Fenton / CPR
Julie / lit
10-21-94

REPRINT FILES - CPR

SUSTAINABLE NON-PRICE ALLOCATION OF IRRIGATION WATER
AN OUTLINE

DR. RAOUF F. KHOUZAM
THE DESERT DEVELOPMENT CENTER
THE AMERICAN UNIVERSITY IN CAIRO

INTERNATIONAL ASSOCIATION FOR THE STUDY OF COMMON PROPERTY
"DESIGNING SUSTAINABILITY ON THE COMMONS"
FIRST ANNUAL MEETING

SEPTEMBER 27-30, 1990
DUKE UNIVERSITY
DURHAM, NORTH CAROLINA
USA

I. INTRODUCTION

Recognizing that implicit free irrigation policy does not lead to any kind of water conservation, the Egyptian Ministry of Public Works and Water Resources (MPWWR; henceforth) is developing a cost-recovery scheme. In some new land areas a farmer is required to pay an annual service charge of LE 88 per feddan ($1=LE2.75) of his farm regardless of the amount of water used or even the area left fallow. Farmers, however, have refused to pay and have challenged the decision in the court of law. MPWWR responded by closing down the irrigation stations; they were reopened within two weeks when the Ministry of Agriculture and Land Reclamation paid part of the charges.

Confrontation between the government and the farmers is the result of designing policy without evaluating its compatibility with the existing institutions. One explanation of this phenomenon is that irrigation departments, knowing about the technical aspects more than about the human ones (Levine 1980; p. 51) emphasize the first. Another possible reason is that local institutions enhance farmers feelings of power and independence which reduces the government's command over the agricultural sector (Hunt 1988; p. 348).

To avoid such conflict, Robert Young advised policy makers:

> "... to better understand the characteristics and motivations of the human components of the irrigation system. ... The well-functioning system will recognize these traits and capitalize on them, rather than ignoring them or trying to manage as though human nature were other than it really is." (Young 1985; pp. 205-6).

Moreover, a "moratorium" on irrigation projects around the world was recommended in order to concentrate efforts on acquiring the benefits of improving the management of existing systems before resorting to expensive structural works (Bromley 1985; p. 173). For example, a four-year half-million-dollar study of a project addressing the problems of seasonal shortage, uncertain supply and saving water for desert reclamation did not consider the possibility of utilizing local irrigation institutions as a solution. The study recommended a technical option: conjunctive use of groundwater (drilling wells and constructing pumping stations) (MPWWR/Ford Foundation 1988). However, if the problems

---

Travel and conference expenses are provided by a grant from the Ford Foundation.

The author thanks Dr. David Nygaard, the Ford Foundation Representative for the Middle East and North Africa, for his valuable comments. Any mistakes that may remain are the author's responsibility.

are, as the report claims, caused by farmers, then causes should have been dealt with first in order to avoid these problems after installing a new system.

Ironically, a successful model to allocate irrigation water among farmer groups is observed in the same area where MPWWR cost-recovery policy is facing resistance. The model achieves, without government coercion, a high degree of fair distribution of water even when water is in short supply.

This paper focuses on farmers group management of a common-property irrigation source. The group-management model is claimed to be better than the neoclassical model in meeting the group objectives. The following section reviews the problems associated with the allocation of water among a group members. Next, it highlights the reasons for resorting to group management. Based on that real-life experience, an outline for a group model (vis a vis central, command area or on-farm model) is derived. The outline may be adopted in other similar areas in Egypt, LDCs and DCs where water distribution faces difficulties.

II. PROBLEMS OF ALLOCATING IRRIGATION WATER

The paradox of water distribution is that whether scarce or plentiful, it is accompanied by economic problems. If scarce, on the one hand, a situation of conflict arises among farmers in their pursuit of appropriating the water they need. As a result, unfavorable social and political tensions arise (Chambers 1980, p. 43 & Keller 1986; p. 336). Further, water withdrawal by one farmer reduces its availability to others (Chambers 1980; pp. 36-37).

On the other hand, the "tragedy" of abundant water is that while individuals are aware of the benefits they derive from exploiting it, most of them are not aware of the concomitant negative aspects. Excessive use of water might lead to water logging and salinity problems as happened in West Nubaria in the Egyptian Western desert (FAO 1978; p. 35) and many of the Nile regions (El-Shinnawy et al. 1979).

The **neoclassical** profit maximization model faces a number of **difficulties** in solving irrigation problems in many developing **countries:**

a) Because irrigation water is distributed free of charge, it will be overused unless water is appropriately priced.

b) Inter-farm allocative efficiency requires farms with comparatively lower productivity to reduce irrigation use permanently or temporarily. The difficulty with this requirement is that, unlike other inputs, water must be regularly applied throughout a plant's life.

c) Marginal-cost pricing is impeded by the indivisibility of most of the structural works. Besides, to meet greater future demand, the capacity of the infrastructure are designed in excess of the actual need at the beginning. That unjustifiably raises the price to current users (Herfindahl & Kneese 1974; pp48-50 and Saunders & Warford 1977; pp. 6-8).

d) Market failure cases and the difficulty to account for water reuse and the effect this has on water quality.

e) Non-existence of water markets in LDCs on which the operation of the neoclassical model depends.

Although one form or another of water markets (water marketing refers to the transfer, through lease or outright sale, of water entitlements; Swaney 1988; p. 33) has been tried in some arid regions in USA (Hamilton et al. 1989; p. 64), it is a remote possibility in LDCs because of water characteristics, technical difficulties and institutional obstacles.

Characteristics that impede water marketability include (Young 1986; pp. 153-55): (a) bulkiness of water, (b) variation in water quality which affects its valuation by different users, (c) broad range of types of utilization which hinders the construction of a standard measurement of various demands, (d) the hydrologic cycle and (e) the flowing nature of water.

The last characteristic underlies the technical difficulties and institutional obstacles facing marketing water. The flowing nature of water makes excludability very difficult; hence, water is characterized by jointness in supply which impedes the establishment of well defined property rights (which is one of the pre-requisites for effective market operations).

In addition to the institutional obstacles, a number of technical difficulties are involved in water pricing.

> "Pricing water deliveries to individual farmers is likely to be prohibitively expensive in most gravity systems serving large numbers of small farms. The cost is not merely in terms of measurement of flows, itself a difficult task, but in the administration, reporting, billing and collection procedures." (Small 1987; p. 7).

Therefore, the inability of the neoclassical model to solve the problems associated with the distribution of water among a number of farmers using the same source-point necessitates the search for an alternative. The following sections discuss a substitute and propose an outline for designing it properly.

III. MODEL DESCRIPTION AND ANALYSIS

Economists have been discussing the conditions that allow the rise of a successful non-market distribution schemes. Wade (1987; p. 104), criticizing some of theories of collective action, listed a number of factors that help in the management of common pool resources: (1) smaller and clearer definition of resource boundaries, (2) higher exclusion cost, (3) greater overlap between users' locations and the resource, (4) greater vitality of demand, (5) more knowledge of sustainable yield, (6) smaller size of users, clearer boundaries and greater power of subgroups, (7) clearer noticeability and (8) ability of state to penetrate rural localities. Quiggin (1988; pp. 1083-84) suggested: a) redefinition of private rights as social ones, b) specification of users, and c) establishing an institutional framework. Neither study is empirically tested. Another set of qualifications from a model observed in real life is discussed below including some qualifications that agree with previous ones, others that disagree and a few that are new.

The successful role group management plays in the distribution of irrigation water is recognized in many areas in the world: in South and Southeast Asia (Wade 1982; p. 81), in Japan (Breadsley et al. 1980, p. 143), in Sri Lanka (Chambers 1980; p. 30) and in the old land regions in Egypt (Mehanna et al. 1983; p. 15).

The model under study relies in its operation on a hierarchy of associative groups (the terms "group" and "associative group" will be used interchangeably). Participation in an associative group is voluntary for the purpose of managing a common property in a way that achieves net benefits (gross benefits minus organizational costs) greater than that would be obtained if every member acts on his own. In doing that, the members commit themselves to respect a set of rules that may work against some of them sometimes.

In an irrigation system, group management is concerned with the distribution of whatever quantity of water delivered. Increasing supply is beyond its means because that role belongs to higher levels in the system's decision hierarchy. A group member has limited set of actions: (a) defect and irrigate out of turn or use prohibited method, or (b) respect the rules even if losses are incurred. The choice of an action depends on the pay-off matrix which depends, by its turn, on the distribution system (canals, lines or wells), yield-water response and behavioral attitudes of farmers. Depending on the nature and size of the system, users are divided in a bottom-top hierarchy of groups each with specific set of responsibilities in managing the common-property resource.

The environment for successful group management has to meet certain conditions which are described below.

1. **Motive.** To induce individuals to form a group, to respect and to enforce its rules, they must realize considerable

positive net benefits from its formation (Wade 1987; pp. 102-103). Actually, realized net benefits is the built-in force that sustains the continuity of the model. If net benefits drop, for a reason or another, group members will be tempted to defect as the returns to defection will get greater. As a result, privileged farmers (for example, at the head of a canal, socially powerful, or aggressive) will be able to appropriate water at the expense of the others.

Another option is coercive power as the only guarantee for faithful cooperation. But this implies either irrationality of the members who give up net positive benefits or the lack of any benefits to be gained from cooperation. If so, there is no ground for the formation of a group to begin with. Hence, the realization of considerable net benefits is a precondition for the formation of group management.

2. STructure of the System and the Corresponding Groups. The design of the potential roles of groups requires identifying the physical components of the irrigation system within the domain of the prospected group(s), the irrigation institutions and the points of joint interest. In actual practice, distinction among various levels of groups is not sharp; considerable overlap takes place. However, delineation of group levels is important for conceptual formation of the model.

3. Inter-Relationship among Associative Groups. Naturally, the specification of an institutional framework is necessary to enact rules for resource management, to distribute duties, to provide groups with authority against violators and to draw the relationships among groups as well as between group(s) and the state.

4. Group Specification. Specification of a group of farmers is essential for its success in the management process. Specification includes both the size and the location of the group. In that respect, expressing the size in sheer number may be misleading. For example, communication may be weak between two farmers miles apart, whereas it is strong among larger number of small farmers served by a short canal.

Further, the number of the members of an associative group is inversely related to (Olson 1971; p. 48): a) the degree of enthusiasm to cooperate faithfully with the group, and b) the ability and willingness of a subset of the group to supply, at their own expense, part of the services to the whole group.

On the other hand, the number of members is directly related to the organizational costs. As a matter of fact, this relationship has a vicious-circle effect on eroding the group chances to survive. Greater organizational cost reduces net benefits, less net benefits will induce more members to defect which will require more policing, greater organizational cost and so forth.

Other factors limiting a group size are weaker communication, less strict penalty system and lower capability to settle disputes.

5. **Resource Vitality.** The more vital a resource, the greater the benefits to be gained from proper management and, consequently, the more enthusiastic the users to cooperate and resist cheating.

6. **Resource Specification.** Resource specification depends on the nature of the distribution system. In a surface system, irrigation rotation, credibility of delivery and the system capacity are important items for specification. If water is delivered through lines, then water pressure and the design of the irrigation network are important pieces of information.

7. **Observability.** Fear of being deceived is one of the factors undermining the viability and continuity of group management. In order, then, to assure the model's sustainability, arrangements must be made to secure observability such that every member is able to check if another cheats so that counteraction can be taken.

Observability does not have to be direct visual contact (which is not possible in large irrigation systems); some other indicator would suffice as will be shown below.

8. **Means of Control.** Another way that can be integrated with, or even substitute for, observability is to provide means of control. It is an artificial way to achieve a degree of excludability. The opportunity to insert effective means of control depends on the nature of the system. In Egypt, the Nile system is divided into main canals, canals, branches, tertiaries and ditches. Such division provides means of control for large groups. Once water is delivered to a group, it becomes their common property: none can be excluded and none has exclusive rights.

9. **Strict Penalty System.** Penalties are non-positive elements in users' pay-off matrices contingent on adopting actions unacceptable to the group. A rational farmer is expected to adopt actions with non-negative rewards. The effectiveness of a penalty depends on the farmer's utility function, the magnitude of penalty, the probability of being caught (which depends on observability) and the seriousness of applying penalties. Further, financial returns generated from penalizing violators should be credited to the group not to some central government office.

10. **Cost of Exclusion.** Wade states that "the higher the costs of exclusion technology ... the better the chances of

success" (Wade 1988; p. 104). Group management is needed because the cost of exclusion is far greater than its returns. However, high cost of exclusion may encourage resource overuse. If a farmer is aware that the cost of exclusion is exorbitant, he will expect that exclusion will not be a penalty against him if he abuses the common property of interest. Contrarily, if the cost of exclusion is relatively low, every farmer will take into consideration exclusion as a penalty. As such, he will compare the benefit to be gained from a violation with the cost of being excluded.

11. **Sustainability**. Continuity of group management emanates from its ability to internalize a number of negative externalities; specifically: 1) free-rider problem, 2) head-tail problem of water distribution, and 3) organizational cost.

Some externalities can be internalized by forming an economic unit large enough to absorb those externalities provided that positive net benefits are gained at the end (Herfindahl & Kneese 1974; p. 52). Hence, expanding a small farm to a group of farms to manage its common property resource as one unit would meet that objective.

However, internalization of the free rider problem may not work if the number of the free riders is large enough to increase the cost to the extent that it swallows the benefits collected by the rest of the group. However, it is believed that under tough circumstances less free riding takes place (Harrison & Shleifer 1989; p. 202). It follows that the number and the cost of free riders are expected to stay within a range acceptable by the sub-group.

Head-tail problem is, the same as many others, avoided as the group jointly agrees to a distribution scheme acceptable by all parties.

The conditions discussed above are observed in some areas in the Egyptian desert. There, the model has been fulfilling its purpose. The following section explains how those conditions work in reality.

IV. CASE STUDY

Tahaddi sector (TS for short) is located 140 km northwest of Cairo with an area of about 37 thousand feddans (1 feddan is almost 1 acre). After being reclaimed, it started in 1967 as a state farm, then was privatized in 1977-1978. Now, it is farmed by about 500 graduates and 2,100 small holders. A graduate holds a degree in agriculture (B. Sc. or agriculture school diploma) and has some agricultural experience (DDC 1985; pp. 17-18). The farm size of a graduate ranges from 10 to 30 feddans, depending on his level of education.

The educational level of a small-holder, on the other hand, is below secondary school certificate. The irrigated area of his farm tends to be uniform: 3.25 feddans (DDC 1986; pp. 12-13).

The relatively large size of graduates' farms encouraged the allocation of 24 percent of their land to perennials (mainly citrus). Other than that, the main cropping patterns of both graduates and small-holders are similar: berseem and peas in winter and peanuts in summer (DDC 1985; p. 40 and DDC 1986; pp. 91-92).

The area is fed by surface water from the Nile. Water is lifted and distributed to farms under pressure by electrical pumping stations. The small-holders, as well as the graduates, mostly use portable sprinkler lines. Both of them identified irrigation as one of the most pressing problems they faced. The problem is due to power failure, inefficiency of government pumping stations, poor maintenance and/or irregular water supply (DDC 1985; pp. 50-55, DDC 1986; pp. 124-125, DDC 1987; p. I.26).

Graduates' and small-holders' farms are separated in different villages. Consequently, each pumping station serves, on average, 20-60 graduates farms (624 feddans) or, alternatively, about 192 small-holders. As such, the irrigation institution of the small-holders is more complex. The larger the number of irrigators the more the disputes and; subsequently, the greater the need for stronger institutions to settle them. Hence, it is more interesting to confine the study to the small-holder's situation.

The irrigation institution in TS comprises government, farmers and joint components. MPWWR is responsible for the system's management to the pumping station, which is a point of cooperation between MPWWR and farmers. Beyond a station level, it is the farmers' responsibility.

Farmers served by a station make up a "station group". Every station comprises four electrical pumps each serves 48 small-holders who form a "pump group." They are further divided into four **housha** (basin) groups each consists of 12 farmers. Six farmers who use one portable line and one valve (header) key make a "line group." Every two farmers using the same valve form a "valve group" which is the elementary level in the group hierarchy.

In the proposed model, a "station group" consists of the leaders of the four pump-groups. A station group favorably interferes in the government's management of the station. For example, it helps in drying the station in rainy days when pumps stop because of the water penetrating the ceiling. Additionally, they pay incentives to the operators to extend the station's running time.

When canal water is low, one line is shut every day to maintain higher pressure in the other three lines. That action either lengthens the period between irrigations or, alternatively, each farmer takes less irrigation time (usually 4 hours instead of 7 hours) a sacrifice that farmers accept in good will.

Problems related to a single pump, such as paying for small spare parts to reduce red-tape delay, is the responsibility of the pump group. Housha groups are concerned with settling many of the members disputes.

If a station goes out of order for mechanical reasons or because of power cut-off, a line group arranges for the line to stay with the farmer whose turn (time) has not been completed until the system works again and he completes his time. Moreover, a line group, is responsible for the maintenance of the portable line (welding it if broken or cracked), and for rotating the portable sprinkler line and the valve key. Changing a valve rubber is the responsibility of the valve group.

Violation in TS takes the form of opening a valve and flood irrigating. That action reduces the pressure significantly in the whole pump network. Penalty, in this instance, ranges from a blame to reporting the incident to the cooperative where a five-member board, following the majority rule, fines the violator (LE110). If the violator does not pay, the issue is taken to the District Attorney for enforcement. The penalty may be lifted if the violator promises not to repeat the violation. However, if he does, the penalty would be doubled in the second infraction.

As fines are credited to the cooperative account, a double benefit is gained from penalizing the violator. First, applying the penalty to a violator passes the right message to the whole group. Second, crediting the fine to the group enhances a strict penalty system. As a result, far less organizational cost is incurred as compared, for example, with the policing system followed in Haryana in India which requires extensive flying squads patrol canals and channels (Chambers 1980; p. 47).

The effectiveness of the penalty system in TS depends on a number of factors: observability, means of control and limited social differences. First, violation is detected by observing the height and width of the water fountain coming from the sprinklers. Higher and wider fountains indicate strong water pressure which implies that nobody is withdrawing water off his turn. If a farmer suspects cheating, he goes along the pump line searching for a violator.

Second, having water running in lines, one valve-key and one portable sprinkler line assures that only one farmer out of six can irrigate at a time.

Third, the members of a village in a new desert community are socially homogeneous (have close social rank) due to the government selection process. As a consequence, a group is more neutral and stronger in enforcing the rules.

Since 1978, this model has been working successfully in distributing irrigation water in TS under both normal and short supply conditions. Resource vitality and ability to internalize negative externalities are behind the continuity of that model.

While group-management has better chances for success in the desert, it has been rejected elsewhere. In the old lands, where comparatively more water is available, farmers refused to coordinate irrigation scheduling because of the difficulty of reaching an agreement among themselves and to avoid interpersonal conflicts (Knop et al. 1982; p. 9).

Further, because of the vitality of irrigation to desert agriculture, members are willing to pay for fixing the stations --although formally it is the responsibility of MPWWR-- in order to keep the system working and avoid bureaucratic delay. In addition, some farmers allocate considerable investments in drilling private wells in order to secure the farm's water supply.

As for negative externalities, head-tail problem is avoided by providing equal irrigation time with fixed frequency. In a housha-group every farmer irrigates once every six days. Moreover, although about one third of the farmers do not share in the costs incurred by the group, the rest share the whole costs. In that, recognizing the sizable benefits, the group members are willing to accommodate the free riders.

Freq Dep

V. SUMMARY AND CONCLUSION

Associative group management has survived the challenge in Tahaddi sector in the Egyptian desert and in many other areas in the world. The model is particularly important for areas with large number of farmers commonly sharing the same source of water such as the youth farms in Egypt where thousands of feddans of reclaimed areas are broken down into five-feddan plots distributed to youngsters who share the same irrigation source.

Furthermore, associative group management might be of great help to the Irrigation Improvement Program (IIP) to save or to support technical solutions for identified problems.

To fulfill its objectives and to assure its sustainability, associative group management must be properly designed. First, significant net benefits must be realized by the members as a return to faithful participation. Second, the group size and location need to be identified. Third, the structure of the group hierarchy and the duties and the rights of each component in the hierarchy have to be designed. Fourth, resource vitality and the cost of exclusion need to be assessed. Observability, means of control and strict penalty system should be designed in a way that keeps organizational costs as low as possible.

Real life observations indicate that associative-group management succeeded where the neoclassical model failed in distributing common irrigation water fairly. Nevertheless, intensive economic research is needed to assess the allocative efficiency (which is the ultimate goal of the neoclassical paradigm) of associative group management. Many studies have advocated the efficiency of group management (Rowland 1979, Runge 1986, Levine and Coward Jr. 1989), yet none is conclusive. Perhaps, the assessment of the allocative efficiency of associative-group management in Egypt be the topic of future research.

REFERENCES

Beardsley, Richard K., John W. Hall and Robert E. Ward. In E. Walter Coward, Jr. (ed.) Irrigation and Agricultural Development in Asia: Perspective from the Social Sciences, ch. 6, pp. 127-52. Ithaca: Cornell University Press, 1980.

Bromley, Daniel W., "Irrigation Institutions: The Myth of Management." In Wayne R. Jordan (ed.), Water and Policy in World Food Supplies, Proceedings of the Conference, Mar. 26-30, 1985. Texas A & M University, College Station: Texas A & M University Press, 1985, pp. 173-76.

Chambers, Robert, "Basic Concepts in the Organization of Irrigation." In Coward Jr., op. cit., ch. 2, pp. 28-50.

DDC, "Desert Community Aspects in AUC Desert Development Systems." Phase One: Initiation of the Research Unit, First Progress Report, the American University in Cairo, March 1985 (typewritten report).

-----. "Desert Community Aspects in AUC Desert Development Systems." Phase One: Second Progress Report, the American University in Cairo, May 1986 (typewritten report).

-----. "On-Farm Demonstrations and Socio-Economic Studies in the South Tahrir Community." Phase Two: First Progress Report to the Ford Foundation, the American University in Cairo, April 1987 (typewritten report).

El-Shinnawy, A. El-Atty, Melvin D. Skold and Nasr Lotfi, 1979, "Economic Costs of Water Shortages along Branch Canals," Egypt Water Use and Management Project, Cairo, 1979.

FAO. Control of Waterlogging and Salinity in the Areas of West of the Noubaria Canal, Egypt: Project Findings and Recommendations. Rome, 1978.

Grossman, Gregory. Economic Systems, 2nd. ed. Foundations of Modern Economics Series. New Jersey: Prentice-Hall, Inc., 1974.

Hamilton, Joel R., Norman K. Wittlesey and Philip Halverson, "Interruptible Water Markets in the Pacific Northwest." American Journal of Agricultural Economics, 1(Feb. 1989): 63-75.

Harrison, Glenn W. and Jack Hirshleifer, "An Experimental Evaluation of Weakest Link/Best Shot Models of Public Goods." Journal of Political Economy, vol. 97, 1(1989):201-25.

Herfindahl, Orris C. and Allen V. Kneese. Economic Theory of Natural Resources. Charles E. Merril Publishing Co., 1974.

Hunt, Robert C., "Size and the Structure of Authority in Canal Irrigation Systems." Journal of Anthropological Research, vol. 44, 4(Winter 1988):335-55.

Keller, Jack. "Irrigation System Management." In K. C. Nobe and R.K. Sampath (eds.), Irrigation Management in Developing Countries: Current Issues and Approaches, ch. 11, pp 329-352. Studies in Water Policy and Management No. 8. Boulder: Westview Press, 1986.

Knop, Edward C., et al., "Social Dimensions of Egyptian Irrigation Patterns," EWUP Technical Report No. 26, Cairo, Egypt, Sept. 1982.

Levine, Gilbert, "The Relationship of Design, Operation, and Management." In Coward Jr., op. cit., ch. 3, pp. 51-62.

----- and E. Walter Coward, Jr., "Equity Considerations in the Modernization of Irrigation Systems," Irrigation Management Network, Paper 89/2b, Dec. 1989.

Mehanna, Sohair, et al. "Water Allocation among Egyptian Farmers: Irrigation Technology and Social Organization." Social Research Center, The American University in Cairo, December 1983 (mimeograph).

MPWWR / Ford Foundation, ""Groundwater Extraction and Use in Irrigating Old Lands in the Nile Valley," Final Report, Main Report, Cairo, Egypt, Jun. 1988.

Olson, Mancur. The Logic of Collective Action: Public Goods and the Theory of Groups. Massachusetts: Harvard University Press, 1971.

Quiggin, John. "Private and Common Property Rights in the Economic of the Environment," Journal of Economic Issues, vol. XXII, 4(Dec. 1988):1071-87.

Rowland, Francisco Leon de la Barra, "Analysis of Experiences of Self-Help and Public Participation in Rural Water Supplies: The Case of Mexico." In Duncan Miller, op. cit., pt. II-A, pp. 30-74.

Runge, Charlisle Ford, "Common Property and Collective Action in

Economic Development," World Development, vol. 14, no. 5, pp. 623-35, 1986.

Saunders, Robert J., Jeremy J. Warford and Patrick C. Mann 1977. "Alternative Concepts of Marginal Cost for Public Utility Pricing: Problems of Application in the Water Supply Sector. World Bank Staff Working Paper No. 259.

Small, Leslie, "Irrigation Service Fee in Asia," Irrigation Management Network, Apr. 1987.

Swaney, James A., "Trading Water: Marketing Extension, Social improvement, or What?," Journal of Economic Issues, vol. XXII, 1(Mar. 1988):33-47.

Wade, Robert. "The Management of Common Property Resources: Collective Action as an Alternative to Privatization or State Regulation." Cambridge Journal of Economics, 11(1987):95-106.

______. Irrigation and Agricultural Politics in South Korea. Boulder, Colorado: West View Press, 1982.

Young, Robert A, "On the Allocation, Pricing and Valuation of Irrigation Water". In K. C. Nobe and R. K. Sampath (eds.), op. cit., ch. 6, pp. 151-178.

------, "Market Versus Non-Market Management of Irrigation Water: A Review of the Issues." In Wayne R. Jordan (ed.), op. cit., pp. 205-11.