmers downstream were generally unwilling to steal from each other but, on occasion, banded together to secure additional water from upstrean irrigation groups.

Eyre's [1955] study of the Twelve Village Irrigation Cooperative in Japan shows location to be the most important factor associated with irrigation conflict. Intersystem conflicts are greater and more difficult to resolve than intrasystem conflicts, corroborating Vandermeer's finding.

Gillespie's [1975] study of the Lam Pra Plerng Irrigation Project in Northeast Thailand also shows that the farther a farmer's field is from the main source of water supply, less water is received and the less dependable is the supply.

In Indonesia, the Research Institute of Social Sciences (RISS) of Satya Wacana University reports on six case studies of irrigation organization [1975]. In several systems including some in Central Java, the village watermaster is part of a rather strong and traditionally oriented village leadership, and the rice land whose produce is used to pay the village leadership is given first

priority in water distribution. Duewel's [1976] review of this and other studies of Indonesian irrigation, shows that current water distribution procedures, unlike those of the past, generally favor the interests of the rural elite who have command over rural resources. He attributes the growing inequity in water distribution to a physical deterioration in water control facilities, changed social values, and expanded linkages of peasants with their surrounding socio-political and economic environment.

In other situations, especially where landholdings are relatively uniform and local leadership is more development-oriented, the RISS found evidence of rather equitable water distribution. One such site was in Central Java, another in Bali. Birkelbach's [1973] study of Balinese irrigation associations (subak) shows relatively little inequity in the access of various cultivators to water and other institutional arrangements tending to mitigate over time interpersonal wealth differences. Pasandaran's and Taylor's [1976] study of East Javanese irrigation also shows evidence of rather finely tuned and equitable distribution of irrigation water among cultivators.

Central and Latin America

Several authors deal with water distribution in Chile. Stewart's [1976] case study in the Illapel Valley shows that despite all farms having equal formal rights to water per acre, actual water receipts are positively related to size of landholdings and nearness to main canals. Further, when formal disputes over water go to judicial or administrative hearings, the largest landholder usually wins out.

Parks' [1976] study of water use on farms of different sizes in Chile shows diminishing marginal returns to water on all farms. Since larger farms generally have better water control, however, they reach their maximum net revenue with

less water per unit of land. He concludes that reduced uncertainties of irrigation water supply would lead to larger relative gains for small farmers.

Thiesenhusen [1971] also cites a Chilean study showing that water delivery per acre is positively related to size of farm, proximity of fields to the main canal gate, and a farmer's position in local water user associations.

In Mexico, Millon, et al. [1962] report the results of a study on conflict in the Teotihuacan Irrigation System. They find that conflict arises mainly because of location, with downstream irrigation communities often having inadequate water supplies during periods of water scarcity.

The Hunts' [1974] study of irrigation in the San Juan area of Mexico shows marked discrepancies, in practice, from the officially prescribed egalitarian distribution of water on cultivators' fields. They report actual water allocation to be influenced inter alia by differences in the wealth and power of irrigators, the water needs for various crops, and the size and quality of fields.

Summary

Emerging from these studies on water management and equity are the following conclusions. Although most large-scale canal irrigation systems in LDC's have been planned to allow equal allocations of water per unit irrigated, different classes of irrigators often have different degrees of access to water. The factors most commonly associated with the differential access are the following:

1. The location of farmers' fields relative to their source of water, with those fields most distant from the source of water most likely to have least reliable water supplies.

The greater unreliability of water supplies can be attributed to the greater cumulative effect of seepage and evaporation losses on fields more distant from their water source, and the greater possibility of intervening irrigators interrupting the flow of water on its way to tail-end fields. Further, inequities

of distribution and resulting conflict are generally reported to be greater among irrigation groups than within irrigation groups, presumably reflecting tendencies for greater cohesion within smaller groups in which individual members are personally acquainted with each other and are in more regular contact.

2. The economic position of farmers, with those having a stronger economic position more likely to have reliable water supplies. The most common measure of economic position reported is size of farm, although general references to wealth are frequently made.

3. The social status of farmers, with those enjoying the highest social status more likely to have more reliable water supplies. Reflections of social status include a cultivator's political and administrative position and/or power, personal connections, and caste or other symbols of cultural position.

It appears that economic position and social status can contribute to water security in the following ways. In the short run, those with greater economic power and social status may have an inordinate influence on the formulation and implementation of irrigation schedules so that their fields receive earlier, larger, and more assured deliveries of water. Further, if water distribution regulations are broken, larger farmers may be able to secure more favorable resolutions to the charges assessed against them. In the longer run, those with more power and status may be able to influence decisions on the redesign of irrigation systems so that their fields become more satisfactorily served with water. In addition, over time those with more economic power may be able to buy land having more favorable access to irrigation from those with less power.[10/]

III. TOWARD WATER REFORM

Given the institutional climate in which water is allocated in most LDC's, the primary efforts toward better water management are generally in terms of assurring irrigators of a specific quantity of water per area of land being cultivated. Thus, adequacy of water receipts is concerned with both quantity of water and the time of its delivery, plus some relationship to soil conditions and crops grown; adequate water for upland crops is, therefore, quite different than for rice. Controlling for soil and anticipated crops, water adequacy can be expressed as the average quantity of water received in any single water turn, or for a season. Yet another dimension is the variation between planned and actual deliveries at various times within a season. Inadequate average deliveries and highly variable deliveries will inhibit the adoption of improved technology, with the latter often the most serious deterrent.

Our concern in the area of water adequacy is with the production implications--in an aggregate sense--of uncertainty in water receipts, and with the equity implications of who suffers the most under conditions of water uncertainty. It is fairly well documented that limited reliability of water inhibits the adoption of improved technology, and the inhibitory effects are not uniformly distributed across irrigators in a system, nor between systems. The following is a first step toward explication of this problem.

Consider Figure 1. Here we depict a hypothetical system consisting of but two irrigators--individual A who is a large, wealthy, and influential farmer, and individual B who is small, poor, and without much influence. With a certain aggregate quantity of irrigation water available in the "typical" year, its allocation between A and B can be depicted as in the figure. Under the current system, individual A possesses a production function per unit of land given by $E(TR_A)$, while individual B possesses a production function per unit of land given

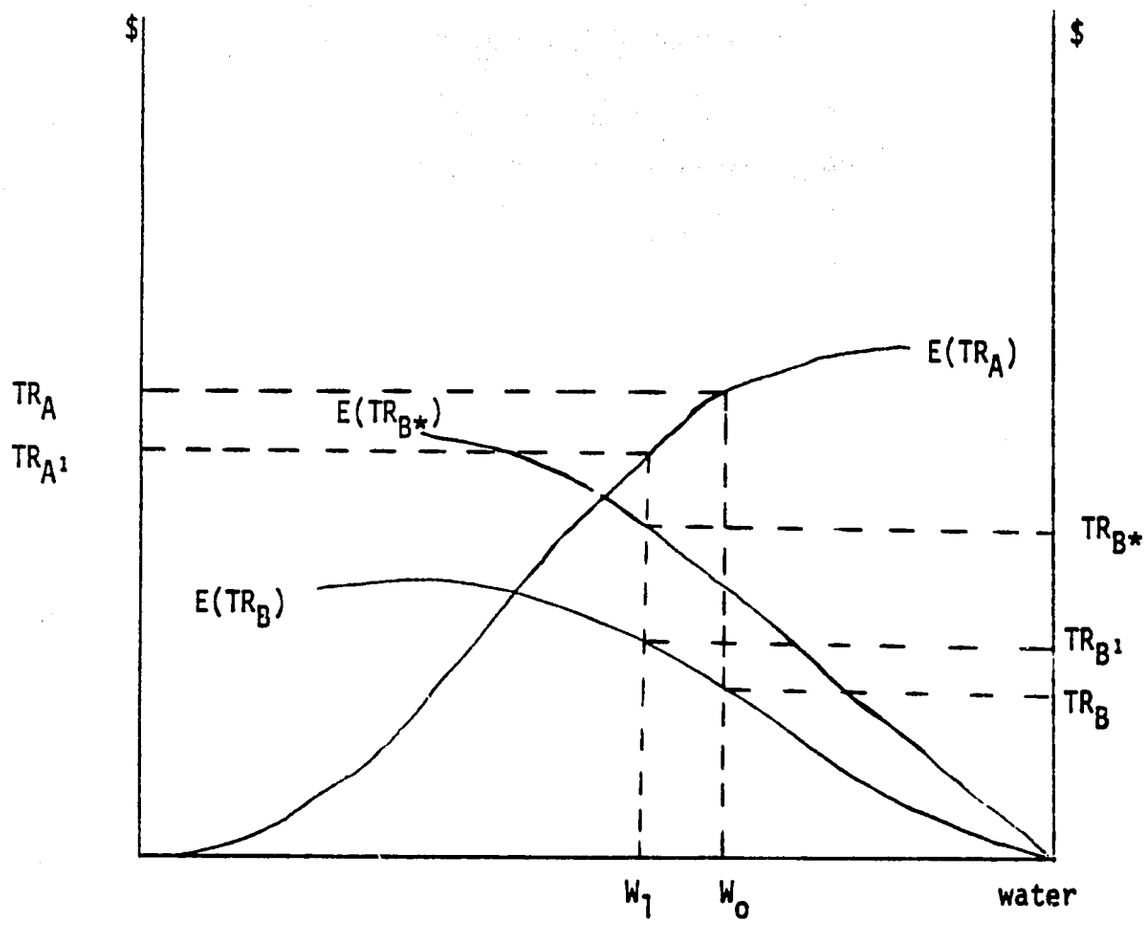

FIGURE 1.

by $E(TR_B)$. Assume that initial water distribution is as depicted at W_0. The gross value of A's production is given by TR_A, while for B it is given by TR_B.

A one-time adjustment of water allocation to W_1 could be expected to result in a move from TR_A to TR_{A1} and from TR_B to TR_{B1}. Under these circumstances we would not expect the increased production from B to exceed--or, indeed, even match--the reduced production of individual A. However, under the assumption that institutional design could be such as to guarantee the allocation denoted by W_1 over the long run it is our hypothesis that the production function for individual B would shift to $E(TR_{B*})$. Now, with greater tenure security in water deliveries, we would expect to find the smaller, more traditional irrigators adopting modern technology such that their production functions shift upward. It is also assumed that the change for individual A would represent a mere movement along the same production function; in most cases individual A would merely reduce the quantity of water used with current (rather modern) technology. In sum, the aggregate production from the two irrigators would be hypothesized to increase.[11/]

It is also possible to consider situations in which farmer A would react to the smaller allotment of water by improved management or technology in which case $E(TR_A)$ would shift up. Also, improved water management could result in greater water reliability for both farmers A and B [Valera, et al, 1975]. But, the impact upon production functions is an empirical issue, while our central concern is conceptual.

Our interest is in understanding the types of institutional changes which would be required to protect the interests of those irrigators now bearing the brunt of the costs of water unreliability. It is our hypothesis that current interest in the plight of the small farmer renders the concept of the least advantaged irrigator particularly pertinent for institutional design. That is,

many irrigation systems are being operated in such a manner that the poorest and least powerful irrigators are the primary victims of water shortages. Put somewhat differently, the administration of a system in its three essential components--operation (water allocation), maintenance, and enforcement--is "loose"; certain influential irrigators are able to intervene in the administration and often procure returns that are not equally available to all irrigators. Such favorable dispensation may merely mean that water is received when there is "none available," or it is obtained in slightly larger quantities than conditions warrant such that others must go without--or with less than their "allotment". Additionally, it could mean that the burden of system maintenance is altered such that a few are spared either the time or the expense of "doing their share". Finally, it could mean that the system of enforcement is sometimes altered such that otherwise punishable actions are ignored, or treated lightly. In sum, we start from the presumed existence of an organizational structure in which some participants are treated "more fairly than others". This naturally leads to cynicism and reduced economic welfare for the disadvantaged, as well as to frustrations in achieving increases in agricultural production among the bulk of LDC farmers.

If research is to focus on ways to help alleviate this problem, it is necessary to become more explicit about principles for institutional design. We consider it imperative to move beyond mere declarations of concern for the plight of the small farmer, and to confront the realities of how a government would begin to implement such institutional reform. For this, we propose five general principles for institutional design drawn from Rawls' A Theory of Justice [1971].

The first general principle is that each participant in the irrigation system possesses an equal right to the most extensive liberty compatible with similar liberty for others. This merely solidifies the existence of strict equality among

all irrigators, and precludes one from enjoying undue influence over water receipts, or system maintenance, or system enforcement.

The second principle is that any institutional system must be widely understood by all of the participants in it; the rules of the game must be clearly understood by all. This would mean that any organizational arrangement would require rather extensive involvement by all individuals in the irrigation system, and that such involvement should be facilitated by the official agencies of the government.

The third principle is that there must be a shared concept of what is just, and what is unjust. That is to say, a situation in which certain irrigators are continually denied necessary water while a few influential irrigators receive too much must be recognized as basically unjust by all -- or virtually all -- of the participants. It is possible to imagine situations in which even those denied water might be reluctant to label the situation unjust. After all, those who constantly face economic and social adversity have often constructed defense mechanisms which may tend to help them rationalize the status quo; how else could some of them remain so sanguine in the face of perpetual and severe discrimination? It is much easier to imagine that the favored irrigators would be less inclined to describe the current situation as unjust. But a workable system of water allocation requires a definition of just and unjust actions. This matter would necessarily occupy a great deal of time by those helping to establish new institutions. These efforts need not be restricted to abstract philosophical arguments. Agronomists could demonstrate the production response from increments of water, and demonstrate that perhaps the individual who is able to secure more water than is really necessary might experience little (or no) decrease in yield from reduced water deliveries: certainly the drainage problems of many farms would offer evidence to this effect. Showing that a reallocation of water may permit the formerly

disadvantaged to significantly increase yields while the negative impact on yields of those heretofore using great quantities of water might be minimal would be a way of helping to develop a concept of just and unjust based primarily on biological and economic arguments. Still, we cannot underestimate the difficulty of persuading the currently powerful to accept the idea that their advantage over the powerless is unjust.

The fourth general principle flows from the preceding one, and states that there must exist a system of formal justice in which there is impartial and consistent administration of the rules. A situation is particularly restrictive when there is general agreement as to the justness of rules, yet they are administered arbitrarily depending on who is the violator.

The final general principle is that rules be designed so that the predominant self-interest of individuals leads people to act in ways which further desirable social ends. That is, wherever possible, institutions should be sought such that the "natural instincts" of economic actors are taken advantage of for the general good of the community of irrigators -- and for the country as a whole. In western cultures we might expect that income would be a significant inducement and would thus suggest, perhaps, a reward system which permitted the water master to reap income gains based on the degree of equitable water distribution.

The Rawlsian position is summarized by:

> Assuming the framework of institutions required by equal liberty and fair equality of opportunity, the higher expectations of those better situated are just if and only if they work as part of a scheme which improves the expectations of the least advantaged members of society. The intuitive idea is that the social order is not to establish and secure the more attractive prospects of those better off unless doing so is to the advantage of those less fortunate [1971, p. 75].

The foregoing then, represents the essence of designing institutions which are responsive to the interests of the least-advantaged irrigator(s) in a system. We do not advance them as normative propositions. Rather, we list them as necessary conditions for the successful creation and operation of an irrigators' association in an LDC. We are under no illusions that they will be readily accepted by all irrigators or administrators. However, we do maintain that efforts to establish water users' associations where these principles are not recognized and followed are destined to merely consume a great deal of time, energy, and financial resources while not altering--in a meaningful way--the underlying causes of the inequities.

One way of beginning to identify those factors which contribute to inequitable water distribution is to consider a schematic diagram of the type of irrigation system being discussed. In Figure 2 we depict an irrigation system consisting of the main canal, two laterals, and some sub-laterals. In assessing one's relative position with respect to water receipts in a system we would be interested in the extent of transport losses between the source and an individual plot. With unlined laterals farmers in Zone C could experience severe transport losses, while farmers in Zone E--though roughly equidistant from the water source--would not. Other things being equal we would say that Zone C farmers are less advantageously situated with respect to "net delivery efficiency" than are those in the other zones. Of course this depends upon the porosity of the soil through which the unlined laterals pass. If the lateral to Zone D passes through very sandy soil, while that to Zone C passes through clay soil, transport losses between the source and D_4 could substantially exceed those for C_3.

A second factor in assessing some index of advantage concerns <u>nominal location</u>. Irrigator A_1 appears to be rather favorably situated with respect to the water source, while irrigator C_3 could have the least advantageous nominal location. We

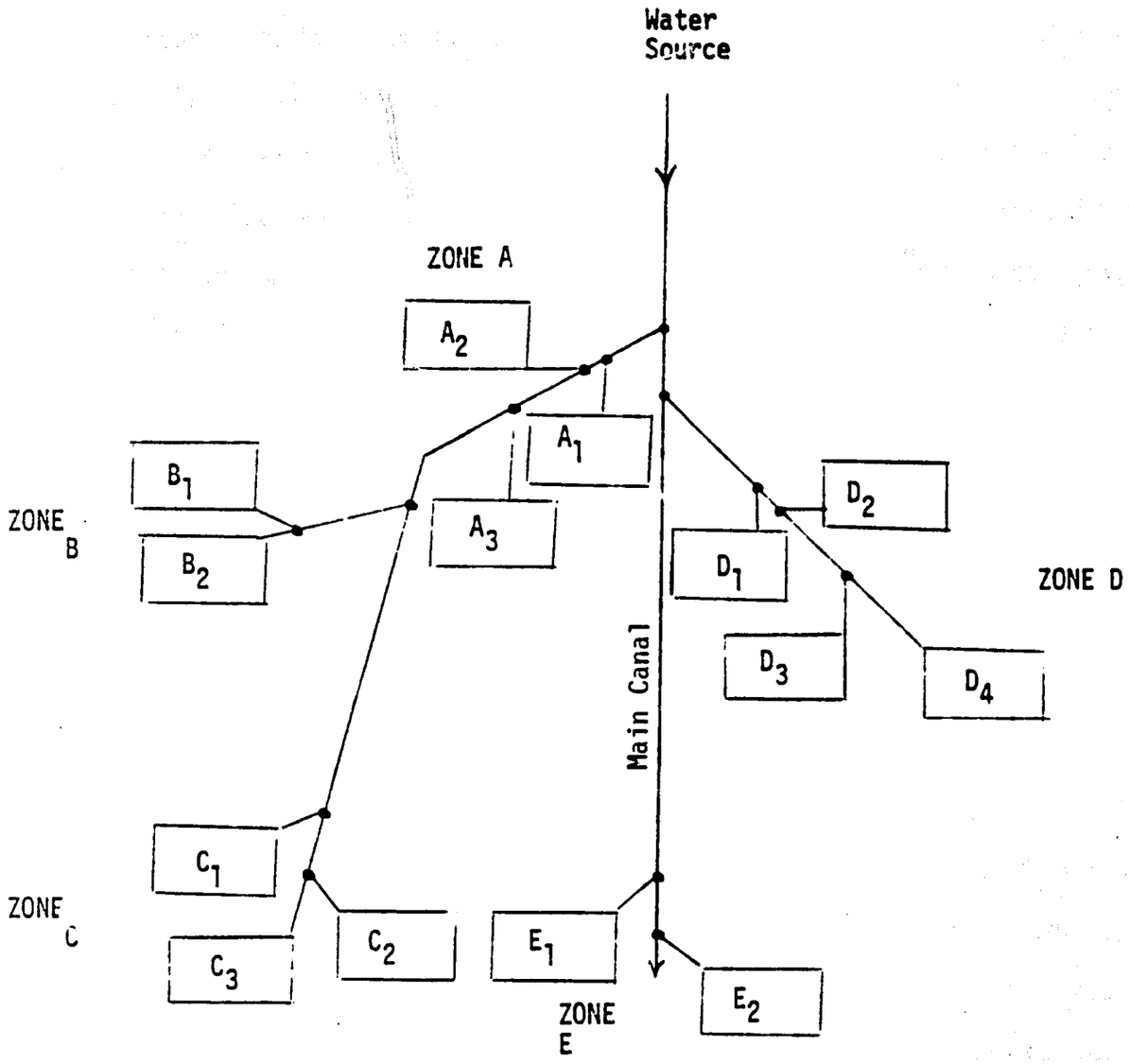
Water
Source
ZONE A
A_2
A_1
A_3
B_1
B_2
ZONE B
D_2
D_1
D_3
D_4
ZONE D
Main Canal
C_1
C_2
C_3
ZONE C
E_1
E_2
ZONE E

FIGURE 2.

assume that the greater the number of other irrigators located between the plot in question and the source, the less favorable the nominal location. This is so because the greater number of "intervening" irrigators increases the probability that there will be unwanted influence exerted over the water receipts of the plot in question; such influence could be subtle political pressure on the way in which water is allocated, or it could consist of water stealing.

And this brings us to the essence of water receipts, real location. If individual C_3 is a powerful individual within the local community then regardless of the transport losses between that plot and the source, and regardless of the fact that the nominal location is not too favorable, water receipts will be sufficient and reliable. The goal of achieving greater equity among irrigators in water receipts can thus be defined as eliminating differences in real location.

To the extent then that planners in LDC's are interested in promoting greater equity among irrigators, water-users' associations are often seen as an appropriate institutional mechanism--a policy instrument. But how are such associations to be constituted? There is ample evidence that many existing associations have not been very successful in creating an environment in which the interests of the least advantaged irrigators are weighed very heavily [Wade, 1975a; Harriss, 1974; Bottrall, 1976]. And yet, it is at this local level where there would seem to be the greatest potential. What seems to have been missing is careful attention to the "working rules" of such organizations. By working rules we mean those operational aspects of the organization which define the relationship among its members.

For this, we might suppose that an irrigation system would form an association consisting of all its members and would begin by adopting--by unanimous agreement--a constitution. Such a constitution may be no more explicit than the five general

principles mentioned previously. Since a unanimity rule turns each participant into a potential quasi-dictator, we might imagine some difficulty in adopting even the general principles. But, an association which is intended to protect the interests of the less advantaged must begin with these principles.[12/]

Once the constitution is adopted, it is possible to begin to worry about the operation of the system. In recognition of the high transaction costs of convening the "general assembly" (all irrigators) to deal with operational matters it makes more sense to establish a Board of Irrigators. This could be an elected body consisting of, say, one irrigator from each of the distinct zones in the system (as in Figure 2), and several irrigators--depending upon the number in the system--elected at large. Additionally, there could be from 1-3 non-elected irrigators appointed from that group identified as the least advantaged under current operation. The constitution could specify such matters as who chairs the Board of Irrigators, the voting rules (simple majority, 2/3, etc.) for actions by the Board, and who chairs the General Assembly (possibly the irrigator who receives the most votes--he may also chair the Board).

In general, the Board of Irrigators would administer the normal affairs of the system, supervise the Water Master (who actually "runs" the system), determine the maintenance schedule and the contribution from each toward maintenance, and the like. Additionally, in periods of water surplus or water shortage the Board would make the incremental allocation decisions consistent with the general dictates of the constitution.

In most instances, a single water source--such as a dam or a diversion canal from a river--will serve several main canals (irrigation systems). Here, there is an obvious problem of allocating a (usually) limited water supply among several systems before it can be allocated within a system. Here, there might be a Project

Council presided over by an Executive Committee consisting not of irrigators but of representatives of various ministries concerned with agricultural development (agriculture, national economic planning, agricultural finance, agrarian reform, and water development/management/distribution). The representative from the ministry of agriculture might be the chairman of this Project Council. The other members on the Project Council might come from the respective systems and consist of: (1) the chairman of each Board of Irrigators; and (2) the least-advantaged irrigator(s) within each system.

The functions of the Project Council could be to deal with all matters pertaining to intersystem relations including water allocation, extraordinary water supplies, fee structure, cropping plans, and total project maintenance. The irrigator members of the Project Council might serve in an advisory role only, with all decisions being made by the Executive Committee. While the Executive Committee is in general control of all water allocation on a project, its control over cropping plans is more indirect. That is, farmers' intentions are crucial to the water allocation process and excessive planting of certain crops with high water requirements may jeopardize water supplies for the rest of the irrigators. While control over actual planting will vary by the degree of central control in the various countries, we would imagine the Executive Committee's most effective role would come in the area of denying water to those who ignore "reasonable" planting advice and/or government planting desires.

By way of justifying this transition from an irrigator-based organization at the system level to a bureaucrat-based system at the project level, it is important to recall that in many countries central agricultural planning is quite prominent and intersystem allocation of water does not differ greatly from allocation of limited supplies of seed, fertilizer, and chemical insecticides. That

is, we assume that allocation of water among competing systems is a problem of national interest to be made by national government individuals--with the advice of irrigators from each system. The provision for irrigator representation on the Project Council insures that the views of irrigators in the various systems are heard, but places the major water allocation decisions in the hands of those responsible for obtaining the nation's agricultural goals (including protection of the least-advantaged system in a project). We would suspect that in many countries intersystem water allocation is currently made by national bureaucrats and our suggested institutional structure insures that irrigators get some input into that decision.

As for enforcement at the project or system level, various cultures will deal with that matter in their own way. Valencia, Spain has its Water Court which has operated continually for approximately 1,000 years. Other countries may use the existing civil or criminal court systems, while others may find that formal courts are rarely required.[13/] The most important element is that all irrigators--regardless of economic or social position--receive equal justice.

As an example of an effort to begin to deal with the institutional aspects of better water management, the Philippines is in an early stage of developing Irrigator's Service Association (ISA's). The goal of the program administered by the Farm Systems Development Corporation is to organize (by 1980) 1,100 ISA's involving 85,000 small farmers (1/2 - 2 hectares each) in project areas averaging 100 hectares. While most of those currently under way are pump (from rivers) systems, gravity systems are also envisioned. As of March 1977, there were approximately 395 ISA's on 47,620 hectares involving over 21,000 farmers--the majority of whom grow rice.

The by-laws (constitution in our terminology) are adopted by a 3/4 vote of all members, with membership open only to those actually engaged in farming -- regardless of the tenancy arrangement of the land being farmed; absentee owners cannot, therefore, belong. Membership carries with it the right to vote on all matters brought before the general assembly of all irrigator members, to be eligible for any office, and to examine the records of the association. It carries the duties of obeying the rules and regulations, of attending all meetings and seminars, of paying dues and irrigation fees (usually 5 cavans (1 bushel or 50 kilograms) of rough rice per crop per hectare), of contributing personal services to the association in constructing and maintaining the irrigation system, of participating in the purchasing and marketing activities of the association, of granting rights-of-way for the necessary irrigation canals and ditches, and of adopting and applying agricultural techniques taught or suggested by government specialists.

A quorum of the general assembly consists of 75% of the membership, and the assembly elects and removes officers and committee members, and is the final arbiter in any dispute between or among the members, the Board of Directors, the committees, and the officers. The Board of Directors is elected by the general assembly and consists of the Chairman (also the President of the ISA) and four directors. The Board elects its own Secretary (who also becomes the Secretary of the Association), and then upon the recommendation of the President appoints officers and committee members (chair plus two members) to the following committees: (1) irrigation management; (2) production management; (3) education management; and (4) business management.

In addition, the general assembly elects an auditor who serves as chairman of the audit and inventory committee, and a counsellor, who is chairman of the grievance committee. The members of these two committees are also elected by the

assembly. The officers of an ISA are thus the president, the secretary, the treasurer, the auditor and the counsellor. The Board elects and/or appoints the secretary and the treasurer, and they meet at least once a month. No member of the Board may serve more than two consecutive one-year terms. Finally, there is the kaisahan, an areal designation--usually totalling 15-25 hectares--which consists of the farmers in a rather homogeneous region within the irrigation area. The kaisahan elects a leader, and it also becomes the basis for rotating irrigation turns among all farmers. Most ISA's have from 4-6 kaisahans.

A disturbing aspect of the ISA constitution (by-laws) is that an amendment requires only a simple majority of the members at any meeting, while other business requires a 3/4 quorum to even be brought to a vote, and the original constitution required a 3/4 vote for adoption.

Yet another interesting aspect is that the president of an ISA may not hold any other elective position in the local government higher than a councilman, may not be actively engaged in partisan politics, and may not own or possess (farm as a tenant) more than the average size of farmland within the area served by the ISA.

It is too soon to assess the institutional effectiveness of the ISA's, but the structure is suggestive of that advocated earlier. We would probably urge that the least-advantaged kaisahan be better represented, with least advantaged being determined by distance from the pump, conveyance losses, and the like. A cursory assessment of several ISA's indicates some dissatisfaction among farmers in multi-barrio ISA's where the officers are all from one barrio; the disillusioned farmers soon stop going to the meetings which merely exacerbates the problem. As seen in the literature cited earlier, factionalism within a village--or between villages (barrios)--can be devastating to institutional viability. Here the

matter is not so much small farmer vs. large farmer, or good location vs. bad location, as it is family (group) loyalties, jealousies and the like.

When the service area of an irrigation system does not exactly coincide with a "political" jurisdiction (barrio, village, group, "family") there is almost certain trouble ahead. In these cases, one constructs institutions from the bottom-up rather than from the top-down. Here the kaisahan would be the logical building block, with the Board of Directors perhaps consisting of one or two farmers from each distinct grouping. Each situation would need to be considered individually, but the more open and explicit the squabbles can become, the greater are the chances that the general assembly can help arbitrate for the general welfare of all.

IV. POLICY AND RESEARCH IMPLICATIONS

While land reform receives a great deal of the attention of economists concerned with the plight of the disadvantaged LDC farmer, it is our thesis here that malallocation of water is a serious problems of increasing importance. Moreover, it is a problem which many governments believe they are solving by merely holding training sessions for farmers on water management, or, more commonly, by constructing elaborate and sophisticated engineering devices. However, a necessary first step is to assure all farmers on an irrigation system that thier efforts at improved use of water will be matched by the reliability and predictability of water deliveries to their plots. It does little good to be taught proper water application procedures when the water never reaches your farm -- or arrives so sporadically that planning is impossible.

In this paper good water management is less of a farm-plot concept that it is an among-farm concept; we are primarily concerned with water allocation within (or among) irrigation systems. As we turn to the matter of implementing the equity-based institutional structure advocated here it may be helpful to consider three likely problem situations: (1) no irrigation associations exist; (2) associations exist but are antithetical to equity objectives; and (3) associations exist to foster equitable allocation but there are operational problems.

Taking the latter situation first, we have a case where an association is functioning rather well but the interests of the least-advantaged irrigators are not sufficiently protected. One explanation might be that excessive conveyance losses within the distribution system bestow larger quantities of water on those near the canals and thus less is available for the more distant farmers. If the least-advantaged are represented as we advocate here, then turns and times could probably be modified -- through trials -- until the imbalance is rectified.

If, however, the problem is one of multi-village factionalism -- or, indeed intra-village factionalism -- then the problem is more serious. An explicit effort at "balanced representation" is called for to insure that each political segment of the system is protected. Here the notion of least-advantaged expands to encompass those in the group currently experiencing problems.

The second general type of problem occurs when an organization exists which operates at cross-purposes to the interests of the least advantaged. This is perhaps the most difficult case of any of the three, for here it is necessary to radically alter the behavior of irrigators in a setting which has the appearance -- because of the existence of the association -- of official sanction. There are at least two general situations here: (1) either the decision making within the association is dominated by the more advantaged farmers; or (2) the decision structure is so "loose" that the more advantaged merely do as they please.

In this setting it is impossible to generalize about the proper way to rectify the problem, for each culture/political system will differ as to the extent of coercion of individual farmers. But, as indicated earlier, a possible first step is to employ sound agronomic principles to ascertain production response from alternative applications of water. Once completed this information could form the basis of a concerted effort to reallocate water from those who now receive superfluous water to those who receive too little. This may, in extreme cases, imply the alteration of the structure of the irrigation association, or a change in its officers. Again, the role of the government is this may range from mere facilitation to explicit enforcement.

The final problem situation is probably the most common and covers those irrigation systems characterized by rather extensive capital investments but

little institutional structure. Many Latin American countries have irrigation reclamation organizations which build dams, canals, and some ditches but do little in the way of water management within a system. To varying degrees, those farmers situated near a main canal avail themselves of water when they want it, with others less favorably located getting what is left. The establishment of the sort of institutional structure discussed earlier, though not without serious difficulty, is likely to be easier than the reformation of an existing structure which is counter to the interests of the less-advantaged farmers.

Throughout the foregoing we have assumed that, for the most part, the Rawlsian general principles would be considered reasonable by the bulk of irrigators. We recognize, however, that this is somewhat idealistic. It bears repeating that the constitution (by-laws) should be regarded as a variable in the development of an association, although not to the point where the general principles are sacrificed. Where it seems unlikely that the principles will be accepted by all members, then various means of attaining cooperation will be required. Such means may range from the posting of "ditch-marshalls" to preclude water stealing, to the payment by the government to those hurt by the change to procure their cooperation.

A move toward the sort of principles outlined here implies a shift in relative advantage among irrigators. To the extent that a readjustment implies an income and/or welfare loss for the currently advantaged, and an income and/or welfare gain for the currently disadvantaged, the simple Pareto criterion cannot be relied upon. To the extent that a reallocation results in aggregate income gains for the system as a whole (as depicted in Figure 1) there will be a local surplus which may be used to compensate the losers. However, inasmuch as this

local gain would accrue to the currently disadvantaged, and it is this group which is the target of ameliorative policy, a government may be understandably reluctant to tax some -- or any -- of this gain away to provide compensation for the possible losers. Even if the reallocation were a zero-sum readjustment, the national government may still choose to compensate the losers out of general tax revenues.

But the matter of compensation is complex indeed and rests upon more than the mere existence of a fiscal surplus; compensation is a function of presumptive or real property rights. Consider first the situation of real water rights. In societies where there are secure water rights attached to land and these water rights are abridged through the sort of institutional design advocated here, compensation to the losers may be desirable on simple grounds of justice. However, where such water rights may have been acquired by stealth or "undue" influence, the case for compensation on equity grounds is less compelling.

We suspect that a more common case is one in which water rights are such that the sorts of inequities which now exist arise because those rights are not being protected. That is, the powerful have managed to exercise a presumptive property right over scarce water resources such that the powerless do not receive the water to which they are entitled. Here, the extent to which compensation should be paid for taking something (water) from those who never had actual rights is problematical.

A third case exists in countries where there is no absolute property right in water. Here, compensation to those who relinquish water for the less advantaged may be called for on quite different grounds. One would not refer to it as compensation since that term implies indemnification for something taken. Instead, remuneration may actually resemble a bribe to acquire acquiesence to a new institutional structure. Here, no property right is acknowledged by the government,

yet the peaceful cooperation of the losers is a necessary condition for the success of a new institution. In a sense the government is buying out the disapproval of the currently advantaged in order to ease the plight of the currently disadvantaged.

We wish to reemphasize that there is an impressive literature on the role of water reliability in stimulating increased agricultural production. There is also a substantial literature on the equity considerations in many irrigation systems. And, there has been considerable attention devoted to the design and operation of irrigation associations to improve water management. While much of this literature has addressed the matter of equity, few researchers have dealt explicitly with the nature of the requisite structure for such associations which would clearly protect the interests of the least-advantaged irrigators.

Before closing, then, a word or two about research seems warranted. An obvious need is to begin to work more losely with existing irrigation associations to understand the cultural, sociological and economic explanations for their lack of success. Without meaning to denigrate the literature cited at the outset, there is still a great need for more work. Along with this work, we would urge comparative studies between similar areas with different institutional structures.

With this sort of research, plus continued focus on technical agricultural work we could begin to better understand how to diagnose an irrigation system to determine the greatest problems of water management. We could begin to determine the extent, incidence and underlying causes of benefits from different irrigation development strategies. We could also do a better job of ascertaining farmer response to water insecurity. These findings would be instrumental in advising governments on the institutional aspects of water reform.

Leading towards such reform we have here offered a structure based upon five general principles taken from Rawls. We do not view this Rawlsian framework as anything more than the first explicit discussion of what would be required in order that irrigators' associations actually operate with a distinct equity objective. That is, we do not consider this an argument for considering absolute equity -- though our values do indeed run in that direction. Rather, we consider it primarily a reminder that it is time to become more explicit when we write about equity among irrigators.

As indicated earlier, each situation will be unique and must be developed on its own merits. But the dismal production performance of many irrigation systems is ample evidence that sound irrigation projects require more then dams, pumps, canals, and control structures. Indeed, given the choice, it is probably better to have a good workable institutional structure than it is to have the most modern pumps and canals; other things being equal the economic position of the small farmer is probably better with a good organization of irrigators than with an ideal engineering approach. However, the best of both is clearly preferred. It is our hope that the foregoing will help in the creation of an institutional structure commensurate with the engineering works in many LDC's.

FOOTNOTES

1. For instance see Myrdal [1968].
2. See Lazaro, et al. [1977] for possible approaches with new irrigation projects that can contribute to the realization of greater equity.
3. This would refer to situations in which poor and otherwise powerless irrigators have become resigned to circumstances, and social obligations and cultural norms reinforce their lack of assertiveness. Thus, irrigation systems may have important shortcomings in their infrastructure, operation, maintenance, and/or enforcement such that the less powerful are not well served, and yet open conflict may not be in evidence. This paper is not limited, therefore, to only those irrigation projects in which there is overt conflict over irrigation water.
4. The literature listing in this section is rather extensive. Those already familiar with the literature will want to proceed rather directly to the next section.
5. Reidinger [1974, pp. 81-82] discusses the risk adjustment of farmers to an insecure water environment. Risk-averse farmers may select crops with lower average profit potential but which are more drought resistant and/or they may apply less than optimum levels of inputs as a hedge against possible water shortage. He indicates that less than optimum input use applies to irrigation water as well, citing evidence of North Indian and West Pakistani farmers spreading scarce canal water supplies over larger than optimum acreages.

   Abel [1975, pp. 16-18] on the other hand, argues that farmers with insecure water supplies will -- if possible -- over-irrigate their land so as to have reserve supplies of water in case of later delays in receiving water. As a result, given quantities of water are spread over less than optimum areas with consequent negative effects on potential aggregate levels of production.

He does not provide supporting empirical evidence but indicates that this was the basis for certain modifications in the 1950's in the physical design of -- and the management of water distribution in the Taiwanese irrigation systems.

6. In the reports of Philippines irrigation, the variable under study is "water adequacy," reflecting either observed water stress in irrigated fields, or a perception by irrigators of water shortages in their fields. While the field observations reported in these studies are not probabilistic, it would seem that they could be taken as proxy measures of the impact of water insecurity on production.

7. It is recognized, of course, that in some cases the achievement of greater productivity and greater equity is not mutually reinforcing. For example, if water shortages in an irrigation system are extreme, distributing the water to head-end users only (thereby avoiding seepage and evaporation losses from transporting the water over longer distances) might well lead to higher production but obviously less equitable distribution.

8. However, land is only one possible resource with respect to which water may be equitable divided. Such an approach is far from eqalitarian if people are the focus of consideration, for it leads to larger amounts of water being allocated to those who already have larger amounts of land [Reidinger, 1974].

9. The Hunts [1976] describe this system as the "Syrian model"; a system in which water rights are separable from land so that water can be bought and sold is the "Yeminite model." In commenting on their article, Bennett [1976] suggests that as water supplies become increasingly scarce relative to

demands over time, one observes shifts from the Yeminite model to the Syrian, whereas Glick [1976] suggests a reverse sequence. The Hunts respond by indicating that if one looks at the evidence in the Middle East and Mexico, it is possible to observe some shifting back and forth between the two systems. In spite of this interchange, the Hunts concede that the contemporary incidence in large-scale canal irrigation systems in LDC's of the Yeminite model is extremely limited; in fact, in some countries (India) trading in water is illegal [Gustafson and Reidinger, 1971]. Of course, where a market for irrigation water exists, the chances of the system leading to a less egalitarian distribution of water and income are substantial [Glick, 1976].

10. These findings, of course, manifest the potential power represented by irrigation which is so widely discussed in the literature, beginning with Wittfogel's [1957] classic piece on China's "hydraulic civilization." For particularly useful reviews and criticisms of the hydraulic civilization literature, see Lees [1974] and Mitchell [1973].

11. In this sense, although the physical distribution of water involves a zero-sum game [Wade, 1975a], the production effects from the utilization of the water may not. Reidinger's [1974] conclusions about the possible reallocation of irrigation water from large to small farmers in India are consistent with our hypothesis.

12. For a detailed treatment of constitutions and unanimity see Buchanan and Tullock [1962].

13. There are several instances where actions against those charged with breaking regulations have been settled out of court. Examples are RISS [1975] in Indonesia, Eyre [1955] in Japan, and Vandermeer [1971] and Pasternak [1972] in Taiwan.

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