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COMMON PROPERTY AND COLLECTIVE ACTION:

COOPERATIVE WATERSHED MANAGEMENT IN HAITI

by

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TABLE OF CONTENTS

Common Property and Collective Action:

Cooperative Watershed Management in Haiti

Introduction

The debate over common property among development professionals is increasingly active. This includes the growing concern for international environmental disputes and transboundary externalities and questions as to the appropriate role of self-governance in resource management. Growing numbers of theorists and practitioners question the application of the "tragedy of the commons" paradigm to resource overuse, yet a broader and more elaborate theory of common property is only now emerging.[1] A series of theoretical efforts have drawn attention to the possibility (but by no means the universality) of cooperative behavior in resource regimes (e.g., Axelrod, 1984; Axelrod and Dion, 1988; Bromley, 1989, 1991; Ostrom, 1990; Runge, 1981, 1984; Young, 1982). Yet the systematic empirical examination of the factors responsible for successful collective action is relatively recent (e.g., Wade, 1988; Tang, 1992). Such empirical analyses can help inform policy makers when and where collective action and self-governance can work. In this paper, we undertake such an examination in a region

[1]The International Association for the Study of Common Property, created following the formation of a U.S. National Academy of Sciences Panel on Common Property Resources, is one indication of the level of interest in this issue. The Association now includes over 4,000 individual and organizational members in 153 countries.

widely deemed to be one of the least auspicious environments for voluntary collective action in the world: rural Haiti. If common property management can function effectively here, it would be reasonable to suppose that it can succeed in more favorable environments.

The paper is divided into four sections. First, watershed management in Haiti is presented as a problem of voluntary collective action in which small watersheds are the common responsibility of a group of users. Second, this situation is given formal expression as a "public goods" problem, in which obligations to contribute time and labor to the maintenance and management of watersheds are treated as conditional or contingent commitments to cooperate (rather than defect). Individual choices are modeled first, followed by a model of collective outcomes of individual behavior. Third, an empirical analysis is presented in which key economic and cultural factors are tested to determine those that best explain the individual propensity to cooperate and the conditions necessary for collective action to emerge. Fourth, we interpret these results in light of the model, and suggest some generalizations and extensions of theoretical and empirical research on common property and collective action.

1. Watershed Management in Haiti

Haiti is one of the poorest countries in the western hemisphere, and one of the most environmentally degraded. Deforestation and soil erosion began in the colonial period, when forests were cleared for coffee and sugar cane production, and have continued to the present day. In response, the government, since 1826, has legislated over 100 laws and policies aimed at protecting natural forests and soils. These laws have taken the form of taxes, prohibitions, and penalties (Pierre Louis, 1989). This legislation has apparently not provided incentives or conditions for appropriate land use decisions, and degradation has been little affected. With the failure of policy instruments, aid agencies and the government of Haiti, since the early 1950s, have directed their resources and attention to the implementation of reforestation, soil conservation and watershed management projects. The vast majority have also produced disappointing results (AID, 1990; BREDA, 1988; Murray, 1979). Such efforts have predominantly utilized the conventional equipement du territoire approach to environmental rehabilitation, characterized by large-scale treatments of contiguous land and ravines and the provision of monetary and commodity incentives to attract peasant participation (Lilin and Koohafkan, 1987).

The use of this approach for the treatment of privately held lands -- the vast majority of lands in Haiti are privately owned -- has been criticized by many development professionals because sustained adoption and maintenance of the techniques promoted has failed to result (Bureau, 1986; Lilin, 1986; Pierce, 1988; Pierre Jean, 1991). Basic weaknesses cited include a focus on the protection of downstream investments rather than on-site benefits; a disregard for individual landholder knowledge or techniques, and indifference to socio-cultural institutions and land tenure complexities (Murray, 1979 and Lilin, 1986). When commodity or financial incentives are provided, critics have charged that they reduce dignity, self-reliance, depress local crop prices, and cause farmers in adjacent areas to stop adopting techniques voluntarily.

Given this legacy of failure, a new approach to watershed management began to emerge in the early 1980s, based on the "agricultural parcel" (STABV, 1990). The new approach recognized that:

1. farmer remuneration was not necessary for technique adoption and sometimes even acted against technique maintenance and diffusion;
2. a number of low input, indigenous, anti-erosion techniques and agroforestry practices existed which could be improved upon, and;
3. peasants had a natural incentive to conserve soil in order to increase agricultural production.

This approach has proved more successful. Numerous farmers have voluntarily adopted and maintained soil conservation measures in diverse areas of Haiti. The approach takes a farmer rather than an engineering perspective of soil erosion, and views watersheds primarily as a set of agricultural parcels within a physically defined space rather than as one contiguous physical unit. However, implementation of this approach does not resolve problems of erosion which cross private property boundaries, occurs between two private boundaries, or in public domain lands. These "transboundary" erosion issues multiply with growing land subdivision as ridges and gullies are increasingly used to delineate boundaries. Unless such erosion is treated, the agricultural parcel approach does not result in improved overall levels of agricultural production and environmental rehabilitation.

A demand has emerged for development approaches which build on the success of the agricultural parcel approach yet explicitly target transboundary erosion. This involves finding an appropriate combination of private incentives respecting individual parcels, and public incentives for transboundary problems. In Haiti, where parcels are small and erosivity high, such an approach also needs to address the nonseparability of individual land uses -- how upstream land use affects downstream productivity, and how both upstream and downstream landholders are better off if erosion is reduced. Such an approach also must promote a combination of landholder land use agreements and independent landholder action, and collective agreements and collective action to reduce transboundary soil losses. Both require landholder cooperation and thus new program strategies and policy approaches to encourage that cooperation.

These problems of cooperation and questions as to the appropriate role of projects in encouraging cooperation revolve around a central issue: Under what conditions is voluntary collective action best maintained in watershed management? For the Haitian farmer, this involves an individual choice: whether to participate in a voluntary watershed management scheme (cooperate) or not to participate (defect). But the sum of these individual choices has collective consequences: insufficient participation leads to inadequate watershed management of an agricultural parcel and environmental degradation, while sufficient participation yields joint benefits in the form of reduced erosion and increased productivity in which the individual shares. There is thus an individual and collective component to the problem, making it one of "public goods" provision, in which the public good is the watershed itself.

Such problems have traditionally been described as "tragedies of the commons," in which too many people who "free ride", overly concerned with their own benefit, have ruined their common environment. This explanation has been popular in Haiti, where experts have categorically characterized Haitians as having extremely limited identification with any purpose greater than self or family survival and aggrandizement. This lack of social concern has been cited as the cause of consistent exploitation of those of lower standing (USAID, 1985). Haitians are also noted for their historic opposition to authority and the high value placed on economic freedom (de Young, 1958). USAID's first major report on the human resources of Haiti, written in 1962, concluded that the peasant "except under extreme duress, is incapable of group action to defend his interests" (Schaedel, 1962:iii). These characterizations, in essence that individuals are prone to defection and would "free ride" at every opportunity, have strongly influenced environmental policies and development project strategies alike.[2]

Yet, anthropologists have long recognized various labor exchange groups as fundamental and widespread institutions in rural Haiti and have argued for their integration into development strategies. Many other authors and development workers have cited the need to recognize and empower local, indigenous groups in natural resource projects in order to facilitate cooperation. Cernea (1989) has called for watershed management approaches which form "watershed groups" (groups of farmers based on land ownership within watersheds) to establish and maintain watershed and forestry treatments. In a similar vein, Murray (1990) has promoted the establishment of

[2]In the OAS's first "Inventory of Information Basic to the Planning of Agricultural Development in Latin America: Haiti," the statement "no farmers' organization in the ordinary sense exist in Haiti" comprises the entire chapter titled "Farmers Organizations." OAS, 1963.

"hillside units" of Haitian farmers to collaborate on the treatment of contiguous watershed lands. Uphoff (1986) also recommends the recognition and promotion of local groups for watershed management. McKean (1984) states that the though limited, the literature from Japan shows that collective management is capable of assuring stable and productive use of watersheds over a long period of time. None of the above authors have explicitly proposed methods to form such groups, or discussed requisite incentive structures for farmer participation.

In sum, there is consensus in the literature of the failure of conventional approaches and that the achievement of watershed management requires the maintenance of cooperative institutions. But understanding such institutions, how they might be identified, evolve, or be promoted, is limited. How is a balance of incentives to free ride or cooperate arrived at, and what factors tip this balance in one direction or the other? When, and at what level, are externally provided incentives or coercion necessary? In order to develop improved theories concerning the emergence of cooperative institutions for watershed management, there is a need to understand these factors. A number of basic questions arise: What economic incentives do landholders have to participate? How does this incentive vary with landholding position in the watershed? What social or cultural attributes (including religious affiliation, age, wealth, land tenure or preexisting cooperative groups) are correlated with watershed cooperation or defection? Research into these questions was conducted at the Save the Children Federation (SCF) Watershed Management Project in Maissade, Haiti, which has utilized a cooperative watershed management approach since 1988. Before examining the project in detail, we first consider five key theoretical issues.

2. Theoretical Issues in Collective Action

Whether to cooperate through voluntary contributions to a public good, or to defect by failing to contribute, in a central problem in social and economic theory. In the case of watershed management, the problem is one in which the sum of individual decisions affects the welfare of the group as a whole. The theoretical components of the problem may be reduced to five:

(2.1) the nonseparable costs of watershed management;

(2.2) the critical role of expectations and contingent choice;

(2.3) the collective public consequences of individual behavior;

(2.4) the redistributive function of shared responsibilities;

(2.5) the survival capacity of the watershed management institution.

These theoretical issues will be presented and discussed in turn.

2.1 Nonseparable Costs

Watershed management decisions generally involve certain nonseparabilities. If a farmer attempts to maximize benefits from a watershed in which the actions of other watershed users matters (such as those upstream) then only by establishing some level of security concerning these actions will a rational choice be well-defined (Runge, 1981).

Formally, let the cost functions of two farmers (1, 2) who share the watershed be given by C_1 (q_1, q_2) and C_2 (q_1, q_2) where q_1 and q_2 are the quantities of a composite input of labor time and maintenance effort offered by farmers 1 and 2 respectively. If the function is separable, then the profit maximizing rule for each is to set price equal to marginal cost, which involves only the argument of the farmers' own labor time and maintenance effort. Such an example would occur where no transboundary effects affect the calculus, as in the functions:

$$C_1\,(q_1, q_2) = A_1 q_1^n + B_1 q_2^m,$$

$$C_2\,(q_1, q_2) = A_2 q_2^r + B_2 q_1^s,$$

where A and B and superscripts n, m, r and s are parameters.

Profit maximization would then imply that price be set equal to marginal cost. First order conditions (assuming second order conditions are satisfied) are:

For farmer 1: $$\frac{\partial C_1}{\partial q_1} = nA_1 q_1^{n-1}$$

For farmer 2: $$\frac{\partial C_2}{\partial q_2} = rA_2 q_2^{r-1}$$

Note that for farmer 1, only q_1 enters the first order conditions, which is his own labor and maintenance, and likewise for farmer 2, whose decision is based on variations in q_2.

But if transboundary affects do affect this calculus, they generally take the nonseparable form. For example:

$$C_1\,(q_1, q_2) = A_1 q_1^n + B_1 q_1 q_2^m\ ,$$

$$C_2\,(q_1, q_2) = A_2 q_2^r + B_2 q_2^t q_1^s\ .$$

Profit maximization by each individual would then imply the following first order conditions:

For farmer 1: $$\frac{\partial C_1}{\partial q_1} = nA_1q_1^{n-1} + B_1q_2^m ,$$

For farmer 2: $$\frac{\partial C_2}{\partial q_2} = rA_2q_2^{r-1} + tB_2q_2^{t-1}q_1^s .$$

Here the first-order conditions include not only the farmers own actions, but the other farmers' actions as well. Hence, farmer 1 cannot define an optimal level of labor time and maintenance effort solely in terms of his own labor effort (q_1), but must also consider farmer 2's labor effort (q_2) as well. The reverse is true for farmer 2. Each farmer's optimum investment is based on the actions expected of the other. Most, if not all, externalities of interest take this nonseparable form.

2.2 Expectations and Contingent Choice

The implication of nonseparability is that expectations of the behavior of other farmers matters, since if farmer 1 does not know what level of labor time and maintenance effort to expect from farmer 2 (q_2), his optimal labor time and effort cannot be determined. Since watershed management rules or institutions help define these expectations, the willingness to cooperate is built on this institutional structure (see Bromley, 1991). If expectations did not matter, a "dominant strategy" would exist for each farmer, as in the separable case (Runge, 1981). If this strategy were to defect, the situation would reduce to a prisoners' dilemma (PD) game, and the equilibrium outcome would always be mutual defection, equivalent to the provision of inadequate labor and maintenance to keep up the benefits of watershed management. But where the actions of one farmer are conditional or contingent on his expectations of the actions of others, multiple outcomes are possible, including either joint cooperation or joint defection, at varying levels of labor and maintenance. In these cases, the problem is assurance concerning these actions and of the reciprocated investment of labor, time and effort in managing the watershed. This assurance problem (AP) has been contrasted to the prisoners dilemma (PD) (Sen, 1967; Runge, 1981, 1984).

Schelling (1973) has proposed a graphical representation of this problem which illustrates a wide variety of possible outcomes, depending on the nature of mutual expectations involved, and the implied institutional framework (see Appendix A). Watershed institutions internalize nonseparable externalities common to the group. Watershed management rules coordinating the resource use of villagers can be thought of as a search for "coordination norms," to use Schelling's (1960) phrase. These norms are endogenous adaptive responses to the demand for scarce information about the likely behavior of others: that is, the management scheme specifies the labor time and maintenance expected by farmer 1 of farmer 2 (q_2) and vice versa (q_1). By providing the assurance that others will not misuse common resources, such watershed management institutions can make it rational for the individual to respect them. Although expectations of wide-spread free rider behavior may be quite likely to provoke a corresponding response, leading to a downward spiral of overuse, it is also possible for institutions to promote a critical mass of resource conserving behavior.[3] There is no reason, a priori, to suppose that such institutions cannot occur in rural Haiti.

At the same time, there is also no reason to suppose, a priori, that the payoff to individual farmers from cooperative management will always lead watershed management schemes to succeed. For example, a plausible argument can be made that the incentive to cooperate is low where the number of others expected to do so is low, rises as that number passes a critical mass, but falls at some point as the temptation to free ride becomes large because so many others are cooperating (see Appendix A).

Schelling's analysis, when applied to watershed management (indeed, all public goods) suggests that neither free riding nor cooperation are likely always to be a dominant strategy. In the past decade, a growing number of descriptive studies (e.g., McKean, 1984; Wade, 1988; and Tang, 1992) support this claim, and have shown that collective action can successfully manage a wide variety of resources, but is also capable of breakdown. The key observation is that both cooperation and defection emerge from the construction and breakdown of a variety of different rules or norms which vary from group to group, watershed to watershed, and society to society.

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[3]Axelrod (1984), Taylor (1976), and Hardin (1982) have shown that cooperation is consistent with self-interested behavior, even inside the PD framework, if repeated plays are allowed. Repeating the game opens the door to expectations of others' behavior. The conditions for cooperation then turn on whether the players are sufficiently forward looking and formulate a "tit-for-tat" rule motivated by expectations of others' cooperation and fear of retaliation in the case of noncooperation. Similarly, Sugden (1982, 1984) has noted that a "principle of reciprocity" may operate in actual situations of collective choice (see below). This principle does not say that one must always contribute or cooperate, but that one must not free ride while others are contributing. The individual villager has obligations to the group from whose efforts he derives benefits. The model of reciprocity which Sugden develops is based on commitment to a rule of behavior, conditional on the expectation that a sufficiently large group of others will adhere to it too. This is the same concept as the "critical mass" discussed above.

There is thus no theoretical basis for supposing, a priori, that either individual cooperation or defection are universally dominant strategies. Moreover, the incentives facing farmer 1 will probably be different than those facing farmer 2. Whether cooperation or defection predominates in a watershed or elsewhere is determined by those forces which change the individual payoff to various types of behavior. The sum of these individuals' behavior determines the overall benefits and costs of maintaining the watershed at a given level. These benefits are likely to be both economic and social in nature, the result of conditions affecting the entire group of individuals in a watershed.

2.3 Collective Consequences of Individual Behavior

The link from individual incentives to collective economic and social consequences may be described as a public goods problem, following Sugden (1984), in which reciprocal obligations to cooperate are conditional on the expected behavior of others, and succeed in providing watershed management only insofar as they assure that all will "do their part." This assurance problem (AP) reflects both the nonseparability of choice and the problems of expectations explored above.

Let the individual welfare of farmer i be (W_i), an increasing function of his individual benefits from watershed management. The total gains of such watershed management are the public good z and are shared collectively. The individual farmer, farmer i, has decreasing welfare in the labor time and maintenance effort put into the watershed (q_i) but increasing welfare in the benefits such management provides him and the group of users as a whole (z), of which his share (z_i) is a part. In addition to the environmental and financial gains, there are social gains from individual participation and penalties for defection that are important both in and beyond the watershed.

We hypothesize that a group of farmers can sustain a watershed management scheme through "conditional commitments." Well-defined obligations exist to a group to which one belongs and from which one derives benefits. Such commitments do not stipulate that a group member always cooperates by contributing time and maintenance. They say only that if others in a well-defined group are contributing what is judged a "fair share," then a group member is obliged to do the same. It should be noted that individuals may belong to several such groups simultaneously, and that the benefits may extend beyond the issue of watershed management. This issue will become relevant in the empirical section below.

Let the welfare W_i of each farmer i in the watershed be an increasing function of his gains from watershed management measured by z, and a decreasing function of labor time and maintenance effort. Hence:

$$W_i = W_i(q_i, z) \qquad (i = 1, ... n) \qquad (1)$$

If $h_i(q_i, z)$ is the marginal rate of substitution between z and q_i then by definition:

$$h_i(q_i, z) = -(\delta W_i/\delta_{qi})/(\delta W_i/\delta_z) \qquad (i = 1, ... n) \qquad (2)$$

Two additional restrictions, reasonable for one good (gains from watershed management) and one bad (labor time and maintenance effort) are:

$$\delta h_i(q_i, z)/\delta q_i > 0 \qquad (i = 1, ... n) \qquad (3)$$

and

$$\delta h_i(q_i, z)/\delta_z > 0 \qquad (i = 1, ... n) \qquad (4)$$

Total gains from watershed management are a function of the resources devoted to maintaining the watershed by individual farmers. The "production function" for the watershed is thus the <u>weighted</u> sum of individual farmers' time and effort spent to maintain it.

$$z = f\left(\sum_{i=1}^{n} \alpha_i q_i \right) \tag{5}$$

The function $f(\cdot)$ is assumed continuous, increasing and concave (or linear in the limit). The parameter α_i (a positive constant) is the "weight" or impact on the watershed of different farmers' actions, on the assumption that equal time and effort need not have an equal impact. This opens the possibility of disproportionate contributions or damages by certain farmers to the watershed, such as upstream users, or steep slopes. If these users substantially increased their maintenance time and effort, for example, the impact on total gains from the watershed (z) would be disproportionately felt. Now define a total contribution function $F(\cdot)$ for a given level of farmer efforts $\overline{q} = (q_i, \ldots q_n)$ by a group G and a given level of total labor time and maintenance effort τ, such that where $\tau \geq 0$,

$$F(G, \tau) = f\left(\sum_{j \in G} \alpha_j \tau + \sum_{k \notin G} \alpha_k q_k \right) \tag{6}$$

This says that for any group of farmers G, and level of labor time and maintenance effort $\tau \geq 0$, $F(G, \tau)$ is the gain from watershed management that would result if every member of a group in the watershed j had contributed to its management through time and effort τ, taking as given the contribution of non-members, with each non-member k contributing q_k. (This function must be continuous, increasing and concave in τ.) For this group, given the contributions of non-members q_k, let qi^G be the value of τ that maximizes welfare $W_i[\tau, F(G, \tau)]$.

If each farmer i could choose a welfare-maximizing level of labor time and maintenance effort for the each member of the group, qi^G is the level he or she would choose. The principle of reciprocity says that farmer i is obligated to contribute qi^G, conditional on every other member of G doing the same.[4] If farmers pursue self-interest subject to these obligations, then they will make the smallest contribution to watershed maintenance that is compatible with their obligations to all groups of which they are a member, including to themselves, the group G = {i}. Hence, pure self-interest is allowed expression, since every farmer has an obligation to contribute at least as much (or as little) labor time and maintenance effort as self-interest requires.

The essential features of this model are that (a) equilibrium exists; (b) it is not necessarily unique; (c) one equilibrium is Pareto-Optimal -- the Samuelsonian one in which the marginal rate of substitution between q_i and z is equal to the marginal rate of transformation; (d) every other equilibrium involves undersupply of watershed

[4]The following formal definitions may be stated (Sugden, 1984, p. 777):

Obligations. For any vector of contributions $\overline{q}$, for any group G, and for any group member i, i is meeting his obligation to G if and only if either (a) $q_i \geq qi^G$ or (b) for some other agent j in G, $q_i \geq q_j$.

Equilibrium. An equilibrium is a vector of contributions $\overline{q}$ such that for each farmer i, given the contributions of other farmers, q_i is the smallest contribution that is compatible with all of i's obligations.

management.[5] These Pareto-inefficient equilibria, in which watershed management is insufficient, are due to the fact that not enough farmers "do their part" in terms of labor time and effort.

If insufficient labor time and effort is expended to maintain a watershed, the theory outlined here suggests the assurance problem (AP) as an important explanation. Failed management schemes are those in which every farmer would increase his time and effort if only he were assured that others would do so too (Sen, 1967; Runge, 1981, 1984).[6] This does not suggest that the problem of watershed management will be solved -- only that it can be solved. In theory, even if farmers had identical preferences, reciprocal obligations could break down in the face of the assurance problem. This breakdown is even more likely where farmers have widely varying preferences and attitudes (Sugden, 1984, p. 783).

Of course, whether the AP explains watershed management better than some other model is ultimately an empirical question. Nonetheless, the above theory suggests that the reciprocal obligations defined by a watershed management institution are an important basis for improved resources use. One of the important predictions generated by the theory is that if farmer 1's labor time and maintenance effort is at a minimum, an

[5]Sugden (1984) proves these results for the case of homogeneous agents. Where agents are heterogeneous, the results are qualitatively the same, but the assurance problem is exacerbated, as discussed below.

[6]If the problem were a multiperson prisoners' dilemma (PD), rather than an assurance problem (AP), then no farmer would increase his time and effort, even if every other farmer did. Defection would be a dominant strategy. In the AP, there is no dominant strategy.

increase will be likely to bring about an increase in other's contributions as well. The model also predicts that larger and more heterogeneous groups will find higher levels of provision more difficult than smaller and more homogeneous groups. This is so because the AP (which is fundamentally a problem of information acquisition about the likely behavior of others) becomes more difficult to solve when agents are diffuse and dissimilar (see Runge, 1984). But group size is only one aspect of the problem of information acquisition. Group size is typically compounded by the increasing heterogeneity of the parties' interests. The model predicts that the AP is more easily solved by smaller and more homogeneous groups, in which the relevant "n," and thus the relevant "critical mass," is smaller. This generates the corollary prediction that large groups may break themselves into smaller, more homogeneous units in order to resolve difficult issues of watershed management, and may eliminate or purge noncooperating members from group status.

2.4 Redistribution and Shared Responsibility

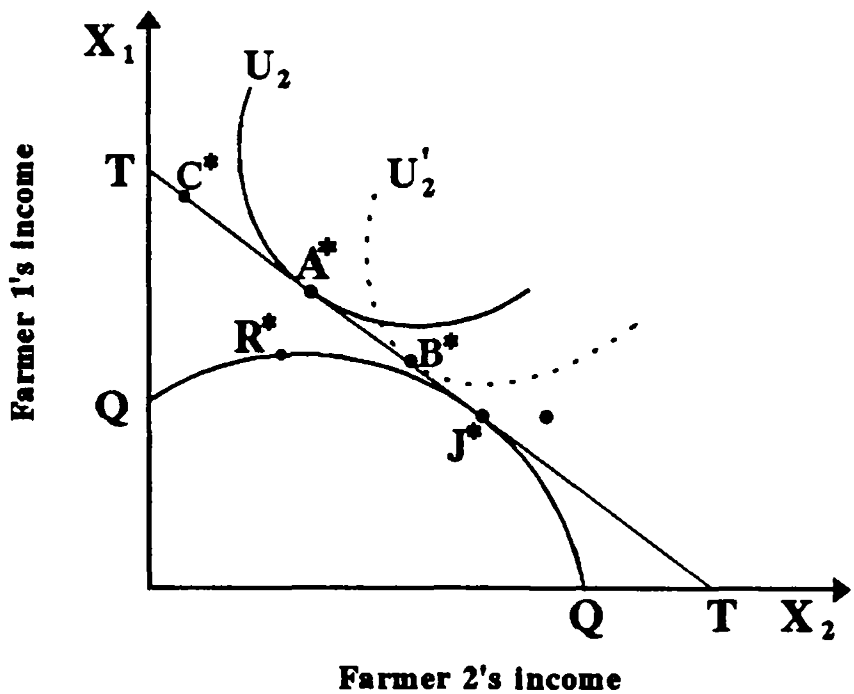
The willingness to cooperate by participating actively in watershed management has been described thusfar as a form of conditional commitment, in which farmer i will cooperate if institutional arrangements make the payoff from collective action and the assurance that a critical number of others will also cooperate sufficient. But is this purely a matter of maximizing behavior, or is there also a redistributive function served by water management institutions?

Becker (1976) has argued that in closely knit groups (such as families), individuals may actually be willing to suboptimize in the short-run, if they are assured that others will redistribute to them over time. Thus, even if cooperating with a watershed management scheme is less than optimal from a short-run maximizing perspective, the assurance that its benefits will be redistributed (even if in the long-run) can make it a superior strategy.

This may be shown with the aid of a diagram (see Figure 1). Let farmer 1 be an upstream watershed user who participates in a management scheme, even though some benefits go to downstream participants, such as farmer 2. Farmer 1 may even be outside the watershed altogether, but may contribute labor time and maintenance effort, in the expectation that reciprocal rewards from farmer 2 may be forthcoming.

Let X_1 be farmers 1's income and let X_2 be farmer 2's income. Farmer 2's indifference curve is U_2. Let QQ by the joint productive opportunity locus for both farmers. If farmer 1 selfishly maximizes his opportunity by choosing point R^*, he maximizes income in the short run but devotes no time or effort to maintaining the watershed. If instead some time and effort went to this collective good, and he were to suboptimize and choose J^*, then farmer 2, starting from J^*, could redistribute income resulting from the gains of watershed management along locus TT to a point, such as A^*. Such redistribution might be an explicit part of the management scheme, or simply a favor done or due. At A^*, both farmer 1 and 2 are better off than they would have been at R^*, because of income increases due to watershed improvement, plus the rewards of sharing behavior. In short, for farmer 1 to participate in the watershed management scheme can be a superior strategy even if somewhat inefficient, if farmer 2 reciprocates by redistributing some of the gains to farmer 1.

Figure 1.



Source: Adapted from Hirshleifer, 1985

Several conditions must be met to make this scheme work. (1) Farmer 2 must be able at J* to have enough income or resources to make the transfer to farmer 1 at A*. (2) Farmer 2's indifference curves must reflect a preference for this type of redistribution; their shape must allow a move to a point northeast of R*, for the result to be mutually beneficial. At B*, for example, farmer 2 redistributes, but the result is insufficient to lead to an improvement for farmer 1. At C*, farmer 2 "overcompensates," making farmer 1 much better off, but farmer 2 actually worse off, than at R*. (3) Farmer 2 must act "last," or sequentially, in relation to farmer 1, who acts as a leader.

However, even these conditions are enlightening. The first condition says that the farmers in a watershed management scheme must have a minimum level of resources to make such redistribution Pareto-optimal. Without this minimum, self-interested defection may indeed be a dominant strategy. The second condition says that there is an optimal degree of watershed "group spiritedness" (or reciprocity), reflected in preferences leading to outcomes such as A*. Too little such spirit leads to outcomes such as B*, too much to outcomes such as C*, both strictly Pareto-inferior to A*. Condition (3) again implies a form of AP, arising from the nonseparable interests and reciprocity required for successful watershed management. If farmers 2 is assured that farmer 1 will choose J*, allocating a portion of his labor time and maintenance effort to watershed management, rather than self-interested defection at R*, then his own preferences are more likely to be in favor of redistribution, rather than self-seeking. Only if farmer 1 is assured that farmer 2 will redistribute, following his lead to maintain the watershed, will he be inclined to choose J* rather than R*.

2.5 Group Survival as a Dynamic Choice

A final issue concerns which watershed management groups survive over time. Here we draw on some recent work by Hirshleifer (1985) and Hamilton (1964). The biological basis of sharing behavior within kin-groups is, of course, the perpetuation of a set of genetic characteristics. While this argument applies on a biological basis to those with similar genetic make-ups, it may also be applied to those whose similarity is not genetic but social, political, or cultural. Hence, joint use of a watershed may reflect kinship ties, or a more general set of social, political, or religious affiliations. If groups that emphasize rules of reciprocal obligation actually prosper vis-a-vis those that do not, then the trait is reinforced.

As noted above, the degree of group homogeneity reinforces reciprocal behavior that is Pareto-optimal, and reduces the assurance problem. If preferences for redistribution between farmer 1 and farmer 2 are similar, cooperative solutions are more likely to emerge. It is more likely that these differences will be less, and the propensity to reciprocate greater, among individuals with similar preferences. This homogeneity may be conferred by class, culture, community, religion, or country, to name but a few in an infinite set of possible homogeneity/heterogeneity distinctions.

3. An Empirical Analysis of Watershed Management

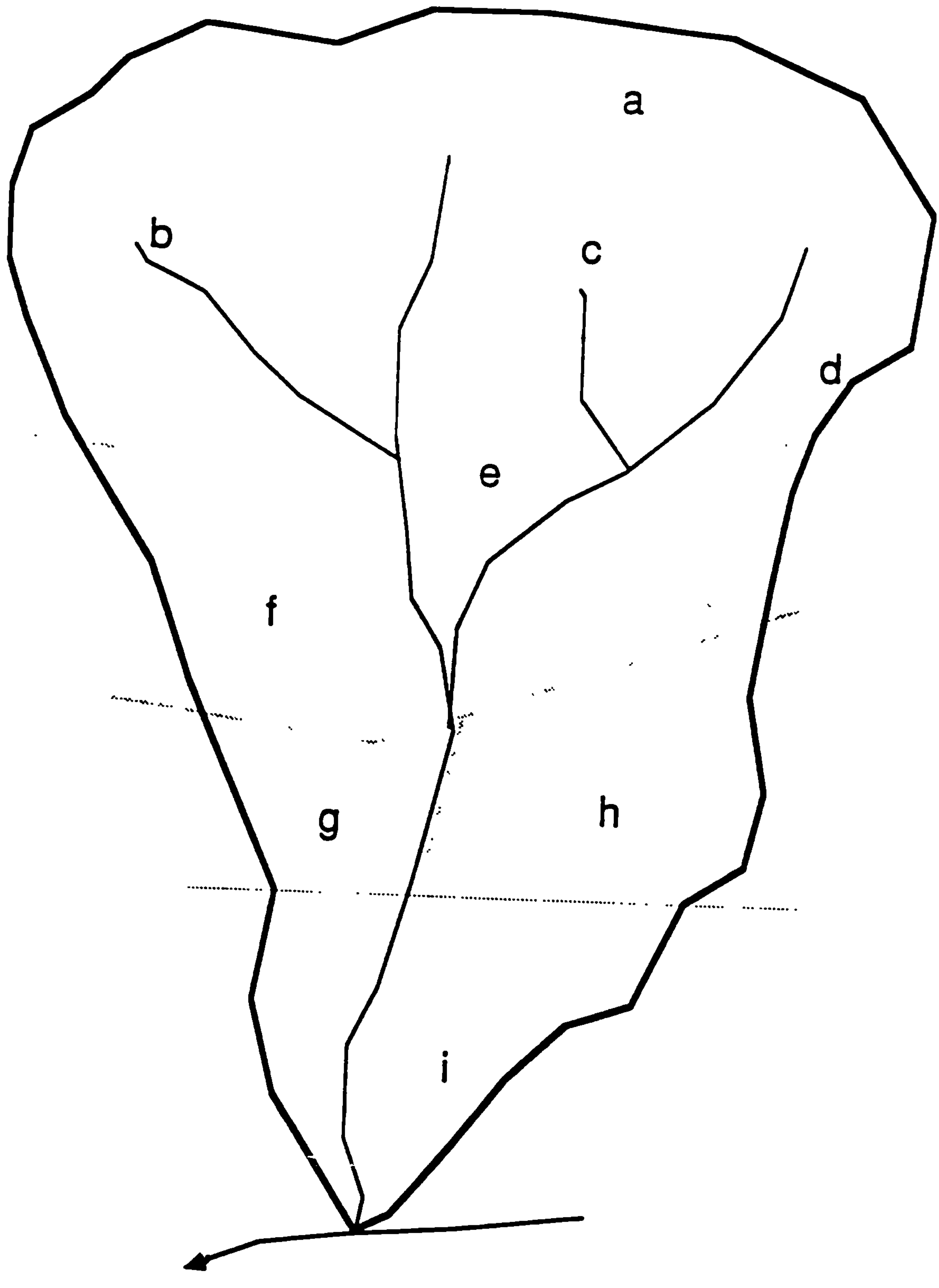
3.1 Watershed Management as Common Property

A watershed is an area drained by a single water course system. The watershed is thus a functional unit established by physical relationships where upstream land use can incite a chain of environmental impacts affecting downstream areas. The fundamental tenet of watershed management is that water flows downhill, irrespective of political boundaries. This trans-boundary water flow is an externality, that can be either positive (adding to the value of downstream areas) or negative. Another key characteristic of watersheds is that they hold multiple, interconnected natural resources: soil, water and vegetation. Impacts on one resource invariably affect the status of others, suggesting that these externalities are generally nonseparable.

In essence, watersheds are physically defined subsets of rural society, and watershed management is a question of social relations and coordination between individual vested interests. Since their productivity is a result of by upstream action, downstream holders seek to influence upstream landholders' behavior. If landholders coordinate land use, then each can operate to optimize their land's productivity. A failure to cooperate results in a Pareto-inferior outcome.

Landholder exposure to externalities is predominantly a function of their location in the watershed. As illustrated in Figure 2, most of the upstream landholders (a, b and d) are not effected by the land use of others. Midstream landholders (c, e, g and h) are effected by upstream actions, and the holder of the most downstream position (i) is theoretically the most vulnerable of all. Landholders e and g would be effected by f's land use due to surface flow of water and or soil.

Figure 2. Schematic of a watershed with nine landholders.



From Figure 2, landholder i would seem to have the greatest incentive to induce watershed treatments because of his/her location, while holders a, b, and d are more favorably situated and have less obvious incentives to do so. If c and e (who are the most exposed to gully erosion) decide to install treatments to reduce erosion, then all those downstream (g, h, and i) will benefit. If downstream users do so without assisting c and e to establish the treatments, then they are "free riding".

3.2 Research Setting, Objectives and Methods

In 1986 Save the Children Federation (SCF), with financing from USAID, initiated a pilot, Integrated Watershed Management project in Maissade, Haiti. Project planners combined two new, yet apparently successful extension approaches. The first was the formation of *groupman* for peasant mobilization[7] and community development activities. Second, economic benefit-oriented tree planting and soil conservation was to be promoted. Following 2 years of successful intervention at the individual farm level, the project initiated a small watershed treatment program. The purpose of the program was to encourage (1) the voluntary treatment of small degraded watersheds (averaging 9 hectares) and (2) the creation of new watershed specific management institutions. After 2 years of activity in 22 watersheds, a total of 590 checkdams were constructed with an average of 27 checkdams constructed per watershed.[8] Principal ravines were completely treated in 10 watersheds, partial treatment was achieved in 7 and only scant treatment

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[7]*Groupman* are peasant groupings established upon traditional social linkages. The groups commonly engage in collective social and economic activities and average eight members.

[8]See Appendix B, Tables B-1 and B-2 for summary data on watershed characteristics and management activity.

was achieved in 5 watersheds.[9] Checkdams were constructed on the lands of 49 percent of all landholders. An average of 3 checkdams were constructed per land holding.

Of all landholders, 54 percent participated by voluntarily contributing labor time and effort to watershed management. An average of 4.6 landholders participated per watershed. An average of 3.7 individuals who did not own land in the watersheds also participated per watershed. These individuals are referred to as the "non-watershed" group participants in the following text, and correspond to "nongroup members" in the model above. The number of landholder person/work events averaged 32.2 per watershed, and the number of non-watershed person/work events averaged 18.5. Thus, an average of 57 percent of all person/work events were contributed by individuals without lands in the watershed. Landholding participants who benefitted from checkdam construction on their land averaged a total of 8 work events at the time of the survey; landholding participants who did not benefit from checkdam construction on their land averaged 6 work events; and non-watershed participants averaged 5 work events.

The first objective of the research described in this paper is to gain a greater understanding of the factors associated with individual choice to cooperate or defect in the collective watershed management activity described above. Why did some individuals cooperate and others not? The second objective is to investigate the affect of resource scale and variable heterogeneity on the emergence of the collective watershed

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[9]The "completely treated" watershed category includes those in which the principal ravine is treated from the uppermost parcel to the most downstream parcel. The "partial" category includes those in which more than one checkdam has been constructed on more than one parcel. The "scant" category includes those watersheds in which less than 10 treatments have been installed on one or fewer parcels.

management institutions. Why was there a high degree of cooperation in some watersheds and not in others?

Various survey instruments were utilized to acquire information in a short period of time, as well as to permit cross-referencing. These instruments were implemented by the first author with the assistance of the SCF staff of agroforestry technicians and animators (peasant organizers) during August, September and December, 1990. Field data was compiled in database form and included 19 socio-economic parameters for each of the landowners of the 22 watersheds studied, and for each of the activity participants (n = 268). The landowners were divided into those who participated (n = 101) and those who did not (n = 85). Another category was comprised of the participants who did not own land in the watershed (n = 82). This data was assessed in terms of selective individual incentives for participation and the conditions for collective action. Hypotheses and discussion for the two sets of analyses follow.

3.3 Selective Incentives: Factors Associated With Individual Choice to Cooperate[10]

The first objective was to determine which types of individuals participate, which do not, and why. As the role of "non-watershed" group participation became apparent, it also became imperative to understand who these contributors were and what incentive they had to participate in the watershed treatment. The compiled data and summaries of the statistical analyses of the factors influencing participation are presented in Appendix B Tables B.3, B.4, and B.5.

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[10]For a more complete treatment of the selective incentives, hypotheses and results see White (1992).

In order to fulfill this first objective, the following factors were compared between participant (cooperator) and non-participant (defector) populations to determine differences and correlation with cooperation:

(a) Potential to directly benefit economically due to individual exposure to trans-boundary erosion. This factor is indicated by landholding position in the watershed (sideslope, upstream, midstream, downstream) and length of principal ravine on individual's land holding.

(b) Actual relationship between individual effort and realization of direct economic benefit. This factor is indicated by the location and number of checkdams constructed, and whether their location is commensurate with individual participation.

(c) Land tenure of agricultural parcel held in the watershed.

(d) Individual's religious affiliation. This factor is indicated by two variables: official religious affiliation (Catholic or Protestant) and participation in *voodoo* ceremonies.

(e) Individual's wealth. This factor is indicated by total number and size of lands held, and the number of cows and pigs owned.

(f) Individual's membership in *groupman*, and the manner in which the individual acquires labor for major agricultural tasks.

(g) Age of the individual.

(h) Individual's prior adoption of soil conservation techniques.

(a) <u>Potential Gain: Landholder Exposure to Trans-boundary Erosion and Potential for Direct Economic Benefit</u>[11]

Payoffs in the form of direct economic benefits are generally argued to be a prime

[11]Direct economic benefit is indicated by checkdam construction on an individual's land. Because of rapid sediment accumulation, checkdam installation results in the establishment of an enriched, micro-site for cropping higher-valued crops.

motivation for participation in collective action. The potential for landholders to experience direct economic benefit is indicated by landholding position in the watershed (sideslope, upstream, midstream, downstream) and length of principal ravine on an individual's land holding. Following the logic presented in the introductory section, we tested the hypothesis that individuals whose lands were in the upstream and sideslope position would participate less than those with landholdings in the mid- and down-stream positions. Similarly, individuals who own lands in the mid- and down-stream position were hypothesized to participate to a greater degree because they have both the most to gain from watershed treatment activity, and the most to lose from inactivity. Finally, individuals with greater lengths of ravine are hypothesized to participate to a greater degree than those who own no ravine because more checkdams would be built on their land, and thus they have more to gain from cooperation.

The null hypotheses that participants and non-participants owned the same proportion of parcel position types (sideslope, up-, mid- and down-stream) and owned the same length of ravine was rejected (see Table B.4).

Participants tended to own greater lengths of ravine than non-participants (68 meters versus 55 meters). The majority of participants held either up-stream or mid-stream positions (67 percent), while the majority of non-participants held sideslope or down-stream positions (63 percent). This influence is not absolute; 34 percent of participants held sideslope or down-stream positions, while 36 percent of non-participants held up- or mid-stream positions. These findings counter the hypothesis that individuals with down-stream holdings would disproportionately participate because of their enhanced exposure to risk and potential to benefit. This finding is discussed again in succeeding sections. But these findings do support the claim that those whose "weight" is greatest in terms of affecting the quality of the watershed, also participated most. The up- and mid-stream landholder thus functioned as "leaders."

(b) Actual Gain: Relationship between Individual Effort and Realization of Direct Benefit

Conventional wisdom among watershed management planners in Haiti predicts that individuals would not voluntarily contribute by working on (i.e., treating) non-participant lands. This view is influenced by the notion that Haitians are very individualistic and have limited social loyalty to those outside of their immediate group, and would thus not build checkdams for those who were not participants. It is thus important to test whether the placement of interventions is dependent upon participation or not.

The null hypothesis that participants and non-participants held the same proportion of parcels on which checkdams were built was rejected (see Table B.4). In addition, the null hypothesis that the mean number of checkdams constructed on lands held by individuals in the participant and non-participant categories are the same was also rejected (see Table B.4).

Though a majority of participating landholders benefitted from checkdams constructed on their lands (66 percent of all landholding participants), checkdams were also constructed on 28 percent of non-participating landholder lands. Of a total of 590 checkdams constructed in the watersheds, 460 (78 percent) were constructed on participant land and 130 (22 percent) were constructed on non-participant land. Thus, though participants did actually benefits disproportionately, land treatment was not precluded by non-participation. Field observations indicated that on numerous occasions participants would go upstream to treat non-participant lands in order to assure the stability of downstream treatments, and participants would occasionally treat the lands of an absent companion. This suggests that individuals participate to a degree corresponding roughly to their potential for direct economic benefit but may also contribute to non-participants suggesting something more than narrow self-interest or expected reciprocity in the short-term.

Further tests were therefore performed to examine the relationship between labor time and effort contributed in terms of work events, and the degree of direct economic benefit (see Table B.4). These tests showed that landholders who did not actually benefit (with checkdams on their lands) contributed the same amount of labor to the collective activity as the landowners who did benefit.

These additional tests indicated that participation is not closely correlated with direct economic benefit. There was no significant difference in the amount worked by those who benefitted and those who did not. Contrary to conventional wisdom, participation did not appear based on direct economic gain at least as measured in the study. It is hypothesized that either the non-benefitting participants benefitted in ways other than those measured, that participants are building up "favor banks" which they expect to be reciprocated in the future, or that other socio-cultural factors such as kin or labor exchange obligations may also influence their decision to participate. These will be discussed below.

(c) Land Tenure of Parcel Held in Watershed

Haiti's mixed and largely uncodified land tenure system is claimed by many watershed management professionals to be a major constraint to the adoption of soil conservation techniques and overall watershed rehabilitation. Undivided inheritance (*indivize*), rented (*fem*) and share-cropped (*demwatye*) lands (representing about 47 percent of all parcels in the watersheds studied) are frequently defined as "insecure" tenures; and thus are not seen as potential sites for soil conservation investment. These conventional opinions are held despite the lack of valid research on the matter.

In the watersheds studied, the center of the ravine defined the property boundary (and thus was jointly owned) in 14 percent of all parcels. In these cases neither one landowner nor the other has an explicit right or duty to treat the ravine. This complication suggests the prediction that ravines in this category will be less likely to be treated than ravines that are completely owned by one individual. We tested the hypothesis that landholders of "insecure" parcels and jointly held ravines would participate less than those who hold "secure" tenures and sole rights to the ravine.

Results indicated that there was no significant difference in land tenure status of agricultural parcels held by participants and non-participants, and thus participation was not dependent upon the land tenure arrangement of lands held in the watersheds (see Table B.4). Contrary to conventional views, participant lands are disproportionately "insecure" (54 percent of their lands) when compared to both the non-participant and combined categories (39 percent and 47 percent respectively). Further examination found that 58 percent of all checkdams were constructed on owned land (*te tit* or *te* *achte)*, 28 percent were constructed on undivided inheritance land *(te indivize)*, 7 percent were constructed on rented land *(te fem)*, and 9 percent were constructed on crop-shared land *(demwatye)*. As watersheds were categorically treated from the top-down and the skipping of parcels was rare, and as these percentages reflect closely land tenure patterns in the watersheds (52 percent owned, 33 percent inherited, 8 percent rented and 5 percent crop-shared), land tenure appears to have had little impact on the placement of ravine treatments in the watersheds. This finding also suggests that the "insecure" classification is not useful in determining which landholders might invest in soil conservation. Land "security", and willingness to invest in soil conservation is thus apparently more a product of other variables than tenure type.

A second test indicated that there is a significant difference in the proportion of landholders who jointly hold ravines between participants and non-participants. Only 9 percent of participants have joint ravine tenure while 14 percent of all watershed landholders and 20 percent of non-participants have such an arrangement. This finding suggests that joint ravine tenure can hinder participation in collective watershed management efforts. As the majority of "joint ravine tenure" cases exist in the farthest down-stream position, this tenure complication helps explain why "down-stream" individuals participate less than hypothesized.

(d) Individual's Religious Affiliation

The possible correlation between religious affiliation and participation was also examined. Though opinions on the matter abound, to the authors' knowledge, no empirical studies of the link from soil conservation to religious affiliation have been conducted in Haiti.

Results indicated that participants are disproportionately Protestant, to a statistically significant degree (see Table B.3). Of non-participants, 83 percent expressed a Catholic affiliation. These results might be explained by the hypothesis that in Maissade, where 74 percent of all landholders are Catholic, individuals who are Protestant reject the *status quo* and are active in pursuing a different tack. This rejection of the *status quo*, and active participation in watershed groups, is reinforced by the Protestant churches. Anecdotal evidence suggests that Protestant institutions in Haiti promote evangelicalism. Protestant "missions", in which groups of the devout march to other areas to preach or raise churches, are frequently seen in the Maissade area.

Though 70 percent of all landholders regularly conduct *voodoo* ceremonies, 80 percent of non-participants do the same.[12] A second test indicated that these differences are statistically significant (see Table B.3). Regardless of official religious affiliation, a majority of rural Maissadeians practice *voodoo*. Protestant churches (and many Protestants) publicly claim to reject *voodoo* to a greater extent than the Catholic church. The Catholic church in Haiti is often painted by Protestants as the refuge for *voodoo*. Thus, fewer Protestants actively practice *voodoo* than do Catholics, and thus fewer participants and non-watershed individuals regularly conduct *voodoo* ceremonies.

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[12]It is assumed that the vast majority of Haitians believe in some aspects of the *voodoo* religion. The people of Maissade distinguish between those who regularly practice by donating food to ancestral spirits, and those who have ceased this practice. It was this distinction that was used to categorize the individuals surveyed.

(e) Individual's Wealth

With increasing wealth, the relative importance of potential benefits is decreased and thus the potential for participation could decline. In Haiti, increasing wealth is associated with declines in the tendency for the landowner to actively work their own parcel. Generally speaking, the more wealthy the individual, the greater is the tendency to rent out or crop-share lands. This removes the landholder from the agricultural area and thus decreases his or her potential for participation. In this study individual wealth is indicated by total number and size of lands held, and the number of cows and pigs owned.

In sum, tests indicate that though the non-participant landholder population may be sometimes be wealthier than landholders who participate (indicated only by the larger number of cows owned), there is a more remarkable difference in wealth status between the non-watershed population and the combined landholder population (Table B.5). Except for the number of pigs owned, non-watershed individuals were categorically less wealthy than the watershed landholders. Thus, contrary to what might be expected, wealth does not apparently negatively influence landholder participation. This finding also suggests that an element of "leadership" may be wealth, and the corresponding ability to redistribute some of the benefits this confers. In contrast, the poorer, non-watershed participants may be contributing labor towards a watershed landholder's gain, without explicit recognition of future reciprocity. Hypotheses concerning why these less-wealthy, non-watershed participants tend to participate will be presented in the section below.

(f) Previous Membership in Collective Action Groups

It was hypothesized that those who exhibited cooperative tendencies prior to the initiation of the micro-watershed program would participate to a greater degree than those that did not.

Of all watershed landholders, 57 percent are *groupman* members while 79 percent of landholder participants, 29 percent of non-participants and 90 percent of non-watershed individuals are members (see Table B.3). These statistically significant differences in which *groupman* membership correlates highly with participation, are not too surprising, since high degree of membership was one criteria for the watershed selection in the small-watershed management program, and because *groupman* members commonly engage in community development activities. That 90 percent of the non-watershed participants are *groupman* members is striking, especially in light of the finding that non-watershed participants contributed 57 percent of the effort. This finding is important as SCF had made no attempt to rally local *groupman* members to participate or serve as project agents. SCF met with the landholders of targeted watersheds, and it was the *groupman* members themselves who initiated this non-watershed participation.

A second test also found a statistically significant difference between how participating and non-participating landholders, and non-watershed participants, acquired labor for major agricultural tasks (see Table B.3). Approximately 90 percent of non-participating landholders either worked their land individually or hired day labor (or both), while only 53 percent of participating landholders and 36 percent of non-watershed individuals acquired labor in those manners. About 46 percent of participants exchanged labor cooperatively (either in pairs or in groups) while only 10 percent of non-participants acquired labor in this manner. An even greater percentage of non-watershed participants exchanged labor (63 percent). This high percentage of participant engage of labor indicates a reciprocal arrangement which might be a prime incentive for non-watershed contribution.

(g) Individual's Age

Individual age was also tested for correlation with participation. We hypothesized that older people would participate less (either because of infirmity, risk aversion, or wealth) than younger people.

The mean age of participating landholders, non-participating holders and non-watershed participants was 42, 44, and 35 respectively. The mean ages of landholding participants and non-participants were not statistically different (see Table B.3). The tests also indicated that non-watershed participants were significantly younger than watershed landholders, and that landholder participation was not correlated with age. Other research conducted by the author and the literature on labor exchange indicate that it is young, land-poor males who tend to predominate in labor exchange groups (Murray 1979). The finding that non-watershed participants are significantly younger than landholders corroborates the finding that 63 percent of this category participate in labor exchange, and that they are generally less wealthy than watershed landholders.

(h) Previous Adoption of Soil Conservation Technology

A final prediction is that an individual's previous adoption of soil conservation practices would correlate with a potential for participation in cooperative watershed management activities.

The proportions of individuals who have adopted techniques in each category corresponded almost directly to those of *groupman* membership: 56 percent of all landholders had adopted, while 28 percent of non-participants, 79 percent of participants, and 87 percent of non-watershed individuals had (see Table B.3). These differences were statistically significant. Participation is strongly correlated with soil and water conservation technique adoption. This might be due to adopters previous recognition of soil conservation benefits, or perhaps because all adopters are *groupman* members. Whatever the case, this finding is strong evidence that the promotion of individual adoption of soil conservation greatly facilitates the subsequent promotion of collective watershed management activities.

3.4 Relative Importance of Variables Associated with Individual Choice to Cooperate

The statistical analysis above indicated which variables were correlated with cooperation, but not the relative weight of each variable. In order to determine the relative importance of each of the variables, a logit model with a single binary response (cooperation or defection) was formulated. The same database was utilized for the logit analysis, although several variables, notably the wealth indicators, were dropped due to the presence of zeros (i.e., nulls) in the database. Since data for the parcel position and land tenure variables (two of the most interesting variables) were only available for the individuals who owned land in the watersheds, the non-watershed individuals were excluded from the analysis. This data reduction resulted in a total of 177 cases (individuals) and nine variables with 19 explanatory variable columns.[13] Dummy variables were set for the categoric data and the continuous variables were left in the original form. Thirteen models were tested starting with the complete model. Variables with the highest p-values (lowest correlation with the response) were successively dropped from the models considered (see Table B.6).

The model which included the *groupman* membership, conservation technique adoption and member of checkdams acquired provided the best fit of the 13 models tested. The other variables: age, religious preference, voodoo practice, parcel position, labor acquisition type, and land tenure type, were not significantly correlated to cooperation. As indicated in Table 1 below, the final model chosen is: y (cooperation or defection) = -1.6627 + 1.8505 (*groupman* membership) + .6615 (technique adoption) + .1091 (checkdams).

[13]Explanatory variables included in the logit model: (1) age (continuous); (2) group membership (binary); (3) technique adoption (binary); (4) religious preference (binary); (5) participation in voodoo (binary); (6) number of checkdams constructed on parcel (continuous); (7) land tenure type (4 categories); (8) labor acquisition type (5 categories); and (9) parcel position type (4 categories).

Table 1. Logit Model Parameters

	Coefficient	Standard Error (Coefficient)	z	p	Deviance	Degrees of freedom
Intercept	-1.6627	.36986	-4.5	<.0001	245.1	176
"Groupman" Membership	1.8505	.42900	4.31	<.0001	/	/
Conservation Technique Adoption	.6615	.20771	3.18	.0015	/	/
Checkdam Quantity	.1091	.04112	2.65	.0080	172.9	173

The coefficients of the model chosen can be interpreted as the probability of an individual choosing to cooperate or defect. The results are presented graphically in Appendix 2, Graph B-11, and also described below:

1. *Groupman* membership alone increases the odds of cooperation by: $e^{1.8505} = 6.36$ times.
2. Positive technique adoption alone increases the odds of cooperation by: $e^{.6615} =$ 1.94 times.
3. The odds of cooperation increase by $e^{.1091} = 1.11$ times for each checkdam constructed on farmer land.
4. Positive *groupman* membership and conservation technique adoption together increase the odds of farmer participation by $e^{1.8505 + .6615} = 12.3$ times.
5. Participation odds increase by $e^{10 \cdot .1091} = 2.98$ times when 10 checkdams were constructed on the farmer's parcel.
6. Positive *groupman* membership, technique adoption and 10 checkdams together increase the odds of farmer participation by $e^{1.8505 + .6615 + (10 \cdot .1091)} = 36.7$ times.

These results indicate that of the variables significantly correlated with cooperation, *groupman* membership has the strongest association, with technique adoption and checkdam occurrence following respectively. Positive conservation technique adoption and positive *groupman* member results in the highest probability of cooperation at checkdam levels below 16. The positive *groupman* member, no conservation technique adoption combination has the second highest probability trend (see Graph B-11).

In summary, our statistical analysis suggests that in rural Haiti, an individual choice to cooperate in a watershed management scheme is based on (1) assurance of reciprocated contribution (facilitated by membership in *groupman*); (2) knowledge of the value of the watershed improvements resulting from this cooperation (indicated by previous technique adoption); and (3) realization of actual short-term gain (indicated by checkdam construction).

3.5 Conditions for a Critical Mass: Scale, Heterogeneity and the Emergence of Collective Action

The data was then reorganized to investigate the factors affecting the emergence of cooperative institutions. The watersheds were divided into three categories of treatment achieved (complete, partial and scant) in order to represent three levels of cooperative activity.[14] Test statistics were compared between categories to determine what conditions affected the level of cooperation.

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[14]The "completely treated" category includes those in which the principal ravine is treated from the uppermost parcel to the most downstream parcel. The "partial" category includes those in which more than one checkdam has been constructed on more than one parcel. The "scant" category includes those watersheds in which less than 10 treatments have been installed on one or fewer parcels.

(a) <u>Watershed Resources</u>

The mean number of years activity, watershed area, number of landholders and parcel size were the same in all categories (see Table B.7). This indicated that the emergence of cooperation was not associated with these indicators of scale and heterogeneity. This finding contradicts the conventional wisdom that cooperation would be constrained with increasing watershed size and number of landholders. Group size and heterogeneity, per se, are here less powerful predictors of collective action than generally assumed. One might also assume that cooperation would be greatest where the landholders had a longer period of time to organize the new institution. This also was not correlated with collective action emergence. Nor did land tenure patterns predict well: they were the same in all categories. The claim that cooperation will be greatest in watersheds where a majority of parcels were owned outright, and that low levels of cooperation might be due to a high incidence of short-term tenures, was not supported.

However, there was a significant difference in the pattern of parcel position in the different categories of watersheds. A high level of cooperation (indicated by complete treatment) was associated with watersheds with the lowest percentage of sideslope and downstream positions (39 percent of all parcels). Watersheds in the partial and scant categories exhibited a high percentage of sideslope and downstream parcels (55 and 57 percent respectively). The presence of jointly held ravine tenures was associated with low levels of cooperation (evidenced in the partial and scant treatment categories).

(b) Socio-Cultural Factors

Various socio-cultural variables also were tested by watershed category for correlation with the emergence of collective action (see Tables B.8, B.9 and B.10).

The mean ages of landholders and non-watershed participants was the same in all categories. In other words, age was not significantly correlated with the emergence of collective action.

The proportions of landholders who are *groupman* members was not the same in all categories. The finding that 61 percent, 45 percent, and 72 percent of landholders in the "complete", "partial", and "scant" categories respectively were *groupman* members is contrary to immediate intuition. This means that the percentage of landholders who are *groupman* members in a watershed is not correlated with the emergence of collective action. As we know from the above Chi-Square analysis and logit models, *groupman* membership is strongly correlated with individual choice to cooperate. This result indicates that though there might be a minimum level of *groupman* membership per watershed to permit collective action, this is a necessary but not sufficient condition. The presence of other contributing factors is necessary to form the "critical mass" of individuals and incentives required for the emergence of the collective institution.

The proportion of non-watershed participants who are "groupman" members was the same in all categories. This percentage ranged from 87 to 100 percent. The proportion of landholders who are Catholic was the same across categories. Similarly, the proportion of non-watershed participants who are Catholic was the same across categories except at a marginally significant level ($p = .054$).

All indicators of wealth, the number of pigs, cows, hectares and parcels owned, were the same in all categories of watershed treatment. This means that wealth (or poverty) was **not** significantly correlated with the emergence of a collective action institution.

The proportion of landholders who acquired labor in the different manners surveyed was **not** the same across categories. Where there was complete treatment, 40 percent of individuals engaged in labor exchange arrangements (either worked in pairs or groups), while 14 percent and 28 percent did so in the categories representing a lesser degree of cooperation.

(c) Technological Factors

The proportion of landholders who have adopted soil conservation techniques was **not** the same in all categories of collective action. Soil conservation adoption and collective action were positively correlated. In watersheds where there was a high degree of cooperation 64 percent of landholders had previously adopted techniques while levels of technique adoption were 51 percent and 41 percent in the partial and scant categories respectively. The proportion of non-watershed participants who have adopted soil conservation techniques **was** the same in all categories. An average of 85 percent of the non-watershed participants had previously adopted soil conservation techniques.

(d) Summary of Findings

The following variables **were** statistically significant in their association with the level of collective action in the watersheds:

(1) physical distribution of land parcels in the watershed;

(2) percentage of landholders who have adopted soil conservation techniques; and

(3) manner in which both landholders and non-watershed participants acquire labor.

The following variables **were not** statistically significant in their association with the level of collective action in the watersheds:

(1) both landholder and non-watershed participant age;

(2) landholder wealth (as indicated by quantity of pigs, cows, and land owned);

(3) formal religious preference (Catholic or Protestant);

(4) watershed size;

(5) number of years of project activity;

(6) number of landholders;

(7) land tenure patterns; and the

(8) percentage of landholders who were members of pre-existing farmers groups (*groupman*).

In brief, the likelihood of the emergence of collective action **increases** with:

(1) the percentage of parcels that are in the up- and mid-stream position;

(2) the percentage of landholders who have adopted conservation techniques;

(3) the percentage of landholders who engage in labor exchange arrangements.

4. Conclusions: Collective Action and Watershed Management in Haiti

4.1 Selective Incentives: Factors Associated with Individual Choice to Cooperate

Statistical analyses were conducted to test the correlation between various socio-economic parameters and either cooperation or defection. Parameters which indicated the potential for landholders to directly gain from cooperation were significantly correlated with cooperation. The majority of cooperators held agricultural parcels in the up-and mid-stream positions while the majority of defectors held parcels in the sideslope and downstream positions. Cooperators also owned a significantly greater length of the ravine in which the soil conservation treatments were placed. Interestingly, holders of downstream parcels were by and large defectors. Research indicated that a significant number of downstream parcels were jointly held which raised the transaction costs of benefit distribution, and thus decreased the incentive to invest in the cooperative venture.

Tests also indicated that although cooperators tended to benefit more than defectors, defection did not preclude the installation of checkdams on the defector's property. Twenty-eight percent of all checkdams were constructed on property held by defectors. Anecdotal evidence suggests that the majority of these lands were upstream of cooperators land, thus suggesting that downstream owners were protecting their investment by treating upstream land. This finding is a clear indication of the non-separabilities of watershed production. Though cooperators did benefit more than defectors, other tests indicate that their was no difference in the amount of labor contributed between those who benefitted and those who did not. In addition, greater than 50 percent of all labor contributed to the collective activity came from individuals who did not hold land in the watershed. This may indicate that those who did not benefit within the time frame measured by the study might benefit later, or in some other way not measured by the study.

The holding of "insecure" tenures also did not affect the decision either to cooperate or defect. Both groups of individuals held the same percentage of the different land tenure types and checkdams were constructed on land irrespective of tenure. This finding indicates that tenure "insecurity" is not singularly useful in determining the potential for landholders to invest in soil conservation. The finding also indicates that tenure "insecurity" is essentially a question of the degree to which the investor is guaranteed of the benefits of their investment, and that this level of security may be assured either by the watershed management collective action or some other social institution. Landholders of "jointly held ravines," in contrast, did defect to a significant degree. This tenure arrangement was not overwhelmed by local institutional assurance and suggests that this type of arrangement represents a limit to the effectiveness of the collective watershed management approach.

Cooperators were disproportionally Protestant (rather than Catholic) and did not regularly engage in *voodoo* despite the fact that the vast majority of landholders are Catholic and do regularly engage in *voodoo*. This indicates that in our case, the Protestants were more willing to contribute labor to a common cause, perhaps because of sincere desire to act philanthropically, perhaps due to their "missionary zeal" to win converts, or perhaps because they take a more active role in defining their destiny than

Catholics.

Indicators of wealth were not significantly correlated with landholder cooperation or defection in three out of four measures. Defectors were found to own a significantly greater number of cows than cooperators. Except for the number of pigs owned (all categories owned the same number of pigs), non-watershed cooperators were categorically less wealthy than all watershed landholders. Thus, wealth does not apparently reduce the incentive to cooperate. Rather, relative wealth corresponds to a greater ability to contribute, and such contributions might be an act of "leadership". Conversely, poverty may be a factor which causes non-watershed holders to make contributions to the collective cause, despite delayed or uncertain returns, creating a critical mass of labor contribution which may then be reciprocated. It is interesting to note that in cash-poor Haiti, labor is both the medium of exchange between farmers, and the only asset which the poor can contribute to a collective effort. As anthropologist G. Murray noted, in Haiti "...the farmers success in life entails not only the acquisition of land, but the systematic mobilization of the energies of other individuals as well... Much of his behavior will not be understood however, unless his radical dependence on the labor of others is clearly perceived..." (Murray 1977).

Membership in *groupman* farmers organizations was strongly correlated with cooperation and non-membership strongly correlated with defection. In addition, the vast majority of non-watershed cooperators were *groupman* members (90 percent). Similarly the vast majority of defectors either worked their land individually or hired labor, while cooperators tended to exchange labor to a much greater degree. The majority of non-watershed cooperators also participated in labor exchange arrangements. This findings indicated that cooperators tend to be members of reciprocity-based social institutions while defectors are not, reflecting both individual preference and the assurance of reciprocated investment.

There was no difference in average age between cooperating and defecting landholders but non-watershed cooperators were significantly younger. This finding is understandable as non-watershed participants also tended to be both poorer and members of labor exchange groups.

A logit model was constructed to assess the relative weight of the parameters in their association with cooperation or defection. When compared, previous membership in *groupman* had the strongest association with choice to cooperate, with previous adoption of soil conservation second, and the actual benefit of checkdams constructed on the landowners land third. None of the other parameters discussed above were significantly correlated with cooperation at this aggregate level. This finding strongly indicates that choice to cooperate is largely based upon (in descending order) an individual's: (1) "group spiritedness" and assurance for a reciprocated contribution (facilitated by *groupman* membership); (2) knowledge of the significant value of the good being created through collective action (indicated by previous adoption of soil conservation); and (3) the realization of actual short-term gain.

4.2 Conditions for a Critical Mass: Factors Associated with the Emergence of Collective Action

Watershed size, tenure type distribution, the number of years of activity and the number of landholders were not associated with the emergence (or the lack of) collective action. More importantly, increases in these parameters (indicators of watershed heterogeneity) did not constrain collective action. In terms of watershed resources, only the distribution of parcel location (an indicator of potential for economic gain) was correlated with collective action. Collective action was facilitated by greater levels of potential for economic gain (indicated by increased numbers of parcels in the up- and mid-stream position). The social transaction costs of creating a new collective action institution only appeared to be worth bearing in cases in which the potential for gain overwhelmed the cost. In short, when the externality is large enough is it more worth internalizing (i.e., since the potential welfare gain is large).

Indicators of landholder heterogeneity (levels of: wealth, age, religious preference, *groupman* membership) were not important constraints to the emergence of collective action. Increasing diversity did not lead to reduced levels of collective action. These findings suggest either that the population was relatively homogenous in these parameters (at the level tested) or that a high degree of assurance existed in the community which overcame the risk and uncertainty associated with heterogeneity. In terms of landholder heterogeneity, only the percentage of landholders who had previously adopted techniques and the percentage of landholders who engaged in labor exchange arrangements were correlated with the emergence of collective action. As these percentages increased, so did the level of collective action. These findings suggest that knowledge of the value of the collective objective (installing soil conservation treatments) greatly increased the adoption of the collective, watershed management innovation.

It is worth noting, that though *groupman* membership was the parameter most strongly correlated with individual choice to cooperate, it was not found to be correlated with the level of collective action. In fact, the lowest level of action was correlated with the highest level of *groupman* membership. This suggests that *groupman* membership is a necessary but not sufficient condition for action. All of the watersheds tested were apparently above the minimum level of *groupman* representation.

Groupman and labor exchange groups are the primary institutional norms of cooperative activity and are probably the primary facilitators of both the adoption and diffusion of the cooperative watershed management innovation. The strength of these indigenous institutions override population heterogeneity and the linkages based on physical proximity. A high degree of assurance over reciprocated contributions and reduced transaction costs permits members to make "leading" contributions to the collective, thus making these institutions the social basis for collective action and self-governance.

4.3 Implications for Collective Action Theory: Explanations and Extensions

1. Participants will voluntarily treat non-participant land. Twenty-eight percent of all checkdams were constructed on non-participant land. This is the clearest indicator of the non-separability of watershed production.

2. The majority of cooperators did not gain (at least as measured by the study) within the two years of study. The majority thus sub-optimized as they contributed their labor but did not gain directly and economically in the short-run. This does not suggest irrationality, but a larger set of arguments and longer period of time over which reciprocity is likely to occur.

3. Watershed and landholder heterogeneity did not constrain cooperation because the high degree of membership in *groupman* and labor exchange groups permitted a high degree of assurance concerning rule conformance and reciprocity. In addition, the fact that all individuals, rich or poor, had scattered plots engenders a uniformity of interest in watershed management.

4. Rather than thinking of a collective action institutions as one which solves a single public good problem, it is perhaps more appropriate to think of such an institution as a "bundle of opportunities", one which solves different problems for different individuals. Some individuals might cooperate in order to gain social prestige, another might cooperate in order to build up labor debts which would be reciprocated in a labor scarce season, and another might cooperate in order

to reap short-term financial gains. In any case, the collective action unit is an aggregation of the labor invested by diverse individuals for diverse reasons, only part of which is the resolution of the externality. Though the potential for an adequate level of financial gain is necessary for group initiation, these non-financial motivations might eventually be more important (in terms of providing incentives and resulting in effort) than the resolution of the original public good problem.

4.4 Implications for Policy

1. Free riding is not a dominant strategy, rather it is conditional upon pre-existing social relationships and the potential for economic gain. On the contrary, individuals within and beyond the watersheds flocked to cooperate in the new, collective activity. The cooperative watershed management effort represented the opportunity for new wealth and reciprocated labor investments. Defection dominated where individuals were not *groupman*, or labor exchange group members, and where they jointly held a segment of the watershed ravine.

   The finding that cooperation is conditional on the expected behavior of others contradicts a strong individualist assumption made by conventional policy and project interventions in Haiti. It suggest that one low-cost policy would be to encourage self-governance where feasible, using policy instruments such as regulations, taxes, subsidies or investments to "fill the gap" between the capability of local institutions and the level of contribution needed to supply the public good. Such an approach, although problematic in terms of monitoring, would be low-cost, and enhance local institutional capabilities to manage their development.

2. In our case self-governance was limited by: (1) the percentage of holders who participate in labor exchange arrangements; (2) the percentage of holders who had previously adopted soil conservation techniques; and (3) the percentage of parcels in the watershed that are in the up- and mid-stream positions. In short, the collective action approach to watershed management worked upstream of jointly held parcels. The treatment of upland watersheds in Haiti would be promoted by project and policy support of the spread of labor exchange arrangements; prior adoption of soil conservation treatments. Government support of *groupman* membership would also forward collective action. Labor exchange groups could be used as the basis for extension networks. Government oppression of *groupman* and other local institutions reduces the ability of rural Haitians to adequately manage their lands, and has an indirect but substantial negative impacts on the rural environment.

3. Short-term and "insecure" land tenure arrangements did not hinder the installation of either the soil conservation practices or the adoption of the watershed management activity. As stated previously, labor substitutes for cash as the primary medium of exchange between peasants, and access to labor in times of need is thus effectively more important than tenure terms or cash. This

need for labor can overwhelm potential disputes and social friction caused by unfairly administered tenure.

4. Though watershed-specific management groups are not always formed, complete ravine treatment is possible. In sum, different levels of net gain, watershed and landholder heterogeneity will result in different institutional formations. Resource management can be achieved despite watershed and landholder diversity.

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Appendix A

Theoretical Review: Conditions for Cooperation or Defection

Consider Figure 1a, in which two linear payoff curves are drawn for a village population of n + 1, reflecting the benefits of cooperation and defection in an interdependent watershed. These are the payoffs to the (n + 1)th agent: farmer 1, where n equals the number of other resource users. Hence, the graphs reflect the decision calculus faced by an individual farmer: to defect or cooperate? The upper curve corresponds to the dominant choice of defection D. Its left end is labeled 0, the open access equilibrium, in which no agents cooperate and the benefits of management are driven to zero. The D curve rises monotonically to the right. Below it is the dominated cooperation strategy C, which also begins at the open access equilibrium 0, rises monotonically and crosses the axis at point k where positive gains to cooperation begin. The number choosing to cooperate in Figure 1 is denoted by the distance along the horizontal axis.

The vertical axis of Figure 1 shows the payoff to cooperation by farmer 1 when a certain number of others choose to cooperate with the watershed management regime and the remainder defect. At k = n/2 in Figure 1a, for example, positive gains are made by cooperators whenever at least half of the other agents also cooperate. Because D lies everywhere above C, it is a strictly dominant strategy. Monotonicity of both curves in the same direction implies that cooperation leads to uniformly positive externalities, and defection to uniformly negative externalities. The C curve is higher on the right than the D curve on the left, reflecting the Pareto-inefficiency of the dominant defection strategy. The dotted lines show total (or average) values corresponding to the

Figure 1.

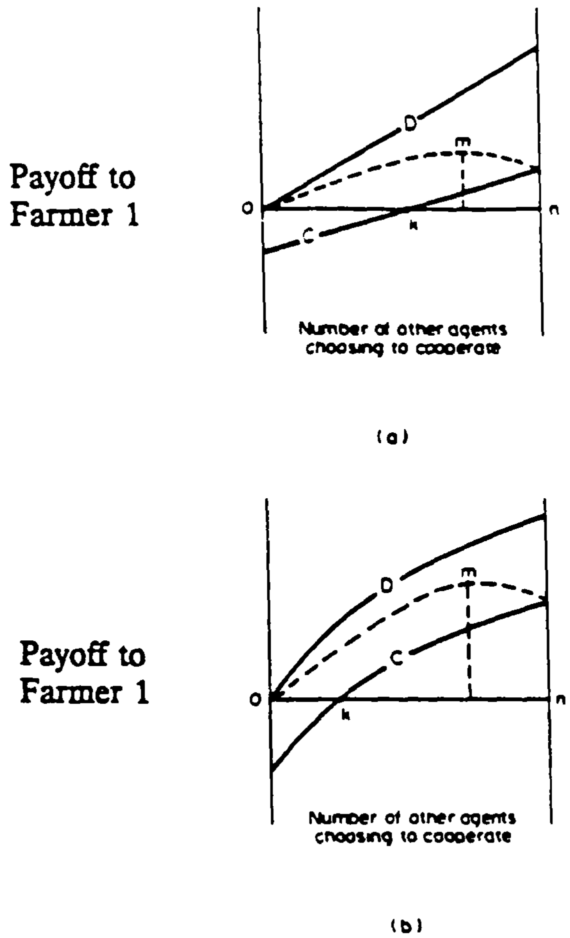


Figure 1.

Source: Runge, 1986, p. 627.

number of agents choosing the two strategies, and point m represents the maximum collective payoff for the group. The slope of these schedules may be interpreted as the marginal payoff to defection and cooperation.

In Figure 1a, D rises more rapidly than C, indicating that the more agents who join the cooperative coalition, the greater is the advantage of defecting. The collective maximum at point m is achieved with some agents choosing D and some C. Point m falls to the right of k on the horizontal axis. This implies that collective gains are greater when there are more than k cooperators, and that these gains reach a maximum at point m, and diminish thereafter.

In Figure 1b, the slopes of the C and D functions reflect an alternative incentive structure, in which the proposed watershed management regime achieves most of its benefits after about half of the population participates, after which benefits increase at a decreasing rate and ultimately decrease after reaching a maximum of m. The collective maximum occurs at about two-thirds participation, with room for gains to cooperators from point k to point m along the horizontal axis. Cases 1a and 1b represent two of an infinite number of possible variations on the case in which defection strictly dominates, making some form of coercion necessary to solve the problem of externalities and public goods. These are all examples of the Prisoners' Dilemma (PD). Restrictive rules and the level of coercion accompanying them alter the payoffs, and thus the level and shape, of the C and D schedules.

Consider the more complex and arguably more realistic case in which neither C nor D represents a strictly dominant strategy. Figure 2 shows a situation in which a linear D

Figure 2.

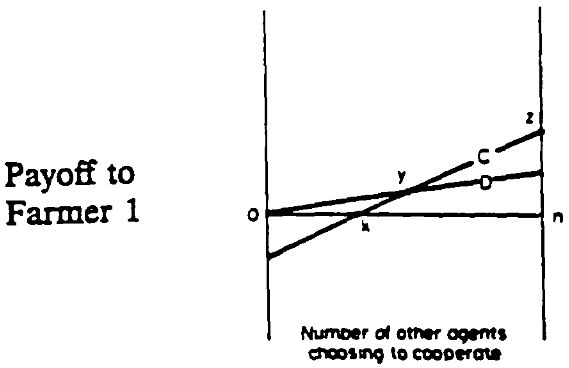


Figure 2.

Source: Runge, 1986, p. 629.

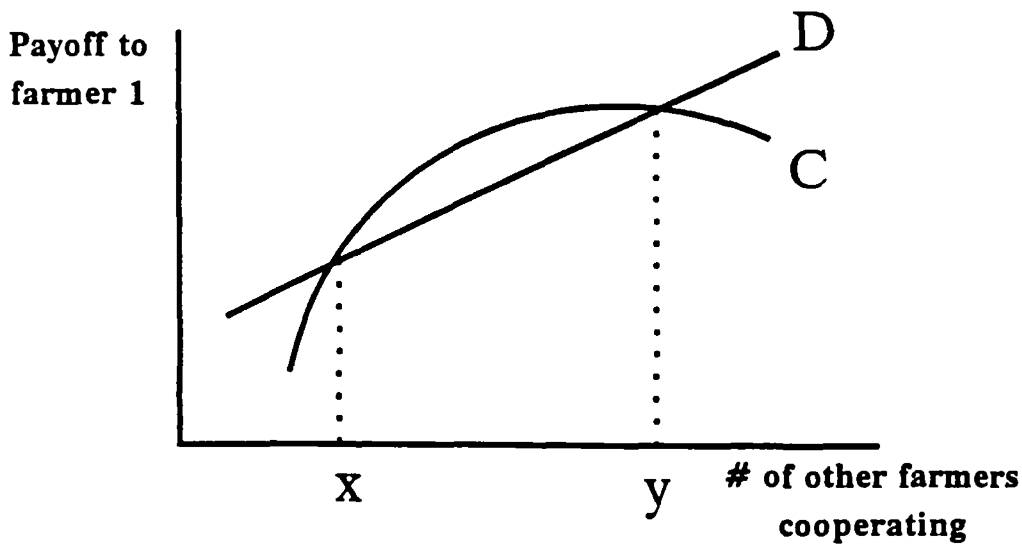
curve dominates a linear C curve until point y, after which C dominates D. The absence of a dominant strategy raises the problem of coordinating the expectations of a "critical mass" of agents around a particular watershed management regime. In Figure 2, there are two equilibria; one at 0 and one at z. The problem of coordination is to achieve the Pareto-superior equilibrium at z. In cases such as these, the coalition must move beyond k to the switch point y; otherwise, defection will dominate and lead to the Pareto-inferior equilibrium at 0. Unlike the PD, in which defection dominates at all levels of participation, implying a continual need for outside coercion, this situation rests on the contingent strategies of agents. If enough people in a village are assured that others will cooperate, then z will emerge as the equilibrium. However, if a Pareto-inferior open-access equilibrium has become established, no agent will decide to join a coalition subscribing to a watershed management rule unless he expects a sufficient number of others to do so. Achieving a Pareto-superior solution will require an organized change in behavior leading a critical mass to cooperate with the watershed management scheme.

Achieving this level of cooperation may require some kind of outside enforcement (or subsidy) mechanism. If the situation resembles Figure 2, however, relatively little enforcement from outside may be necessary to organize a change in behavior. Voluntary cooperation with the watershed management scheme inside the group of watershed users may even be sufficient. As Hayek (1948) argued, in many cases spontaneous recognition of the need for organized collective action occurs on the part of the affected group simply because the payoff to such organization is substantial.

In Figure 3, point x is the threshold for cooperation for farmer 1, while point y is the "point of overwhelming temptation," in which defection once again dominates.[1]

[1]This type of behavior has been suggested in the case of African grazing by Swallow (19__).

Figure 3.



APPENDIX B

Data Tables

Table B.1. Description of Participation and Effort in Watersheds Studied.

Parameters	Watersheds																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Mean	S.D
Initial year of activity.	89	89	89	89	89	89	89	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	/	/
No. landholder participants.	4	5	4	7	2	8	6	3	6	2	3	2	4	8	4	4	1	7	9	3	4	5	4.6	2.2
No. non-wsd participants.	1	5	3	8	3	1	10	2	6	4	3	5	6	3	12	2	5	0	0	3	0	0	3.7	3.2
No. landholder person/work events.	45	37	9	21	16	242	62	8	35	24	26	3	8	38	11	12	5	38	25	12	12	19	/	/
No. non-wsd person/work events.	14	8	8	18	10	33	135	6	14	33	31	11	9	17	26	5	16	0	0	13	0	0	/	/
No. work events in wsd ravine.	0/14	5/5	4/0	2/2	4/7	28/5	11/4	3	13	10	11	3	3	10	4	3	5	8	8	4	0	6	9/6	10/4
No. work events outside wsd.	0/0	0/0	0/0	0/0	0/0	0/0	0/7	0	0	4	2	0	0	0	0	0	0	0	0	1	0	0	.6	1.7
Do wsd groups plan to work in other wsds (1=yes; 0=no)?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Did participants work collectively in the same group prior to program?	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	.1	.4
Did participants work collectively in various groups prior to program?	0	1	1	1	0	1	0	0	1	1	1	0	1	1	1	1	0	1	1	0	0	0	.6	.5
No. checkdams in wsd.	9	26	9	35	19	85	92	2	34	13	12	16	36	54	20	12	9	16	35	20	16	20	26.8	23.3

Notes:
1. Figures presented in this table are the results of a survey conducted in August and September, 1990.
2. Watershed code. 1) Do Pye Moris (1); 2) Do Bwa Pen; 3) Savan a Palm; 4) Zeb Razwa; 5) Paloat; 6) Nan Manwel; 7) Met Pye; 8) Dlo Kontre; 9) Larik; 10) Do Pye Moris (2); 11) La Guam; 12) Vikam; 13) Zeb Gine; 14) Savan a Palm (Talma); 15) Tidjo; 16) Perikit; 17) Fond Pikan; 18) Nan Silinn (LSY); 19) Basya; 20) Ba Simitye; 21) Nan Silinn (MJ); 22) Nan Nikola.
3. The first and second numbers in the work events columns indicate events in 1989 and 1990 respectively.

Table B.2. Physical and Socio-economic Characteristics of Watersheds Studied.

Parameters	Watersheds																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Mean	S.D
Wsd area (has).	4.8	3.6	11.3	3.7	9.1	20.1	8.4	4.0	22.8	8.1	/	5.3	5.7	34.2	6.0	2.1	4.0	3.6	19.1	3.1	5.3	3.7	9.0	8.3
No. land parcels.	6	5	12	14	8	14	15	5	8	5	4	4	10	20	6	5	5	7	17	4	14	7	8.9	4.8
No. land holders.	6	5	11	13	8	14	14	5	7	5	4	4	9	20	4	5	5	7	16	4	13	7	8.5	4.6
Mean parcel size (has).	1.0	.6	.4	.5	.3	1.0	.5	.8	.6	/	/	.4	.3	1.6	.5	/	/	1.0	1.0	/	.9	/	.72	.35
No. parcels with long-term tenure arrangements.	6	4	10	9	7	13	12	4	8	5	4	3	10	19	2	3	5	7	14	3	13	6	7.6	4.4
No. parcels with short-term tenure arrangements.	0	1	2	5	1	1	3	1	0	0	0	1	0	1	4	2	0	0	3	1	2	1	1.3	1.4
Mean slope of parcels (%).	10	5	15	6	30	34	8	6	7	/	/	6	4	4	7	/	/	17	34	/	6	/	12.4	10.7
Length of principal ravine (m).	237	413	455	497	432	1061	417	254	465	/	/	282	337	/	198	190	/	659	717	274	313	/	424	222

Notes:

1. Figures presented in this table are the results of a survey conducted in August and September, 1990.
2. Watershed code. 1) Do Pye Moris (1); 2) Do Bwa Pen; 3) Savan a Palm; 4) Zeb Razwa; 5) Paloat; 6) Nan Manwel; 7) Met Pye; 8) Dlo Kontre; 9) Larik; 10) Do Pye Moris (2); 11) La Guam; 12) Vikam; 13) Zeb Gine; 14) Savan a Palm (Talma); 15) Tidjo; 16) Perikit; 17) Fond Pikan; 18) Nan Silinn (LSY); 19) Basya; 20) Ba Simitye; 21) Nan Silinn (MJ); 22) Nan Nikola.
3. Mean parcel size was converted from fractions of "carreaux" (1 "carreau" = 1.29 hectares) as reported by landholders. As landholders do not know the precise size of their holdings, these means are approximations.
4. Long-term tenure arrangements include purchased ("te achte, te tit"), divided ("te erite"), and undivided inheritance lands ("te indivize").
5. Short-term tenure arrangements include rented ("te fem, pretansyon", and crop-shared ("demwatye").

DATA: FACTORS INFLUENCING PARTICIPATION

Table B.3. Social Profiles of Participants and Non-participants

Variable	Watershed Landholder Category			Non-wsd Partici-pants
	Non-participants	Participants	Combined	
No. of individuals in each category.	85	101	186	82
% who are "groupman" members.	29	79	57	90
% who have adopted soil conservation techniques.	28	79	56	87
% who are female.	6	5	5	10
% who are Catholic (complementary % expressed a Protestant affiliation).	83	65	74	63
% who regularly conduct "voodoo" ceremonies.	80	61	70	57
Manner in which individuals conduct major agricultural tasks (labor acquisition):				
% who work individually ("pou kont yo"):	48	34	41	21
% who work in pairs ("boukante maten"):	6	20	13	16
% who work cooperatively ("asosye"):	5	26	16	47
% who hire day labor ("bay djob"):	14	6	10	2
% who work individually and hire day labor:	27	13	20	13
Mean age (standard deviation in parentheses).	44(14)	41(11)	42(13)	35(11)

Notes:
1. Figures presented in this table are the results of a survey of all watershed landholders and all management activity participants in the 22 watersheds. Data was collected in December, 1990.
2. Statistical analysis: The X^2 statistic was used to compare variable proportions between categories and types for the categorical data (expressed in this table as %).

Test 1 The H_O that true proportions of individuals who are "groupman" members are the same in the non-participant, participant and non-watershed categories was rejected (X^2 = 75.; p = 0.000; df = 2).

Test 2 The H_O that true proportions of individuals who have adopted soil conservation techniques are the same in all categories was rejected (X^2 = 76.5; p = 0.000; df = 2).

Test 3 The H_O that true proportions of individuals who express a Catholic religious affiliation are the same in all categories was rejected (X^2 = 10.2; p = 0.006; df = 2).

Test 4 The H_O that true proportions of individuals who regularly conduct "voodoo" ceremonies are the same in all categories was rejected (X^2 = 11.1; p = 0.004; df = 2).

Test 5 The H_O that true proportions of individuals who acquire labor in similar manners are the same in all categories was rejected (X^2 = 59.4; p = 0.000; df = 8).

3. Statistical analysis: A two-tailed Z-test was used to test hypotheses that mean ages are the same between categories of individuals.

Test 1 The H_O that the mean age of individuals in the non-participant and participant categories are the same was accepted (p = 0.110).

Test 2 The H_O that the mean age of individuals in the non-participant and non-watershed categories are the same was rejected (p = 0.000).

Test 3 The H_O that the mean age of individuals in the participant and non-watershed categories are the same was rejected (p = 0.025).

Table B.4. Indicators of Direct Economic Incentive to Participate

Variable	Watershed Landholder Category: Non-participant	Participant	Combined	Non-wsd Partici-pants
No. of individuals in each category.	85	101	186	82
% of holders who benefited checkdams.	28	66	49	0
Mean no. of checkdams constructed per parcel.	2(3)	4(5)	3(4)	0
Tenure status of parcels held in watershed:				
% owned ("tit" or "achte"):	58	47	52	/
% undivided inheritance ("indivize"):	28	38	33	/
% rented ("fem" or "pretansyon"):	9	8	9	/
% crop-shared ("demwatye"):	2	8	5	/
Position of parcel in watershed:				
% sideslope (i.e. no ravine on parcel):	36	20	27	/
% upstream (i.e. top of ravine):	13	19	16	/
% midstream (i.e. mid-ravine):	23	48	37	/
% downstream (i.e. bottom of ravine):	27	14	20	/
Mean length of ravine owned:	55(37)	68(44)	62(45)	/
% of individuals with joint ownership of ravine:	20	9	14	/
Mean no. of work events in which individuals participated: those who benefited checkdams:	/	8(8)	/	/
those who did not:	/	6(6)	/	5(5)

Notes:

1. Figures presented in this table are the results of a survey of all watershed landholders and all management activity participants in the 22 watersheds. Data was collected in December, 1990.
2. Statistical analysis: The X^2 statistic was used to compare proportions between categories and types indicated with categorical data (expressed here as %).

Test 1 The H_0 that true proportions of landholders who benefited checkdams are the same for non-participant and participant landholders was rejected (X^2 = 26.8; p = 0.000; df = 1).

Test 2 The H_0 that true proportions of tenure status types are the same for non-participant and participant landholders was accepted (X^2 = 5.09; p = 0.165; df = 3).

Test 3 The H_0 that true proportions of parcel position types are the same for both categories for non-participant and participant landholders was rejected (X^2 = 17.0; p = 0.001; df = 3).

Test 4 The H_0 that true proportions of individuals with jointly held ravine parcels are the same for both non-participant and participant landholders was rejected (X^2 = 4.72; p = 0.030; df = 1).

3. Statistical analysis: A two-tailed Z-test was used to test the hypotheses that variable means are the same for the all categories of individuals.

Test 1 The H_0 that the mean no. of checkdams constructed on participant and non-participant lands are the same was rejected (p = 0.001).

Test 2 The H_0 that the mean length of ravine owned by participants and non-participants is the same was rejected (p = 0.029).

Test 3 The H_0 that the mean no. of work events worked by participants who directly benefitted and those who did not was accepted (p = 0.157).

Test 4 The H_0 that the mean no. of work events worked by participants who did not directly benefit and non-wsd participants was accepted (p = 0.386).

Test 5 The H_0 that the mean no. of work events worked by participants who directly benefited and non-wsd participants was rejected (p = 0.008).

Table B.5. Indicators of Wealth Status of Participants and Non-participants.

Variable	Watershed Landholder Category			Non-wsd Partici-pants
	Non-participant	Participant	Combined	
No. of individuals in each category.	85	101	186	82
Mean no. of parcels held ("tit" or "indivize").	3(1)	3(2)	3(2)	2(1)
Mean no. of hectares held ("tit" or "indivize").	2.2(2.1)	2.8(6.5)	2.5(5.0)	1.6(1.3)
Mean no. of cows owned.	2(2)	1(2)	1(2)	1(1)
Mean no. of pigs owned.	1(1)	1(1)	1(1)	1(1)

Notes:

1. Figures presented in this table are the results of a survey of all watershed landholders and all management activity participants in the 22 watersheds studied. Data was collected in December, 1990.
2. Statistical analysis: A two-tailed Z-test was used to test the hypotheses that variable means are the same for the all categories of individuals.

Test 1 The H_0 that the mean no. of parcels held by individuals in the participant and non-wsd categories are the same was rejected ($p = 0.000$).

Test 2 The H_0 that the mean no. of parcels held by individuals in the non-participant and non-wsd categories are the same was rejected ($p = 0.000$).

Test 3 The H_0 that the mean no. of hectares held by individuals in the participant and non-participant categories are the same was accepted ($p = 0.523$).

Test 4 The H_0 that the mean no. of hectares held by individuals in the participant and non-wsd categories are the same was accepted ($p = 0.070$).

Test 5 The H_0 that the mean no. of hectares held by individuals in the non-participant and non-wsd categories are the same was rejected ($p = 0.026$).

Test 6 The H_0 that the mean no. of cows owned by individuals in the participant and non-participant categories are the same was rejected ($p = 0.000$).

Test 7 The H_0 that the mean no. of cows owned by individuals in the non-participant and non-wsd categories are the same was rejected ($p = 0.000$).

Table B.6. Logit Models Tested

Explanatory Variables Included	Deviance	Degrees of Freedom	p-value of tested term	AIC
age, group membership, land tenure, labor type, religious preference, voodoo participation, checkdam construction, parcel position, technique adoption	164.2	160	>.05	21.2
age, group membership, land tenure, labor type, voodoo participation, checkdam construction, parcel position, technique adoption	164 2	161	>.05	19.2
age, group membership, land tenure, labor type, checkdam construction, parcel position, technique adoption	164 2	162	>.05	17 2
group membership, land tenure, labor type, checkdam construction, parcel position, technique adoption	164 3	163	>.05	15 3
group membership, labor type, checkdam construction, parcel position, technique adoption	165 0	166	>.05	10.
group membership, labor type, checkdam construction, technique adoption	168 6	169	>.05	7.6
group membership, checkdam construction, technique adoption	172.9	173	>.05	3 9
group membership, technique adoption	180 8	174	.005	9.8
group membership, checkdam construction	182 9	174	.001	11 9
checkdam construction, technique adoption	192 6	174	<.001	21 6
group membership, checkdam construction, technique adoption, membership/adoption interaction	171 4	172	498	4 4
group membership, checkdam construction, technique adoption, adoption/checkdams interaction	170 8	172	.147	3 8
group membership, checkdam construction, technique adoption, membership/checkdams interaction	172 2	172	402	5.2

Table B.7. Profiles of Watersheds With Different Levels of Cooperation and Treatment

Variable	Watershed Treatment Category		
	Complete	Partial	Scant
No. of watersheds (wsd) in category.	10	7	5
Mean no. years activity.	1.3(.5)	1.3(.5)	1.4(.5)
Mean wsd area (standard deviation in parentheses).	7.7(6.5)	13.1(12.6)	6.4(3.2)
Mean no. of landholders in wsd.	9.0(4.8)	9.1(5.6)	6.4(2.6)
Mean parcel size.	.60(.28)	.83(.45)	.73(.30)
Mean no. of ravine treatments.	37.1(28.9)	25.3(14.7)	8.4(4.0)
Tenure status of land parcels in wsd:			
% owned ("tit" or "achte"):	48	54	59
% undivided inheritance ("indivize"):	32	37	31
% rented ("fem" or "pretansyon"):	12	3	9
% crop-shared ("demwatye"):	8	13	0
Parcel position in wsd:			
% sideslope (i.e. no ravine owned):	27	22	41
% upstream (i.e. top of ravine):	15	17	16
% midstream (i.e. mid-ravine):	46	28	28
% downstream (i.e. bottom of ravine):	12	33	16

Notes:

1. Figures presented in this table are the results of a survey of all watershed landholders in each of the 22 watersheds. Data was collected in December, 1990.
2. Statistical analysis: The small sample, two-tailed t-test was used to test hypotheses that means are the same between the complete, partial and scant categories.

Test 1 The H_0 that the mean no. years activity in the complete and scant treatment categories are the same was accepted ($p = .690$).

Test 2 The H_0 that the mean wsd area in the complete and scant treatment categories are the same was accepted ($p = .683$).

Test 3 The H_0 that the mean wsd area in the complete and partial treatment categories are the same was accepted ($p = .264$).

Test 4 The H_0 that the mean wsd area in the scant and partial treatment categories are the same was accepted ($p = 277$).

Test 5 The H_0 that the mean no. of landholders in the scant and partial treatment categories are the same was accepted ($p = .345$).

Test 6 The H_0 that the mean no. of landholders in the complete and partial treatment categories are the same was accepted ($p = .969$).

Test 7 The H_0 that the mean no. of landholders in the complete and scant treatment categories are the same was accepted ($p = .284$).

Test 8 The H_0 that the mean parcel size in the complete and scant treatment categories are the same was accepted ($p = .422$).

Test 9 The H_0 that the mean parcel size in the complete and partial treatment categories are the same was accepted ($p = .213$).

Test 10 The H_0 that the mean parcel size in the scant and partial treatment categories are the same was accepted ($p = .676$).

3. Statistical analysis: The X^2 statistic was used to compare variable proportions between the complete, scant and partial categories for the categorical data (expressed in this table in % terms).

Test 1 The H_0 that true proportions of land tenure types are the same in all categories was accepted ($X^2 = 7.19$; $p = 307$; $df = 6$).

Test 2 The H_0 that true proportions of parcel position types are the same in all categories was rejected ($X^2 = 15.02$; $p = .020$; $df = 6$).

Table B.8. Profiles of Cooperation in Watersheds With Different Levels of Treatment

Variable	Watershed Treatment Category		
	Complete	Partial	Scant
No. of watersheds (wsd) in category.	10	7	5
Mean total person/work events worked by landholders.	41.5(72.2)	28.8(10.9)	18.2(16.7)
Mean total person/work events worked by non-wsd participants.	25.0(40.1)	11.4(10.8)	15.4(10.7)
Mean no. landholders/work event.	4.3(1.6)	2.8(1.2)	2.2(.8)
Mean no. of non-wsd participants/work event.	2.9(2.3)	1.7(1.1)	2.3(.9)
% of landholders who participated.	58	55	44
% of landholders who directly benefited (with checkdams constructed on their parcel).	64	39	25
% of landholders who could have directly benefited. (including upstream, midstream and downstream parcel positions).	73	78	59
% of landholders who could have directly benefited (excluding those with jointly held ravines).	65	51	53
% of landholders who directly benefited (excluding those with jointly held ravines).	58	37	25

Notes:

1. Figures presented in this table are the results of a survey of the watershed management activity in each of the 22 watersheds. Data was collected in December, 1990.
2. Statistical analysis: The small sample, two-tailed t-test was used to test hypotheses that means are the same between the complete, partial and scant categories.

Test 1 The H_0 that the mean no. of landholders per work event in the complete and scant treatment categories are the same was accepted ($p = .054$).

Test 2 The H_0 that the mean no. of landholders per work event in the complete and partial treatment categories are the same was rejected ($p =$ 017)

Test 3 The H_0 that the mean no. of landholders per work event in the scant and partial treatment categories are the same was accepted ($p = .345$).

Test 4 The H_0 that the mean no. of non-wsd participants per work event in the scant and partial treatment categories are the same was accepted ($p = .341$).

Test 5 The H_0 that the mean no. of non-wsd participants per work event in the complete and partial treatment categories are the same was accepted ($p = .223$).

Test 6 The H_0 that the mean no. of non-wsd participants per work event in the complete and scant treatment categories are the same was accepted ($p = .589$).

3. Statistical analysis: The X^2 statistic was used to compare variable proportions between the complete, scant and partial categories for the categorical data (expressed in this table in % terms).

Test 1 The H_0 that true proportions of landholders who participated are the same in all categories was accepted ($X^2 = 1.88$; $p = .391$; $df = 2$).

Test 2 The H_0 that true proportions of landholders who directly benefitted are the same in all categories was rejected ($X^2 = 20.36$; $p = <.001$; $df = 2$).

Test 3 The H_0 that true proportions of landholders who directly benefitted (excluding those with jointly held ravines are the same in all categories was rejected ($X^2 = 12.55$; $p = .002$; $df = 2$).

Table B.9. Social Profiles of Watershed Landholders and Non-Watershed Participants From Watersheds with Different Levels of Treatment

Variable	Watershed Treatment Category		
	Complete	Partial	Scant
No. of watersheds (wsd) in category.	10	7	5
Mean age of wsd landholders.	41(12.5)	43(13.9)	44(13.3)
Mean age of non-wsd participants.	33(10.0)	36(10.5)	38(13.0)
% of holders who are "groupman" members.	61	45	72
% of non-wsd participants who are "groupman" members.	87	100	93
% of holders who have adopted soil conservation techniques.	64	51	41
% of non-wsd participants who have adopted soil conservation techniques.	87	95	73
% of holders who are Catholic.	75	72	72
% of non-wsd participants who are Catholic.	74	50	47
% of holders who regularly conduct "voodoo" ceremonies.	77	59	72
% of non-wsd participants who regularly conduct "voodoo" ceremonies	72	35	40

Notes:

1. Figures presented in this table are the results of a survey of all watershed landholders in each of the 22 watersheds. Data was collected in December, 1990.
2. Statistical analysis: The small sample, two-tailed t-test was used to test hypotheses that means are the same between the complete, partial and scant categories.

Test 1 The H_0 that the mean age of wsd landholders in the complete and scant treatment categories are the same was accepted ($p = .680$).

Test 2 The H_0 that the mean age of wsd landholders in the partial and scant treatment categories are the same was accepted ($p = .903$).

Test 3 The H_0 that the mean age of wsd landholders in the complete and partial treatment categories are the same was accepted ($p = .761$).

Test 4 The H_0 that the mean age of non-wsd participants in the scant and partial treatment categories are the same was accepted ($p = .774$).

Test 5 The H_0 that the mean age of non-wsd participants in the scant and complete treatment categories are the same was accepted ($p = .427$).

Test 6 The H_0 that the mean age of non-wsd participants in the complete and partial treatment categories are the same was accepted ($p = .560$).

3. Statistical analysis: The X^2 statistic was used to compare variable proportions between the complete, scant and partial categories for the categorical data (expressed in this table in % terms).

Test 1 The H_0 that true proportions of holders who are "groupman" members are the same in all categories was rejected ($X^2 = 7.08$; $p = .029$; $df = 2$).

Test 2 The H_0 that true proportions of non-wsd participants who are "groupman" members are the same in all categories was accepted ($X^2 = 3.01$; $p = .222$; $df = 2$).

Test 3 The H_0 that true proportions of holders who have adopted soil conservation techniques are the same in all categories was rejected ($X^2 = 6.18$; $p = .045$; $df = 2$).

Test 4 The H_0 that true proportions of non-wsd participants who have adopted soil conservation techniques are the same in all categories was accepted ($X^2 = 3.50$; $p = .173$; $df = 2$).

Test 5 The H_0 that true proportions of holders who are Catholic are the same in all categories was accepted ($X^2 = .324$; $p = .850$; $df = 2$).

Test 6 The H_0 that true proportions of non-wsd participants who are Catholic are the same in all categories was accepted ($X^2 = 5.84$; $p = .054$; $df = 2$).

Test 7 The H_0 that true proportions of holders who conduct "voodoo" ceremonies are the same in all categories was accepted ($X^2 = 5.39$; $p = .068$; $df = 2$).

Test 8 The H_0 that true proportions of non-wsd participants who conduct "voodoo" ceremonies are the same in all categories was rejected ($X^2 = 10.25$; $p = .006$; $df = 2$).

Table B.10. Wealth Profiles of Watershed Landholders and Non-Watershed Participants from Watersheds with Different Levels of Treatment

Variable	Watershed Treatment Category		
	Complete	Partial	Scant
No. of watersheds (wsd) in category.	10	7	5
Mean no. of parcels held by wsd holders.	3(5)	3(3)	2(2)
Mean no. of hectares held by wsd holders.	3.2(59.6)	2.1(3.5)	2.1(5.1)
Mean no. of cows owned by wsd holders.	1(9)	1(2)	2(14)
Mean no. of pigs owned by wsd holders.	1(1)	1(1)	1(2)
Manner in which holders conduct major agricultural tasks:			
% who work individually ("pou kont yo"):	40	47	31
% who work in pairs ("boukante maten")·	21	5	6
% who work cooperatively ("asosye"):	19	9	22
% who hire day labor ("bay djob"):	10	9	13
% who hire and work individually:	2	30	4
Manner in which non-wsd individuals conduct major agricultural tasks:			
% who work individually ("pou kont yo"):	21	20	20
% who work in pairs ("boukante maten"):	11	20	27
% who work cooperatively ("asosye"):	60	20	27
% who hire day labor ("bay djob"):	4	0	0
% who hire and work individually:	4	40	27

Notes:

1. Figures presented in this table are the results of a survey of all watershed landholders in each of the 22 watersheds. Data was collected in December, 1990.
2. Statistical analysis: The small sample, two-tailed t-test was used to test hypotheses that means are the same between the complete, partial and scant categories.

Test 1 The H_0 that the mean no. of parcels held by wsd holders in the complete and scant treatment categories are the same was accepted ($p = .679$).

Test 2 The H_0 that the mean no. of parcels held by wsd holders in the complete and partial treatment categories are the same was accepted (means are equal).

Test 3 The H_0 that the mean no. of parcels held by wsd holders in the partial and scant treatment categories are the same was accepted ($p = .533$).

Test 4 The H_0 that the mean no. of hectares held by wsd holders in the scant and partial treatment categories are the same was accepted (means are equal).

Test 5 The H_0 that the mean no. of hectares held by wsd holders in the complete and partial treatment categories are the same was accepted ($p = .845$).

Test 6 The H_0 that the mean no. of hectares held by wsd holders in the complete and scant treatment categories are the same was accepted ($p = .969$).

Test 7 The H_0 that the mean no. of cows owned by wsd holders in the complete and scant treatment categories are the same was accepted ($p = .868$).

Test 8 The H_0 that the mean no. of cows owned by wsd holders in the complete and partial treatment categories are the same was accepted (means are equal).

Test 9 The H_0 that the mean no. of cows owned by wsd holders in the partial and scant treatment categories are the same was accepted ($p = .934$).

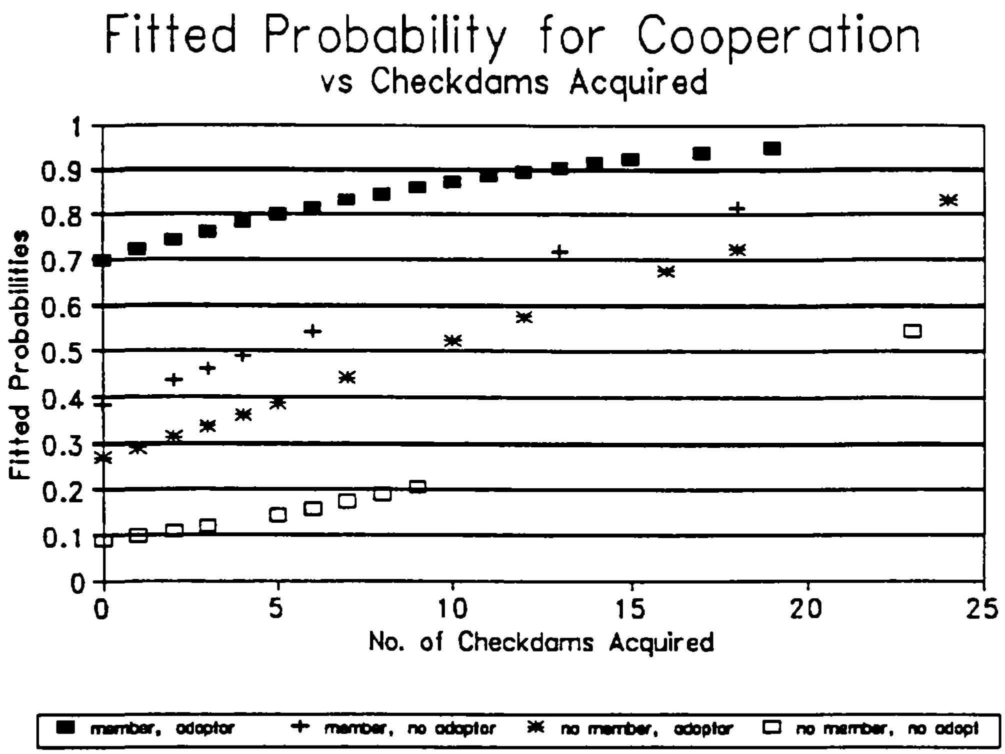
Test 10 The H_0 that the mean no. of pigs owned by wsd holders was the same in all categories was accepted (means are equal).

3. Statistical analysis: The X^2 statistic was used to compare variable proportions between the complete, scant and partial categories for the categorical data (expressed in this table in % terms).

Test 1 The H_0 that the true proportions of wsd landholders who conduct major agricultural tasks in the same manner are the same in all categories was rejected ($X^2 = 21.1$; $p = .007$; $df = 8$).

Test 2 The H_0 that the true proportions of non-wsd landholders who conduct major agricultural tasks in the same manner are the same in all categories was rejected ($X^2 = 21.4$; $p = .006$; $df = 8$).

Graph B.11



Fitted Probability for Cooperation
vs Checkdams Acquired
Fitted Probabilities
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
No. of Checkdams Acquired
member, adoptor
member, no adoptor
no member, adoptor
no member, no adopt