PRELIMINARY DRAFT
NOT FOR QUOTATION

W87-26

12/2/87

ON MAINTENANCE IN IRRIGATION SYSTEMS
A PRELIMINARY ANALYSIS

by

S. Y. Tang
Workshop in Political Theory and Policy Analysis
Indiana University

Prepared for the Common Property Resource Management Conference to be held at the Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, Indiana, December 4-5, 1987.

Preface

In this paper, I report some preliminary analysis on 16 irrigation cases we have coded. Since only the location, resource, operational level, and subgroup forms have been entered in our data base for all 16 cases, I concentrate the analysis on how the attributes of the resource and the community of appropriators affect maintenance of the irrigation systems. Operational and collective choice rules are discussed when they are closely related to this context.

In our coding, we assign a confidence level ranging from "1" (very confident) to "5" (ambiguous information) to most of the answers. In view of the limited number of cases coded, I do not use these confidence levels to differentiate more reliable data from less reliable ones.

These 16 cases may not be representative of all codable cases. They were chosen for the first round of coding because they are easily accessible and provide relatively detailed information needed for our coding. This paper merely illustrates what can be done with our data. An extended analysis will be undertaken when a wider sample of cases is coded.

On Maintenance in Irrigation Systems

A Preliminary Analysis

by

S. Y. Tang

For many common pool resources, a prominent problem is the need to regulate the rate and pattern of appropriation in order to avoid overuse, depletion, or destruction. This is also true for most irrigation systems in which coordination among irrigators with regard to their rate and pattern of water withdrawal is needed to ensure that the available water is utilized in a productive manner. Irrigators using most irrigation systems, however, face an additional problem of maintenance of the irrigation system itself. In order to ensure effective water diversion, retention, and transportation, irrigators may have to cooperate to maintain and sometimes build water delivery facilities, such as dams, canals, ditches, and pumps.

Building and maintaining hydraulic facilities frequently requires the allocation of substantial amounts of capital and manpower. The need for such investment has led some scholars to argue that the organization of irrigation has far reaching political and economic effects. Wittfogel (1957) argues, for example, that large-scale works of irrigation and flood control induced the development of large-scale, centralized state bureaucracies in many parts of the world. Spooner (1974), focusing on the communal level, suggests that the extent of investment in constructing and maintaining water facilities affects property rights arrangements in a community.

Instead of focusing on the political and economic impact of irrigation maintenance, some authors have directed their attention to factors that affect the level of maintenance of an irrigation system. They argue that a key to agricultural development in developing countries is the mobilization of local efforts to improve irrigation facilities (e.g., Barker, 1978; Easter & Welsch, 1986; Hayami & Ruttan, 1985). In their view, rural labor is often abundant in developing countries. Farmers possess few alternative opportunities to earn income during off-crop seasons. If this labor force could be mobilized to construct and maintain irrigation facilities, it would greatly enhance the agricultural productivity of these countries. In this paper, I begin an examination of the conditions that affect farmers' abilities to organize among themselves to maintain their irrigation systems.

The maintenance of irrigation facilities involves two basic tasks. One task is to obtain actual manpower and financial resources to repair and improve the facilities. The maintenance of common facilities is often a collective good in the sense that once a facility is well-maintained, it is difficult to exclude other irrigators from enjoying the benefit of a well operating system. Incentives exist for individuals to refrain from contributing to the maintenance, while hoping to benefit from others' contributions. If everyone acts likewise, an "under-investment" in the maintenance of the facilities occurs.

The second task regarding maintenance concerns individuals' everyday use of the irrigation facilities. It is not enough just to expend resources to repair the facilities; it is also important that everyone use the facilities with care. Allowing heavy animals to walk across a canal may damage the canal; pushing a valve or a gate too hard may break an important part of the water delivery facility. A structure of incentives to induce individuals to use the irrigation system with care contributes to the long-term viability of the facilities.

Throughout the world, one finds cases where farmers have been unable to organize among themselves to construct, manage, and repair their irrigation facilities. One also finds cases in which farmers have developed effective institutional arrangements to manage their own irrigation system. Scholars have attributed the success or failure of irrigators to maintain irrigation systems to a wide variety of factors including the size of the system, the number of irrigators and their characteristics, and the capacity or lack of capacity of local irrigators to organize their own associations and to develop their own rules for allocating water.

One approach to the explanation and prediction of whether irrigators themselves will develop institutional arrangements that enable them to maintain an irrigation system and what form such organizations may take is to analyze the benefit and cost calculus facing the individuals involved (E. Ostrom, 1985; Oakerson, 1986). In the case of irrigation, the expected benefit that an institutional arrangement may bring to individuals may involve increased reliability of water flow and reduced conflict in appropriation. The expected cost can be divided into two parts. One is the cost involved in searching, negotiating, adopting, and changing the set of rules which constitutes an institutional arrangement (E. Ostrom, 1987). The other is the cost associated with running and enforcing an institutional arrangement including the costs of excluding those who are not participants in the arrangement (Coase, 1960; Field, 1986; Williamson, 1985).

The institutional analysis framework as developed by Kiser and Ostrom (1982) posits three interacting elements -- attributes of goods and technology, attributes of community, and configurations of rules -- that affect the action situation facing an individual. Within this framework, the potential factors affecting an individual's benefit-cost calculus can be classified in terms of these three basic elements. As a preliminary analysis, I will discuss hypotheses about how attributes of the water resource and the community of irrigators may affect irrigators' contributions to cooperative effort in maintenance. I will then examine these hypotheses by reference to the cases we have coded so far. I will also show how various physical and communal factors may interact and produce results different from what any single factor would have produced.

Appropriation Resource as Focus

Before examining the hypotheses, I wish to explain how we define the boundary of a resource for our coding. This is important because how we define the boundary of a resource determines how we specify such important variables as the size of the resource, number of appropriators, and the institutional arrangements related to the resource.

The delivery of water may involve four stages -- production, distribution, appropriation, and use (see Plott & Meyer, 1975). Water is "produced", for example, by holding back the flow of a river by a dam and releasing it during irrigation seasons. The "production" of water for irrigation involves making water available at locations and times when it does not naturally occur in the form of precipitation and immediate runoff. A dam or any other form of a "headworks" is considered to be the production resource. From the dam, the water flow may be distributed through a large aqueduct (i.e., the distribution resource) to the irrigated area. In the irrigated area, farmers may appropriate water from the local canals, tanks, or other works which are considered to be the appropriation resource in our study. The water may then be used to irrigate the crops. In our analysis, we focus on the appropriation resource as the resource unit of primary importance to a set of irrigators obtaining water from this common facility.

It is sometimes not obvious how one may distinguish the appropriation resource from the production and distribution resources. For example, we define as the production resource the headworks that is subject to control by humans. Depending on where intervention takes place, the production resource may be clearly separated from the distribution and appropriation resources and be located high in the mountains in which a river originates or as the small diversion works that divert water from a river immediately adjacent to an irrigation canal. In some cases, three very distinctive resources are identified. In others, two resources may be contained in the same boundary. For example, if water is directed to the fields immediately after it leaves the headworks, we consider the distribution and appropriation resources as being identical.

Irrigation systems are organized in diverse manners which must be taken into account when one defines the resource boundaries. First, many unitary communal irrigation systems are managed by a single organization. The production resource is the facility that diverts water from a natural source. If the production resource is adjacent to the irrigated fields, the canals that divert water to the fields are considered as both the distribution and appropriation resources.

Second, federated communal irrigation systems exist where multiple appropriation organizations share water from the same production and distribution facilities. Above the communal organizations, a higher-level organization regulates the production and distribution patterns of the larger system. The members of this higher level organization may be constituted by representatives from different appropriation organizations, or directly by individual irrigators. In these cases, the production resource may be a dam that diverts water from a river. The distribution resource may be the larger canals that deliver water to different irrigation areas. The appropriation resource is then the local canals or tanks managed by an appropriation organization.

Third, a bureauractic-communal irrigation system is a system in which government agencies manage some of the stages of the water production and distribution process while the local irrigators regulate the appropriation process. The most common form of this type is that of a government agency responsible for managing the production resource (e.g., a dam) and distribution resource (e.g., a major aqueduct) while local communities regulate the appropriation resource (e.g. local canals and tanks). In our data base, we have coded detailed information about the appropriation resource in each of these three types of systems and only very general information about distribution and production resources when they are separated geographically and organizationally.

At present, our data base contains sixteen coded cases of irrigation systems (see Figure 1). Among them, eleven are unitary communal, one federated communal and four bureaucratic-communal. Our focus on the appropriation resource allows us to begin this initial analysis by comparing cases across the three types. After we have coded more cases for each type, we will attempt to analyze the three types separately and examine if there are any systematic differences among the three in relation to maintenance.

Maintenance as Dependent Variable

Besides the care taken by the appropriators, a diversity of factors may be responsible for whether an irrigation system is in good physical condition. These factors may include the initial construction and physical environments of the system, and the financial and technological capabilities of the irrigators. When these factors are taken into account, the standard of what constitutes a well-maintained irrigation system may be different for each system.

Most irrigation case studies do not report any objective measure about the physical condition of an irrigation system. In our coding, we ask how well-maintained the appropriation, distribution, and production resources are at the end of the period coded (i.e., ENDCONDA, ENDCONDD, & ENDCONDP). A five point scale is used to rank a resource from "1" (excellent physical condition) to "5" (very poor physical condition). A sixth point "6" is used to indicate "very poor physical condition, but due to a natural disaster." Cases falling into "6" have to be handled separately since the "very poor physical condition" is not a direct result of inadequate maintenance by the irrigators.

Other questions focus on the contribution appropriators make toward maintenance. One set of questions asks:

(1) whether members of a subgroup have invested their own labor or other resources in maintaining or improving the structure of the appropriation resource (OWNLABOR);

(2) whether members of a subgroup have expended resources (at least their own time) to avoid actions that would harm the structure of the appropriation resource (AVOIDHRM); and

(3) whether members of a subgroup have invested their own labor or other resources in constructing or improving production and/or distribution works for maintaining or improving the appropriation resource (ENHANCE).

Another set of question asks the actual number of person-days of labor per year mobilized to maintain/repair the production, distribution, and appropriation resources (LABRDAYS). When this number is divided by the number of appropriators belonging to the appropriation resource, we have a rough measure of the intensity of the maintenance activities (LABRINT).

Before examining how various physical, communal, and institutional factors may affect these three sets of "maintenance" variables, I wish to discuss briefly how some of these maintenance efforts (i.e., OWNLABOR & LABRDAYS) are related to the physical conditions of the appropriation resource (i.e., ENDCONDA).

Appropriators' Labor and Physical Condition of Appropriation Resource

It is possible that an appropriation resource can be properly maintained by some external agencies without the direct labor contribution of any irrigator. Many authors, however, raised doubts about this possibility (e.g., Chambers, 1977; Coward, 1980; Hunt, 1978). Table 1 shows that in all 16 appropriation resources with "excellent" or "good" condition, at least some irrigators have contributed to maintaining the resources.[1] Although this result may be partly due to our sample which includes 12 communal systems out of a total of 16, it remains to be seen whether bureaucratic or bureaucratic-communal systems are properly maintained without the irrigators' labor contribution.

Maintenance Intensity

Few case studies report the number of person-days of labor invested in maintenance. As shown in Table 2, we are able to estimate the maintenance intensity (LABRINT) of 6 out of a total of 16 cases. The intensity ranges from one person-day of labor to 12 person-days of labor per person per year. The case with the highest intensity is the Agcuyo Irrigation system in the Philippines where the production resource (i.e., a cemented dam across a nearby river) has been destroyed several times by floods or strong typhoon. All farmers of

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[1] The only two subgroups of irrigators who do not contribute their own labor belong to the Silag-Butir Irrigation System in the Philippines. In this system, only the regular members of the irrigation association contribute labor in system maintenance. The other two subgroups of non-members who are allowed to withdraw water only during the wet season do not contribute labor in maintenance.

the system (total 50) have to work together for about ten days to do the yearly general cleaning (De los Reyes, 1980). It seems that the maintenance needs of different systems depend on such diverse factors as the physical construction and the rainfall pattern in the location. No one level of maintenance intensity will be optimal for all irrigation systems.

While the intensity of maintenance may not be the only factor accounting for the physical condition of a resource, it may have a significant effect on the kind of institutional arrangement that is required to sustain the particular level of maintenance intensity. Some authors, for example, argue that organizations tend to be more formalized in irrigation systems that mobilize higher levels of labor input into maintenance (e.g. Martin & Yoder, 1983a). Data on the maintenance intensity of each appropriation resource will be useful for examining this kind of argument.

Attributes of Resource and Community of Irrigators

A number of factors may potentially affect the likelihood that irrigators will contribute to collective efforts in maintenance. Two prominent factors are the irrigators' degree of dependency on the appropriation resource and their vulnerability to scarcity and uncertainty in water supply. Furthermore, even if individual irrigators are willing to contribute, they have to expend resources to organize among themselves to assign responsibilities and undertake the actual maintenance. The size of the appropriation resource, the number of irrigators, and the relationships among irrigators are factors that may affect these costs.

Dependency on Appropriation Resource

As far as dependency is concerned, one would expect that the more the irrigators depend on the irrigation system for their livelihood, the more likely they are willing to expend a substantial amount of resources to maintain the system. Two dimensions can be used to analyze an appropriator's dependency on a resource:

(1) one's dependency on the appropriation resource as the major source of water for irrigation -- (A) do members of this subgroup have access to an alternative source of water (SUBALT1)? (B) what is the cost of alternative sources of water for this subgroup (ALTSUPLY)?

(2) one's dependency on the appropriation resource as a major source of income -- (C) for most people in this subgroup, how dependent are they on this resource as a major source of family income (FAMINCDE)?

Tables 3A and 3B show that most of the subgroups that contribute to maintenance (11 out of 15) do not have access to any alternative source of water. Some exceptions (4 out of 15), however, exist. One example is the case of Sananeri Tank in India where many irrigators have private wells as an alternative source of water but are still actively involved in maintaining the tank (Meinzen-Dick, 1984).

It seems that a more important factor affecting irrigators' contribution to maintenance is not whether irrigators have any alternative source of water, but whether the alternative source can totally replace the existing one. In the case of Sananeri Tank, water from private wells is relatively expensive and the amount of water available may not be enough to irrigate all the crops. Well water can only be a supplement to the tank water. The tank remains the major source of water for the crops from which the farmers derive most of their family income. Most people still depend on the tank as a major source of water. It is probable that one's dependency on the resource as a major source of income (i.e., FAMINCDE) is a stronger factor affecting one's willingness to contribute to maintenance. The cases coded so far seem to be consistent with this conjecture (see Table 3C).

Depending on the particular situation, the availability of alternative water source may or may not induce individuals to contribute to maintenance. In some cases, the availability of an alternative water supply may reduce tension among irrigators when water flow in the resource is extremely scarce, thus facilitating long term cooperation among the irrigators. In other cases, irrigators with access to an alternative source of water may be less willing to cooperate with those without. This would be an obstacle to collective effort in maintenance. I will examine these seemingly contradictory effects of the presence of alternative water sources more closely when a wider sample of cases is available.

Vulnerability to Scarcity and Uncertainty in Water Supply

Wickham and Valera (1979), in a study of irrigation projects in the Philippines, conclude that in order to induce farmers to cooperate in managing their watercourses or tertiary canals, an effective system-wide management program is a prerequisite. In other words, farmers have no incentive to organize if they do not have a predictable or sufficient flow of water into their watercourses. On the other hand, Wade (1985), drawing upon experiences in South India, argues that the greater scarcity and uncertainty of the water supply, the greater the likelihood that a community of cultivators will develop collective arrangements to manage and maintain their water source.

In order to examine these seemingly opposite arguments, one coding question asks about "the balance between the quantity of water withdrawn and the quantity of water needed, i.e., the optimal water requirements of the crops in the established fields of the system, at the end of the period coded" (ENDBLNC2). Table 4 shows that while most (10 out of 16) of the well-maintained resources have a balanced supply of water, well-maintained resources also exist where water supply is either abundant or scarce. At one extreme is the Nazareno Gamutan Irrigation System in the Philippines that has an abundant supply of water from a nearby river. Irrigators in this system have put much effort in maintaining the dam and canals that divert water to their fields (De los Reyes, 1980). At another extreme is the Sananeri Tank mentioned earlier, which by itself is inadequate for all cultivation purposes but remains a major source of water. Irrigators are still interested in maintaining this major resource.

Two lessons can be drawn from these extreme cases. First, effective water delivery often depends on the physical condition of the delivery facilities. As shown by the case of the Nazareno Gamutan Irrigation System, great effort in maintenance may be needed to ensure that an abundant and reliable source of water can be utilized effectively. Second, even though water from an appropriation resource may be scarce and uncertain, irrigators may still be interested in maintaining the resource if it can be supplemented by other sources of water. While these two lessons may not be entirely relevant to the discussions by Wade, and Wickham and Valera, they show that there may not be a one-to-one and unidirectional relationship between irrigators' vulnerability to a scarce and uncertain water resource and their willingness to maintain the resource. Multiple factors may interact to produce outcomes which would not have been produced by any single factor alone.

Size of Appropriation Resource and Number of Appropriators

Many authors have argued that, all other things being equal, information-gathering, communication, decision-making, and monitoring costs increase as the size of a resource increases. By the same token, various kinds of transaction costs increase as the number of appropriators increases (e.g. Field, 1986; Bloomquist, 1987; & Buchanan & Tullock, 1962).

These two arguments imply that, all other things being equal, it will be easier to organize maintenance activities in appropriation resources of smaller sizes or with less irrigators. This line of reasoning is consistent with Coward's (1980) suggestion that there need to be nested groups of mini-organizations if the area of an irrigation system is too large for a single agency to organize effectively. These mini-organizations, Coward argues, "would be self-contained and any irrigation problem could be easily isolated and overcome within such units.... [Such an arrangement] also improves farmer cooperation and simplifies irrigation extension" (1980: 207).

In our coding, the appropriation resource is managed by the lowest organizational unit of a system. The appropriation resource is similar to the small, "self-contained" unit discussed by Coward. Tables 5A and 5B show the numbers of appropriators (ENUMAPP2) and the sizes, in terms of square kilometers of fields irrigated (ENDRATE2), of the appropriation resources coded. The number of appropriators ranges from under 25 to over 2500, while the area of fields varies from 0.02 sq. km to 24 sq. km. The two tables indicate that appropriation resources with varying sizes and numbers of appropriators may do equally well in maintenance. Besides analyzing the effects of the size and number of irrigators separately, we also examine the combined effects of the two. Table 5C, for example, shows the average number of appropriators per sq. km of fields (DENSITY1) for each appropriation resource. The number ranges from 26 to 6666. The table indicates that appropriation resources of various DENSITY1 may do equally well in maintenance.

Based on this initial set of data, two research questions are relevant. First, do thresholds exist with respect to the size and number of appropriators of an appropriation resource beyond which the resource can hardly be maintained? We may be able to answer this question when a wider set of cases are coded.

Second, granted that transaction costs increase as the size or number of irrigators of an appropriation resource increases, does this have any systematic relationships with the institutional arrangements for maintenance? More specifically, can some institutional arrangements reduce the transaction costs associated with large size or large number of irrigators? One may, for example, hypothesize that more detailed and precise rules are needed in resources with more irrigators than those with less because more detailed and precise rules can reduce the chances of dispute which may be costly to handle in a large group. Hypotheses like this can be examined when the coding and entry of rules used in various appropriation resources is completed.

The Community of Irrigators

Some collective action literature suggests that a collective good is more likely to be provided if a few individuals have disproportionate interests in the good, since these individuals may be willing to provide the good by themselves or expend resources to organize other potential beneficiaries to provide the good (e.g. Olson, 1960). In irrigation, this means that the existence of individuals with disproportionate landholdings or share of the water flow facilitate maintenance of an irrigation system.

Contrary to this argument, some authors argue that highly unequal distribution of landholdings inhibit local cooperation in managing and maintaining irrigation facilities since unequal distribution of wealth may be a source of conflict among farmers (e.g. Palanisami and Easter, 1986). In order to examine these seemingly opposite arguments, we ask in our coding: (1) how many subgroups of irrigators are withdrawing water from the appropriation resource; and, for each subgroup, (2) the variance of the average annual family income in the subgroup (SUBVAR); and (3) what proportion of the subgroup own land or capital (ASSETS).

Out of the 16 cases coded, three cases involve multiple subgroups of irrigators. In these three cases, some subgroups have priorities over others in terms of rights to withdraw water. In all three, the physical condition of the appropriation resource is either "excellent" or "good".

Thirteen cases out of the 16 cases coded involve only one subgroup. Since few case studies report the distribution of landholdings or wealth among the irrigators, we only have rough estimates of SUDVAR and ASSETS for about half of the cases coded. Tables 6A shows that the subgroups that contribute labor in maintenance are either "low" or "moderate" in their variance of the average annual income. Tables 6B shows that the subgroups that contribute labor in maintenance have varying proportions that own land or capital. From the two tables, however, we find no cases of extreme concentration of land or wealth.

This limited amount of data suggests that groups with fairly equal distribution of landholdings or wealth are capable of organizing maintenance activities. However, the question about the effect of highly unequal distribution of landholdings and wealth, can be tackled only when cases of this kind are coded.

Concluding Remarks

In this paper, I have examined some hypotheses about maintenance in irrigation systems that are derived from the institutional analysis framework and literature in irrigation. I have also discussed how concepts in these hypotheses are operationalized in our coding. This preliminary analysis of the coded cases suggests that many physical, communal, and institutional factors appear to affect maintenance in irrigation systems, and these factors frequently appear to operate interactively. Further coding and analysis will enable us to begin to examine the interactive effects of these factors still further.

Figure 1

Coded Irrigation Cases by Author

Author	Screener	Country	CASE NAME
Beardsley (1980)	158	Japan	Obara Pond (not finished)
De los Reyes (1980)	117	Philippines	Agcuyo
De los Reyes (1980)	127	Philippines	Cadchog
De los Reyes (1980)	155	Philippines	Calaoaan
De los Reyes (1980)	118	Philippines	Silag-Butir
Downing (1974)	119	Mexico	A Tramo in Diaz Ordaz
Geertz (1967)	120	Indonesia	Subak A
Gray (1963)	121	Tanganyka	Kheri Sonjo
Hafid (1979)	94	Indonesia	Saebah
Hafid (1979)	93	Indonesia	Takkapala
Martin (1983)	137	Nepal	Raj Kulo
Martin (1983)	126	Nepal	Thulo Kulo
Meinzen-Dick (1984)	146	South India	Sananeri Tank
Ongkingco (1973)	156	Philippines	Laoag-Vintar
Ongkingco (1973)	157	Philippines	Nazareno Garautan
Spooner (1974)	138	Iran	Deh Salm
Wade (1985)	122	India	Kottapelle

Table 1

Case	ENDCONDA	Subgroup	OWNLABOR
93	1	1	1
94	1	1	1
120	1	1	1
121	1	1	1
		2	1
		3	1
		4	1
126	1		1
137	1	1	1
		2	1
146	1	1	1
117	2	1	1
118	2	1	1
		2	2
		3	2
119	2	1	1
122	2	1	1
127	2	1	1
138	2	1	1
155	2	1	1
156	2	1	1
157	2	1	1

<ENDCONDA>:

As of the end of this period, how well-maintained is the appropriation resource?

(1) ______ Excellent physical condition
(2) ______ Good physical condition
(3) ______ Passable physical condition
(4) ______ Poor physical condition
(5) ______ Very poor physical condition
(6) ______ Very poor physical condition, but due to a natural disaster
(-1) ______ MIC
(-2) ______ NA
______ CL

<OWNLABOR>:

During this time period, have members of this group invested their own labor or other resources in maintaining or improving the structure of the appropriation resource?

(1) ______ Yes
(2) ______ No
(-1) ______ MIC
______ CL

Table 2

Case	LABRINT	ENDCONDA	ENDCONDD	ENDCONDP
119	1.00	2	2	2
94	1.33	1	-2	1
127	2.25	2	-2	2
93	2.56	1	-2	1
120	3.30	1	2	-1
117	12.00	2	-2	6 ←

<LABRINT>:

How many person-days of labor per person per year are mobilized to maintain and/or repair the resource(s)? ______

<ENDCONDA>:

As of the end of this period, how well-maintained is the appropriation resource?
(1) _____ Excellent physical condition
(2) _____ Good physical condition
(3) _____ Passable physical condition
(4) _____ Poor physical condition
(5) _____ Very poor physical condition
(6) _____ Very poor physical condition, but due to a natural disaster
(-1) _____ MIC
(-2) _____ NA
_____ CL

<ENDCONDD>:

As of the end of this period, how well-maintained is the distribution resource?

<ENDCONDP>:

As of the end of this period, how well-maintained is the production resource?

Table 3

A

ALTSUPLY \ OWNLABOR	yes	no	mic	Total
1				
2	4	2		6
3				
4	11			11
mic	5			5
Total	20	2		22

B

SUBALT1 \ OWNLABOR	yes	no	mic	Total
yes	4			4
no	11	1		12
MIC	5	1		6
NA				
Total	20	2		22

C

FAMINCDE \ OWNLABOR	yes	no	mic	Total
1	12			12
2	2			2
3	1	1		2
mic	5	1		6
Total	20	2		22

<ALTSUPLY>:

What is the cost of alternative sources of supply for this unit for this subgroup?

(1) ______ Low cost alternatives are available
(2) ______ Moderate cost alternatives are available
(3) ______ High cost alternatives are available
(4) ______ No real alternative is available without migration
(-1) ______ MIC
______ CL

<SUBALT1>:

Do the members of this group have access to an alternative soruce of supply of this unit?

(1) ______ Yes
(2) ______ No
(-1) ______ MIC
(-2) ______ NA
______ CL

<FAMINCDE>:

For most people in this subgroup, how dependent are they on this resource as a major source of family income?

(1) ______ Very dependent (most of the family income)
(2) ______ Moderately dependent (about half of the family income)
(3) ______ Slightly dependent (a small part of the family income)
(-1) ______ MIC
______ CL

Table 4

ENDCONDA

ENDBLNC2	Excellent	Good	Passable	Poor	Very Poor	Disaster	MIC	Total
Extreme Shortage	1							1
Moderate Shortage		2						2
Apparently balanced	5	5						10
Moderately abundant	1	1						2
Quite abundant		1						1
MIC								
Total	7	9						16

<ENDBLNC2>:

For physical resources at the end of this period, the balance between the quantity of units withdrawn and the quantity of units needed,* given the usual patterns of use for these units, was:

(1) ______ Extreme shortage
(2) ______ Moderate shortage
(3) ______ Apparently balanced
(4) ______ Moderately abundant
(5) ______ Quite abundant
(-1) ______ MIC
(-2) ______ NA
______ CL

* In irrigation, this refers to the optimal water requirements of the crops in the established fields served by this system.

Table 5A

ENDCONDA

ENUMAPP2

	Excellent	Good	Passable	Poor	Very Poor	Disaster	mic	Total
< 25								
25 - 50		2						2
51 - 100	1	2						3
101 - 200	2	1						3
201 - 500	1	1						2
501 - 1000		1						1
1001 - 2500		1						1
2501 - 5000		1						1
> 5000								
mic	3							
Total	7	9						16

<ENUMAPP2>:

General estimate of number of appropriators at the end is: ______

Table 5B

ENDCONDA

ENDRATE2 (km²)

	Excellent	Good	Passable	Poor	Very Poor	Disaster	MIC	Total
0.02		1						1
0.03		1						1
0.09		1						1
0.39	1							1
0.94	1							1
0.95	1							1
1.00	1							1
1.14		1						1
1.50		1						1
1.74	1							1
2.60	1							1
3.00		1						1
5.00		1						1
12.00		1						1
16.00	1							1
24.00		1						1
MIC								1
Total	7	9						16

<ENDRATE2>:

Square kilometers of fields irrigated at the end: _________

Table 5C

ENDCONDA

Density 1

	Excellent	Good	Passable	Poor	Very Poor	Disaster	MIC	Total
26		1						1
28	1							1
47		1						1
50	1							1
90	1							1
131	1							1
160		1						1
208		2						2
293		1						1
555		1						1
6666		1						1
MIC	3	1						4
Total	7	9						16

<DENSITY1>:

Estimate of number of appropriators per square kilometer of fields irrigated: ____________

Table 6

A

OWNLABOR

SUBVAR

	yes	no	mic	Total
Low	2			2
Moderate	4			4
High				
mic	7			7
Total	13			13

B

OWNLABOR

ASSETS

	yes	no	mic	Total
Less than 10%				
10% to 25%	1			1
26% to 50%				
51% to 75%	1			1
76% to 90%	4			4
91% to 100%	1			1
mic	6			6
Total	13			13

<SUBVAR>:

The variance of the average annual family income in this subgroup is:
(1) ______ Low
(2) ______ Moderate
(3) ______ High
(-1) ______ MIC
(-2) ______ NA

<ASSETS>:

What proportion of this group own land or capital?
(1) ______ Less than 10%
(2) ______ 10% to 25%
(3) ______ 26% to 50%
(4) ______ 51% to 75%
(5) ______ 76% to 90%
(6) ______ 91% to 100%
(-1) ______ MIC
______ CL

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