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CENTER FOR INTERNATIONAL AND DEVELOPMENT ECONOMICS RESEARCH
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Rational Fools and Cooperation in a Poor Hydraulic Economy

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University of California at Berkeley

May 1993

Department of Economics

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Abstract

Local community-level water management is crucial for rural development in the poorest parts of the world, in South Asia and sub-Saharan Africa. Local cooperative institutions have been successful in water management in some cases, but there are numerous cases of failure. The paper draws upon the relevant lessons from the theoretical literature on cooperation in game theory, both in economics and evolutionary biology. Then it goes into the evidence from field studies by anthropologists and others on the conditions for success or failure of local cooperation. This points to some additional insights which the theoretical models are yet too constricted to incorporate.

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I.

In the poorest parts of the world, in many ways water is destiny. In South Asia and sub-Saharan Africa -- the two regions where mass poverty in the world is geographically concentrated -- the life of most peasants continues to be a precarious gamble on the rains (even apart from the relentless fact that their children die by the millions from unsafe drinking water and largely water-borne diseases). Controlled supply of water is crucial for agriculture in these areas, marked by generally low and highly variable rainfall and by flood-proneness in areas of high rainfall. In 1853, when Marx[1] and Engels first discussed, in correspondence, the problems of "Asiatic" societies, they immediately agreed on the particular importance of public irrigation in these societies, necessitated by what they called "climatic and territorial conditions". Even though their emphasis on the idea of the centralized hydraulic state (particularly its subsequent extension by Wittfogel (1957) in a drastic form) was somewhat misplaced, it was a valuable insight which gave rise to a large anthropological literature[2] on the relationship between irrigation and social and political organization. In this paper we shall, however, keep our focus on the economic-institutional aspects; also, while there are major problems with the management of the main canal systems and with the structure and practices of the irrigation bureaucracy, we shall concentrate instead on the local community-level issues of cooperation which have often been cited as key to substantially improving the existing levels of utilization of potential in irrigation and flood-control.

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[1]For an account of the roots of Marx's thinking on this question in earlier European tradition as well as a critique of the ingredients of the concept of the Asiatic mode of production, see Anderson (1974).

[2]For a review of this literature, see Hunt and Hunt (1976).

"Water reform" in the sense of building or promoting genuine broad-based community institutions of cooperation from below (as opposed to government-mandated water-user associations) is at least as important as land reform in rural development. These institutions can have variegated functions in different irrigation systems: they aim at pooling efforts and resources in constructing and maintaining field channels at the outlet level of the main canal systems; at regulating water allocation and monitoring violations; in cases of tank irrigation at desilting, weeding and stopping encroachments on tank beds; at repairing, maintaining and controlling water allocation from state and community tubewells; at controlling groundwater over-exploitation with privately owned pumps in areas with fragile aquifers, and so on. But the history of local community-level cooperative organizations of water users in many areas is rather mixed. There are several documented examples[3] of successful local-level cooperation in water management in poor countries (although usually at a rather low level of organizational form), but there are more numerous cases of failure of such cooperation or coordination, often leading to an anarchical regime of scramble for water with the inevitable dominance of the rich and powerful farmers. As an illustration of this "anarchy syndrome" in the appropriation of water, let me quote from an account by Hart (1978) from his walk along one of the watercourses intended to feed 4,300 acres of canal-commanded land in Shirol, a tail-end village of Karnataka's Ghataprabha project in South India:

> Of seven outlet gates at the lower end of the watercourse, six were ripped out of their concrete channels, bent, or otherwise prevented from closing. The seventh was intact, but so hopelessly blocked with sediment that water could never reach it. "It has been like this for three years", said the junior engineer. "The cultivators break the gates. They should be severely punished. But what can we do?"

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[3]See. for example, Wade (1987), Ostrom (1990) and Tang (1991).

> The junior engineer, an exceptional officer, had in fact tried to do something. We saw the need for it, and the difficulties, two kilometers further down the watercourse. At this point water in the channel simply dried up, leaving the last four outlets useless. ...[The irrigators on the middle reaches of the watercourse], having blocked closure of their outlet gates, had also headed up water into them by means of home-made barriers in the bed of the watercourse. This effectively preempted the already insufficient flows from reaching the tail. The junior engineer had instituted closure of all upper outlets of the watercourse... during half of every week, pushing water down to the tail. It was an improvised rotational delivery.
>
> It was not, however, entirely successful. When water began reaching the tail for the first time in many years, part of it was illegally diverted by a large landowner having twenty acres above the watercourse. His land was designed to receive canal water from an entirely different channel higher up. But finding water available here he had headed up the little supply one or two feet, dug an entirely unauthorized ditch to his land, and appropriated what he needed. His illegal ditch stood as evidence that the Irrigation Department was impotent.

Yet from another part of South India Wade (1987) has reported some cases of village-level corporate irrigation organization with considerable cooperation in water allocation and monitoring, functioning on a day-to-day basis. It is thus important for us to understand the conditions working for and against sustainability of local cooperation in situations of economic and social interdependence.

As a young student many years back my first exposure to the general analytical issues of the incentive problem in group behavior in situations of a mixed game of conflict and cooperation in the context of economic development was from the early writings of Amartya Sen: the discussion of isolation paradox and the assurance problem in Sen (1961) and Sen (1967) and of labor allocation in a cooperative enterprise in Sen (1966). These issues have remained a matter of abiding interest for me and in this paper I go back to some of them in the context of local-level cooperation in water allocation and management. I shall first try to draw some lessons from the growing theoretical literature on cooperation in repeated

game theory and in evolutionary biology, and then comment upon some limitations of the theoretical literature, particularly in the light of some of the pragmatic insights one can glean from the available field studies on the subject. My purpose in this paper is largely integrative, putting together evidence from disparate sources, theoretical and empirical.

II

For quite some time the literature on collective action has been characterized by a pervasive pessimism on cooperation, as, for example, in the widely noted work of Mancur Olson on political economy or that of G. Hardin on the tragedy of the (open-access) commons. The theoretical underpinning of this literature has been provided by the standard one-shot prisoners' dilemma game as in Chart 1(a), in which "defection" or non-cooperation is the dominant strategy of each player, no matter what the other players do. But as Taylor (1987) and others have pointed out, the constellation of costs and benefits of collective action on common-pool resources like water is often of a kind which is much more favorable to the possibility of cooperation than the prisoners' dilemma game. Take, for example, the case of what Taylor calls the "chicken" game (or what evolutionary biologists usually call the "hawk-and-dove" game), as depicted in the pay-off matrix of Chart 1(b). Suppose two neighboring farmers are pondering the issue of who will carry out the essential maintenance work on the irrigation ditches which both use. Either farmer can do it by himself but each, of course, prefers to "free-ride" on the other's work. The literature usually jumps to the extreme case of prisoners' dilemma immediately after mentioning the free-rider problem. But in the case of many vital common-pool resources like water the consequences of "defection" on the part of both agents may be so bad that either of them would rather do

the work himself if the other did not. As Chart 1(b) shows, (defect, defect) is not the dominant strategy unlike in the prisoners' dilemma game. Of course, in this case precommitment to an aggressive strategy is individually advantageous, and the powerful people in the village may resort to this, but at least the necessary maintenance work will not go by default.

There are, of course, cases in which an individual farmer cannot by himself do the whole work, and the extra benefits from the part of the work done by him do not fully cover his costs, as in the example of Chart 1(c). In this example, however, each farmer cooperates when the other does, but defects when the other defects. This is an assurance game, which captures a widely observed phenomenon in the field studies: nobody wants to be "suckered", but one tends to be cooperative when the others (at least a critical mass of others, in a multi-person game) are, something that the prisoners' dilemma game fails to capture.

Even in the case of the prisoners' dilemma the earlier pessimism is modified in the repeated game theory literature where it is shown that cooperative equilibria can be spontaneously sustained by the long-run interests of foresighted self-interested individuals. The possibility of cooperation will, of course, depend on the future pay-offs not being discounted too heavily or the short-run rewards to defection (like stealing water) being not too large. The proofs of the relevant theorems in the literature[4] of discounted many-person repeated games work on the basis of the possibility of administering sufficient punishments over time to outweigh the immediate benefits for the defector and of these punishments being credible. But therein lies a second-order collective action problem, since punishment is costly to the punisher, while the benefits are distributed diffusely in the community. The

[4]See Abreu (1988), Fudenberg and Maskin (1986).

CHART 1

Farmer II

Farmer I	C	D
C	3, 3	1, 4
D	4, 1	2, 2

(a) Prisoners' Dilemma Game

Farmer II

Farmer I	C	D
C	3, 3	2, 4
D	4, 2	1, 1

(b) Chicken or Hawk-and-Dove Game

Farmer II

Farmer I	C	D
C	2, 2	-1, 1
D	1, -1	0, 0

(c) Assurance Game

primary trick here is to devise strategies that punish players who fail to play their part in punishing the defector -- i.e. rules of what can be called meta-punishment.

Elster (1989) has raised a question about such meta-punishment rules: do people really punish others when they fail to sanction people who fail to sanction people who fail to sanction a defector? In a large community it is quite likely that sanctions run out of steam at two or three removes from the original violation. But in a small community of irrigators meta-punishments may not be unreasonable (but then, in small communities the social costs of punishment to the punisher as well as the punished may also be larger).

The theoretical models point to a potentially large number of equilibrium outcomes, facing which players may use observed past behavior of others as a guide in their choice. In other words, even when costs and benefits of cooperation are otherwise identical, what degree of trust the players have in one another serves a crucial role. Seabright (1993) has in this context a model of trust where he shows that when many equilibria can exist in which the players' belief about each other's trustworthiness are confirmed by subsequent behavior, there is a tendency of cooperative behavior to enhance the prospects for successful further cooperation. As Seabright points out, when trust matters for the possibility of cooperation, the equilibrium is more renegotiation-proof since the reputation loss in a breach of trust will make it difficult for the violator to persuade the others to let bygones be bygones. This ensures that punishments are more credible.

Conditions under which cooperation survives have also been explored in evolutionary biology. In a framework of limited rationality and learning by trial and error, game theory has been used to explain evolutionary processes. The central concept, as explained by Smith (1982), is that of evolutionary stability. An evolutionarily stable strategy (ESS) is a pattern

of behavior such that if it is generally followed in the population, any small number of people who deviate from it will do less well than the others: no "mutant" strategy can "invade" the population. Let us consider a large population from which pairs of individuals are repeatedly drawn at random to play a particular two-person symmetric game. If V(I,J) is the expected pay-off to playing I against an opponent who plays J, then the average pay-off to playing I in a large population of others playing I is V(I,I), and the average pay-off to playing J in the population is V(J,I). In this case I is an ESS when (a) either V(I,I) > V(J,I), or (b) V(I,I) = V(J,I) and V(I,J) > V(J,J). In a two-person repeated prisoners' dilemma game it can be shown that conditional cooperation (tit-for-tat) is ESS, as long as rates of time discount are not too large, the expected duration of the game is sufficiently long, the rewards to defection are not too great, and the punishment for defection is very costly to the defector. These conditions should be familiar from our discussion in the earlier part of this section.

But while conditional cooperation is <u>stable</u> under these circumstances (i.e. it can defend itself against invasion), it may not be <u>viable</u> in the sense of Axelrod and Hamilton (1981), i.e. it cannot invade a large population of non-cooperators. If, however, we give up the assumption that agents are randomly paired for contests, and allow for the fact that agents are more likely to be paired with others adopting the same strategy, conditional cooperation may be viable as well as stable. As Bowles (1989) notes, when what he calls the "degree of community" is sufficiently great (i.e. the fraction of all contests which are among agents playing the same strategy is large), the likelihood of both stability and viability of the conditional cooperation strategy is enhanced.

III

While the game-theoretic models in general give us important insights into the sustainability of cooperation among self-interested agents in a situation of strategic interdependence in the management of common-pool resources like water, it is at the same time important to recognize that these models in a way divert attention from other salient issues in real-world cooperation which the models are much too mechanical and rigid to be able to cope with any degree of subtlety. For example, they cannot usually handle the impact of on-going interactions among agents in the updating and contingent modifications of the rules of the game, changes in the pay-off matrix (as non-cooperative choices cumulatively drain a common resource[5], as in the case of the overexploitation of groundwater) and the possible evolution of strategy sets as an outcome of successive rounds of a game. The models also ignore the importance of group dynamics, which through deliberation and persuasion may bring about endogenous preference changes and reorientation of values in a community, and the importance of leaders and political entrepreneurs acting as catalysts in initiating cooperation and breaking deadlocks, emphasizing to people how others' efforts are contingent on theirs and enlarging the shadow of the future.

The language of prisoners' dilemma game theory, as Sen (1987) has pointed out, makes it hard to discuss behavior patterns which in adapting to the recognition of mutual

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[5]In a multi-person situation one can imagine the marginal sanction on defectors depending on both the state of the (degrading) resource and the support a cooperator gets from others in the act of sanctioning. If p is the proportion of cooperators, the marginal sanction may then depend on the product p(1-p). If the net benefit from cooperation is linear, then it can be shown in a simple model like that in Brown (1989) that there will be multiple equilibria allowing the possibility of a small amount of "defection" without a total breakdown of the village cooperative effort.

interdependence go beyond what Sen calls "self-goal choice" and work toward the enhancement of the respective goals of the members of a group. Such social norms may be particularly important in a small water community of a village. As Wade (1987) notes in his field study the villagers were not particularly morally motivated, they were more pragmatic, but their self-interest was usually coupled with the moral capacity to recognize the related claims of others. Such social empathy[6] (the ability to imagine oneself in the shoes of others), even sympathy and commitment, if it induces reciprocal behavior, may, of course, be instrumentally useful in the general pursuit of self-goals. Besides, in a world where we often cannot predict each other's reactions, norms provide much-needed rules of thumb and focal points and lend a degree of inflexibility and commitment which form the basis of our binding agreements. As a result, as Elster (1987) points out, we often do better by following norms than by calculation.

Field studies in villages, as well as experimental studies of psychologists and economists, show that quite a large number of people are motivated by the norm of fairness: they don't want to free ride on the cooperation of others nor do they want to cooperate when few others do. Sociologists have emphasized what Coleman (1990) calls "zeal", the opposite of free-ridership, how individuals, particularly in small communities, sometimes incur high costs for what they perceive to be good for their "team", driven by the human desire for approval from others (positive sanctions). Of course, such team spirit may be rare in faction-ridden villages. Internal sanctions or internalization of social norms (often working through guilt, loss of self-respect, etc.), depends on factors like the degree to which the

[6]I agree with Binmore (1991) that "empathy", which is different from "sympathy" in the sense of Hume and Adam Smith, can easily be accommodated in the repertoire of the homo economicus.

individual identifies with the group and the degree to which the norm and its sponsors are seen as legitimate. Intra-village conflicts may thus hamper the process of such internalization. On the other hand, if the conflict is perceived as something vis-a-vis outsiders or common adversaries, norms solidify more easily. As Wade (1987) comments, "...the (Irrigation Department) official who has to be bribed or entreated, the upstream village that has to be stopped from taking too much water, becomes an antagonistic 'them', and being reified, can enhance perception of a reified collective 'us'." As for external sanctions in support of norms and meta-norms, as Axelrod (1986) indicates, they depend on similar structures of punishments and meta-punishments as in our earlier discussion of cooperation in repeated games.

As Ostrom (1990) notes, in actual field setting, unlike in the abstract models, one observes many cases of collectively arranged and financed "enforcers" of cooperative arrangements (like the "common irrigators" in Wade's villages in South India) and a great deal of peer monitoring. In cases of violations, the system of sanctions is often quite flexible and graduated, depending on the seriousness and context of the offense. Such contextuality is usually missing in the inexorable trigger strategies of punishment in the theoretical models. Too much flexibility, of course, can give wrong incentives.

Not surprisingly, cooperation works better in small groups[7] with similarity of hydrologic needs and clear boundaries, and shared norms and patterns of reciprocity. In such communities monitoring is easier, the "common knowledge" assumption of models of

[7]In a game played by rotating irrigators (turntakers and turnwaiters) with self-enforced rules (i.e., without formal guards), Weissing and Ostrom (1990) show that in the equilibrium an increase in the number of irrigators is associated with an increase in the stealing of water, other things remaining the same. But, of course, in actual field settings other things do not remain the same: in larger systems the irrigators often increase the rate of monitoring.

strategic decisions is likely to be more valid, and social sanctions are easier to implement through reputation mechanisms and multiplex relationships of face-to-face communities. Migration and mobility possibilities work against cooperation. Contact with outsiders and the exit option reduce the effectiveness of social norms and the validity of the "common knowledge" assumption. Prolonged repetition of the game also becomes more uncertain, raising incentives for short-run opportunism.

Even with similarity of social norms and of demographic size and composition, different villages can have completely different degrees of success in cooperative irrigation organization, depending crucially on hydrologic circumstances and the extent of ecological stress. Several cases suggest a kind of backward-bending curve relating the success of cooperative organization to (the quantity and reliability of) water supply: when the latter is extremely deficient, cooperation is difficult to organize; then at moderate levels of scarcity chances of success improve other things remaining the same; then again when water is much too plentiful the urge to cooperate diminishes.

As is well known, the models emphasizing opportunism and incentives to break an agreement point to only one aspect of the collective action problem; the other is the bargaining problem where disputes about sharing the potential benefits may lead to a breakdown of the necessary coordination. Here an increase in the disparity in private benefits from common property resource management can lead to a situation in which some parties may lose from cooperation (in the usual case of absence of side-payments) and this may erode a pre-existing cooperative arrangement[8]. Intra-group heterogeneity in pay-offs may thus have an adverse consequence for the sustainability of cooperative agreements.

[8]For a numerical example of this case see Kanbur (1991).

This adds to some of the factors we have cited before to reinforce the conclusion that social heterogeneity and intra-village conflicts and inequality may impede collective action in water management: Internalization of cooperative norms is more difficult under such circumstances; the degree of confidence or trust that individuals have in the likelihood that others will play their part in a cooperative agreement, as in Seabright's model (1993), may be low; the "degree of community" which lends viability to conditional cooperation in the evolutionary models we have discussed may be missing.

Field studies confirm these theoretical expectations. From a study of 23 community irrigation systems in different countries Tang (1991) observes: "a low variance of the average annual family income among irrigators tends to be associated with a high degree of rule conformance and good maintenance". Jayaraman (1981) notes how the relatively egalitarian structure of the community is an important factor in the farmers' coming together in his case studies of farmers' organizations in surface irrigation projects in Gujarat. A study of 10 tank irrigation cases in Tamil Nadu by Easter and Palanisami (1986) shows that the smaller the variation in farm size among the farmers, the more likely they are to form water user organizations. Some other case studies indicate that with the increased access to private pumpsets the powerful people in the village are less interested than before in the maintenance of irrigation channels. Wade (1987) describes how in villages where the rich farmers are able to get enough water for their land without having to organize corporately and without having to incur large additional expenditures themselves since they own the land immediately below the canal outlets, they even block the formation of a cooperative water control committee (which might curtail their own irrigation freedom) at the expense of the small cultivators lower down. Thus the distribution of control over land in relation to

proximity to the outlets strongly influences the nature of corporate response to a given water scarcity situation in a village. Sometimes land fragmentation (which may have adverse effects in other aspects of agriculture) may actually help cooperation, since some of the big farmers may have fragments of land at disadvantaged locations, away from the outlets, and may thus be induced to organize cooperation. Boyce (1987) notes how in tubewell irrigation cooperatives in Bangladesh, when some powerful individuals manipulate the location of the tubewell and distribution of water in their favor, the resentment of those excluded or unfairly treated leads them sometimes to sabotage the pumpsets. Bandyopadhyay and von Eschen (1988), apart from generally noting from their survey some decades back of some villages in West Bengal the marked negative effect of economic and social stratification on cooperation, cite instances of village elites frustrating efforts at cooperation on the part of the poor:

> One instance of a deliberate effort to prevent co-operation took place in a village where several small cultivators tried to co-operate informally to irrigate their land by bringing water from a nearby source. Two of the richer farmers in the area, however, opposed this idea, claiming that the interest on money they had earlier lent these cultivators was greater than the amount the latter intended to invest for the irrigation, and demanding immediate repayment instead. The small cultivators felt the real reason was that, if their irrigation efforts had succeeded, they would no longer have been dependent on the richer farmers, nor could the farmers continue to earn an easy income by loaning money at high interest rates with little risk. The two rich farmers in question successfully frustrated the efforts at co-operation by first lodging false charges with the police of theft and trespassing, and then going to court to seek an injunction against digging irrigation channels on the grounds that these would pass over land which they owned -- land which, in fact, did not belong to them and which they simply seized. This harassment ultimately led the small farmers to abandon their efforts.

This is, of course, a case in which the rich farmers did not themselves belong to the irrigation community, and thus did not subscribe to its norms or obey its sanctions. Even

when they belong to the irrigation community, in cases of sharp class antagonism the sanctions may be less effective if reputation loss beyond one's own class or reference group is perceived as insignificant. This is why Singleton and Taylor (1992) emphasize the importance for cooperation of "mutual vulnerability" (to one another's sanctions).

While the previous points focus on some degree of egalitarianism facilitating cooperation, let us finally note a somewhat contrary factor that one observes in some case studies. In many local communities some rudimentary forms of cooperation have been sustained and enforced over the years by traditional authority structures. While there may have been some bit of a sharing ethic, the predominant social norm was often that of an unequal patron-client system, in which the powerful who might enjoy disproportionate benefits from the institution of cooperation enforced the rules of the game and gave leadership to solidaristic efforts. As the advent of participatory politics and social upheavals erode the legitimacy of these traditional authorities and as modernization improves the options of both "exit" and "voice" for the common people, these solidaristic ties loosen and the old cooperative institutions sometimes crumble. Appeals to supra-local authorities for conflict resolution and arbitration become more common, frequent recourse to external political intervention to reverse local sanctions make them much less effective in punishing defectors from cooperative arrangements, and dependence on the state increases to carry out functions like local water management and repair and maintenance of irrigation structures which earlier used to be in the domain of locally autonomous, though hierarchical, organizations. Many rural communities in developing countries are now in the difficult transition period between the decline of the traditional cooperative institutions and the new water user associations, based on shared reciprocity and defined rights, common lobbying

interest, and legal-rationalistic norms (like regular auditing of accounts or checks and balances on arbitrary use of power), yet struggling to be born. With the growing politicization, accountability of the decision-makers in the local community has increased in many places, but sometimes at the expense of loosening enforcement standards on rules and assignments of cooperative arrangements. With increased political and social awareness villagers are, however, increasingly able to differentiate between domains of relationships which formerly used to be lumped in a dense all-encompassing network. As a result even in a highly conflict-ridden village people sometimes are able to leave their factional disputes or caste conflicts behind when they settle rules of allocation and monitoring in a functionally separate water-user community, enhancing the latter's chances of survival[9].

[9]In a different context Amulya Reddy, a scientist leader in the alternative technology movement in India, has commented on this ability of villagers to separate domains of conflictual issues by referring to the Indian practice of leaving chappals (sandals) outside before entering a temple. Tang (1991) refers to Chiangmai village in Thailand where the major factional division creates numerous conflicts among farmers, but they are able to cooperate on irrigation matters.

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