PN-AAL-289
ISN 13826

Economics Program
Progress Report 26

Social Organization and Small Watershed Development

Victor S. Doherty, Senen M. Miranda, and Jacob Kampen

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh 502 324, India

OCTOBER 1981

PROGRESS REPORTS are informal communications about ongoing research, or thoughts of ICRISAT staff members, which are designed to stimulate thinking and comments of professional colleagues within and outside the Institute. These reports are not to be considered as formal publications bearing the endorsement of the Institute. Progress reports were earlier referred to as Occasional Papers/Discussion Papers.

ABSTRACT

To assess the prospects for development of small agricultural watersheds in the semi-arid tropics we must have a clear idea of potential for cooperation by small groups of farmers. Cooperation would be particularly important if development included collection of runoff water on a catchment and use of the water on upland crops by several farmers. Cases of shared use of wells in southern, semi-arid tropical India are examined and the conclusions are compared with results of literature studies and on-farm research. We suggest a basic distinction between rule-based cooperation and decision-based cooperation, and point out contrasting types of activity for which cooperation among farmers can be expected for small watershed development.

CONTENTS

	Page
Introduction ..	1
Multidisciplinary Research and the Role of Anthropology at ICRISAT	3
Some Measures for Watershed Development in the SAT ..	6
Background to Field Investigations in Group Action ..	7
Organization of the Use of Open Wells for Irrigation in Three Villages of Southern SAT India ..	9
Village Level Experiments in Small Watershed Development ..	14
Conclusions ..	16
References ..	17
Appendix - I ..	19
Appendix - II ..	20

Tables

1. Owned land of sample farmers ..	2
2. Field size data from small watersheds selected for development ..	2
3. Features of Village Level Studies districts	10
4. Well ownership among VLS respondents, 1979-80 agricultural season ..	12
5. Shared ownership and use of wells in VLS sample, 1979-80 agricultural season	12

SOCIAL ORGANIZATION AND SMALL WATERSHED DEVELOPMENT

Victor S. Doherty, Senen M. Miranda and Jacob Kampen*

INTRODUCTION

An overall strategy which has been proposed for the improvement of semi-arid tropical (SAT) crop production is integrated land and water management for development of cropland on a watershed basis (Kampen 1980; Krantz et al. 1978). Research work on such development at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has focused on small watersheds which would usually involve the land of more than one farmer in areas with operational holdings and field sizes similar to those of southern SAT India (Tables 1 and 2). Modelling work and economic analysis at ICRISAT have strengthened this expectation, pointing for example to an 8-16 ha range as a size of small watershed likely to be economically profitable for development on Alfisols and under rainfall and economic conditions similar to those near Hyderabad during the late 1970's (Ryan et al. 1980; Ryan and Pereira 1980). Small watersheds chosen as sites for experimental development in villages lying in three other areas of the southern Indian SAT were close to this size range and comprised the land of 5, 12, and 14 farmers respectively (Table 2). These circumstances mean that an understanding of conditions for group action among farmers is needed for small watershed development.

Identification and understanding of anthropological conditions for group action has been a major research focus in ICRISAT's Economics Program since the latter part of 1976. Approaches taken have included study of the literature regarding cooperation for agricultural production, examination of particular cases from India in this area, and a study of relevant anthropological work on group size and function (Doherty and Jodha 1979; Doherty 1980). Analyses have also been made in connection with on-farm experiments in watershed development, begun in 1978-79, carried out by

---

* The authors are respectively Principal Social Anthropologist (ICRISAT), Principal Scientist in Land and Water Management (ICRISAT), and Agriculturist, South Asia Projects Department (IBRD). They are grateful to colleagues and staff in the Farming Systems Research Program and the Economics Program of ICRISAT who participated in the research described and who commented on this paper. Particular thanks are due to James G. Ryan for his comments on earlier drafts, and to K.L. Khanna and P.S.S. Raju who provided assistance in field data collection regarding well ownership and use. The authors alone are responsible for the contents and analyses presented.

ICRISAT Conference Paper No.39. This is a revised version of a paper presented at the workshop on The Role of Anthropologists and Other Social Scientists in Interdisciplinary Teams Developing Improved Food Production Technology, 23-26 March 1981, The International Rice Research Institute, Los Baños, Laguna, Philippines.

Table 1. Owned land of sample farmers*
Three villages of southern SAT India, 1975-76 crop season

	Aurepalle	Shirapur	Kanzara
Mean (ha)	6.0	5.0	5.5
Median (ha)	2.6	5.0	3.1
Range (ha)	0.3-38.6	0.8-14.2	0.8-28.4
Standard deviation (ha)	8.3	3.3	6.2
Coefficient of variation (%)	138	66	113

* Landowners in ICRISAT's Village Level Studies (see Jodha et al. 1977). Sample size: Aurepalle = 29; Shirapur = 30; Kanzara = 30.

Table 2. Field size data from small watersheds selected for development
Three villages of southern SAT India, 1978-79 crop season

	Aurepalle	Shirapur	Kanzara
Farm owners per watershed*	5	14**	14**
Average field size (ha)	3.5	1.2	1.4
Total watershed area (ha)	17.7	16.8	19.9
Number of fields in size category:			
0.1 to 1.0 ha	1	7	8
1.1 to 2.0 ha	1	3	2
2.1 to 5.0 ha	2	2	2
5.1 ha and above	1	0	1

* Not all farmers participated in the actual watershed development experiments; see page 14 below.

** In two cases in Shirapur and one in Kanzara two members of a joint family have formal title to portions of the same field.

staff of ICRISAT's Farming Systems Research Program and Economics Program in collaboration with Indian institutions, and carried through the 1980-81 season. An analysis is presented below of cases of cooperation involving well ownership in the same three southern Indian villages in which the small watershed development projects were carried out. Some results of the on-farm experiments are also noted.

An important part of our general anthropological conclusions from this work is that two distinct types of cooperative behavior can be discerned in human groups. Knowledge of these types of cooperative behavior can be applied along with knowledge of the relative sizes, longevity, and appropriate tasks for human groups under different conditions (Doherty 1980). A summary statement regarding the two types of cooperative behavior, as well as appropriate group size, follows:

> Rule based behavior can be carried out by individuals, small groups or large groups. It is predominantly passive and can persist over the long term. The actions required by rule-based behavior are in principle predictable and invariant, although the rules themselves may change from time to time. Effective, long-term rules are most often generated and sanctioned by relatively large groups.
>
> Decision based behavior requires management judgements and will call for different actions at different times. This behavior is situational. It is effectively carried out by individuals, or by small groups which cohere only for the short-term, decision-making task at hand. Such small groups may have a cross-culturally optimum size. They can cohere over the long term and make repeated, variable management decisions only if they have the strong and continually reinforced, rule based sanctions of a large group or of an active, well-organized administration to support them. Decision based activity may weigh the application of potentially conflicting rules, or it may deal with areas where no rules apply.

We feel that in combination with the results of experiments in land and water management and of economic analysis such conclusions can be important in the design and successful large scale implementation of technology and programs to improve agricultural resource use in the SAT on a small watershed basis.

MULTIDISCIPLINARY RESEARCH AND THE ROLE OF ANTHROPOLOGY AT ICRISAT

Studies to increase our understanding of how improvements to land and water management in SAT areas can be carried out on a watershed basis provide an example of how multidisciplinary research is conducted at

ICRISAT, and of how anthropological work contributes to the results of such studies. The two types of study on which details are given in following sections are 1) a special investigation focusing on unadministered, cooperative use of wells by farmers in southern SAT India, and 2) experiments in small watershed development on farmers' fields in the same area.

At the time work on small watershed development technology was initiated at ICRISAT there was no anthropologist staff member. Scientists in the Economics Program and Farming Systems Research Program were agreed, however, that problems of social organization and group action could be expected since the proposed technology depended upon an area-based rather than field-based approach and thus would involve the land, resources, and interests of more than a single farmer in its operation. It was felt that knowledge about possibilities and limits for group action would be necessary even in a research station context for proper design, development, and evaluation of the technology. On-farm trials were also planned, for an early date, and it would be necessary to have an anthropologist as a member of the on-farm team to participate in analysis of farmers' assessments of the watershed-based technology.

As a result an anthropologist was recruited and placed with ICRISAT's Economics Program, the position being funded for two and a half years by the Rockefeller Foundation under its postdoctoral program in the social sciences, and after that as a core ICRISAT position. The anthropologist was to work primarily on problems of group action connected with watershed development.

As a first step, a joint anthropological and economic analysis was made of theoretical literature and of cases from India of cooperative action by farmers (Doherty and Jodha 1979). This study, carried out in 1976-77, was followed by a more detailed examination of anthropological literature (Doherty 1980). Experiments on farmers' fields were begun during the 1978-79 agricultural season with agronomic tests to prepare the way for field testing in the following season of a modified package for small watershed development. These studies have been the joint work of a number of scientists from ICRISAT's Farming Systems Research Program and Economics Program, and of scientists from member institutions of the Indian Council of Agricultural Research. During 1979-80 the studies of cooperation involving wells were carried out.

On-farm experiments and studies are a particularly important area in which ICRISAT researchers of different disciplines and from separate programs combine their efforts, within a common framework, to focus on practical solutions to problems of SAT farmers. An important context for this cooperative, multidisciplinary research at the field level has been the Village Level Studies or VLS (Jodha et al. 1977; Binswanger and Ryan 1980) which were initiated by members of the Economics Program in

cooperation with agricultural universities of Andhra Pradesh and Maharashtra states in India in 1975. The studies have been expanded recently to Gujarat and Madhya Pradesh, with the collaboration of the agricultural universities in these two states as well. The studies are designed to provide a wide range of baseline data from a stratified, random sample of farm and labor households in villages typical of Indian SAT subregions, to enable analysis of farming practices and problems. The study villages have also been envisioned from the first as areas where a wide range of on-farm experiments is possible, from evaluation of existing practices, to biological and physical observations, to the experimental testing of particular technologies such as the watershed development technology.

The anthropological work noted has been of several types, each typical of a particular sort of work carried out at ICRISAT. The initial study of anthropological and economic material regarding group action was a cross-disciplinary effort similar to work on rainfall runoff modelling, which was begun at ICRISAT in 1975 by scientists of the Economics Program and Farming Systems Research Program, and which is continuing. In each case, researchers of different disciplines pooled their insights and their knowledge of existing findings to suggest answers to aspects of a technological problem concerning ICRISAT as a whole. In each case, preliminary results were reached which suggested different sorts of experiment and investigation to follow. In the group action investigation, it was clear that two sorts of study would be needed. One would be on-farm experimentation, in which researchers from a number of disciplines would be involved in the field application and evaluation, along with farmer, of technology designed according to hypotheses about what would be agronomically, economically, and organizationally successful.. A brief account of the framework of these experiments in watershed development and of some of their results in the area of social organization is given below. A full, joint report on the first three years of the experiments is under preparation, to include analyses by researchers from all the disciplines participating.

In addition to on-farm experimentation, however, it was clear to the anthropologist, to the economists, and to the others concerned in the Farming Systems Research Program and the Economics Program that additional studies of a disciplinary, focused kind would be necessary to resolve questions raised by the early studies on group action. Such special purpose studies would also be needed if ambiguities likely to arise in the results of the on-farm work were to be resolved. These considerations led to the studies of indigenous cooperation around wells, reported below.

The research for the study on wells reported here was carried out by an anthropologist working independently with two field assistants, to gather data which would be useful in solving problems which were the focus of continuing ICRISAT team efforts. The results of the study are evaluated here by a group of authors, including researchers whose disciplinary background is in land and water management. The results of this team analysis are presented in the conclusions and in the appendices, where suggestions are made for further team studies and for testing of modified watershed development technology in the real world of the farmer.

SOME MEASURES FOR WATERSHED DEVELOPMENT IN THE SAT

In an agricultural sense the term watershed development may be taken to mean the conservation, improvement and use of soil and water resources in a given drainage area, for increased crop production. Development may or may not involve areas used for trees and grassland; this will depend upon the demand for different products and upon the nature of the resource base. Natural resources include soils, subsurface geology, rainfall with its runoff and drainage patterns, and groundwater and surface water. Water resources may include aquifers and rivers, which may not depend wholly upon precipitation in the particular catchment. One can envision a variety of types of resource use and associated problems. Where rainfall intensity and surface and subsurface drainage are limiting for crop production, attempts to improve land drainage should form a major portion of watershed development. Periodic water stress is often a limiting factor in crop production in the SAT; in such areas efforts for water conservation and for its storage in the soil profile as groundwater, or in surface reservoirs, will assume great importance.

Watershed development research at the ICRISAT Center in Patancheru, near Hyderabad, India is designed to identify principles which can be used to develop successful, profitable, intensive farming systems, for areas with low and seasonally concentrated rainfall and with relatively infertile, tropical upland soils. Work has focused on improved land and water management techniques suitable for small watersheds of from three to fifteen or more hectares. The goal has been to do as much as possible on the bases of the land itself and the rainfall reaching it. Techniques of broadbed-and-furrow cultivation on a slight grade have been utilized to improve the chances of rainfall infiltration and its storage in the soil profile, while still providing for surface drainage and for protection during intense rainstorms. Runoff is conveyed through grassed waterways and collected in small storage reservoirs or ponds arranged in series so as to recapture overflow.

This approach to watershed development and resource use has performed well in experiments at the ICRISAT Center and elsewhere. The technique may be particularly useful in promoting intensification of cropping in some deep Vertisol areas of India where rainy season fallowing is common at present (Binswanger et al. 1980). In some of these areas farmers are faced with drainage problems which can prevent cropping in the rainy season. Broadbeds and furrows could alleviate the drainage problem and still allow significant amounts of soil profile moisture to be carried over into the dry season.

A 70 years' simulation shows that on Alfisols optimum small watershed sizes are from 8 to 16 ha under conditions such as those at the ICRISAT Center, if runoff is impounded in ponds and pumped to irrigate a second, post rainy season crop (Ryan et al. 1980). Studies are continuing to simulate benefits to rainy season or post rainy season use of water for supplementary irrigation under different crop, rainfall and soil regimes. Water use could be improved the more flexibly decisions could be made on cropping pattern, planting date, and irrigation pattern in response to seasonal and market variations. On Vertisols, with better moisture storage and less runoff, the economics of ponds seem less attractive. This situation becomes more pronounced the lower the rainfall and the deeper the Vertisol (Ryan et al. 1980). A better understanding is needed of potential for runoff collection and use of different soils and under different rainfall regimes. Options for use of stored runoff during the rainy season itself need to be examined, particularly for low rainfall, Alfisol situations. Intensive, interdisciplinary efforts are presently underway at ICRISAT to study these problems by field experimentation and using simulation techniques.

BACKGROUND TO FIELD INVESTIGATIONS IN GROUP ACTION

The suggestion that runoff collected in ponds be used for supplementary irrigation on small, upland crop watersheds raises many questions. What are the organizational, physical, and economic feasibility of this upland crop system, vs. collection of runoff in tanks[1] for gravity irrigation of paddy rice? what would be the returns to ponds for supplementary irrigation of upland crops, vs. returns to wells? Could percolation tanks be built more profitably, to recharge groundwater and thus to improve the

---

1. In this paper the common South Asian term tank is used to refer to traditional reservoirs with earthen dams, for the collection of runoff. These can have catchments varying greatly in size and irrigate from 10 to 100 ha or more. In South Asia the water is most often used for paddy rice.

yield of wells? The hydrological, agronomic, and economic answers to these and other questions, as well as the formulation of the questions themselves, will be location specific. In all cases however one can expect questions to arise about the social organization of ownership and use of such irrigation facilities.

The present paper therefore concentrates not on any particular situation in any given area, but upon the derivation of social organizational principles which can be applied along with physical, biological, and economic principles. Ponds for runoff collection could be desirable in a particular situation from other viewpoints, but one must also be able to decide on the most efficient system of ownership and management, and be able to judge whether such a system can be instituted in practice. The type of social organization required will vary not only according to the nature of the resource but also according to the results that are desired; and it will be in part defined and limited by crosscultural, social and cultural elements.

Data are given in Table 1 on owned land for farmers in three typical regions of the southern Indian SAT. For situations in which median holding sizes are 2.6, 4.1, and 3.1 ha, optimum watershed sizes of 8 to 16 ha seem too large for most farmers to be able to undertake development profitably on their own. Actual plots suitable for small watershed development are often much smaller than farmers' total owned areas (Table 2). This is due to diversification of holdings by soil and location, as a risk avoidance mechanism and as a result of fragmentation at inheritance. From the data in Table 1 and 2, one could expect to encounter small watersheds owned by groups of from two to ten or more farmers if one were to begin a small watershed development program on an operational scale in areas of similar ownership pressure on agricultural land. If the farmers who own the fields on these small watersheds were to develop them in common, and were to build and operate runoff collection ponds for supplementary irrigation, they would have to expect to be able to cooperate over the long term and to make a large number of varying decisions regarding water use and maintenance from season to season.

In such a situation we need to know if there are rules, particularly crosscultural rules, for cooperation in small groups. We then need to know, based on an understanding of such rules, the potential for cooperative ownership and management of ponds for runoff collection and use on small watersheds. In two earlier papers regarding cooperation among farmers, focused particularly on ways in which cooperation might be expected to contribute to the spread and to the efficiency of improved land and water management, a key concept sought to be developed was that of matching appropriate group size and function (Doherty and Jodha 1979; Doherty 1980). In each of these papers it was stated that on the basis of a comparative ethnographic view, one could hypothesize that small groups

of unadministered, independent individuals are likely to be most effective only as short term task groups; while much larger groups are likely to be needed to support social mechanisms for continued, variable decision-making and for the drafting and enforcement of impersonal rules. In both papers it was also hypothesized that individual interests as well as group interests would have to be served, and that this would be particularly important where individual farmers are independent decision-making agents. Some preliminary findings regarding this predicted individualism are presented on p. 15 below in our discussion of on-farm experiments in watershed development.

Based on the general hypotheses regarding group action, a specific hypothesis was advanced regarding preference of farmers for type of ownership and operation of runoff ponds and similar facilities. This hypothesis stated that farmers would prefer that small-sized sources for supplementary irrigation be privately (individually) owned (Doherty 1980: 115). Data which provide a partial test are presented in the section immediately following.

ORGANIZATION OF THE USE OF OPEN WELLS FOR IRRIGATION IN THREE VILLAGES OF SOUTHERN SAT INDIA

The data to be analyzed in this section, on ownership and management of wells in three villages of southern SAT India, were collected in order to provide a partial test of the hypothesis that farmers would prefer individual ownership of small sources for supplementary irrigation.

The cases to be considered are the rules for ownership and management of open wells found in the same three villages where the experiments in small watershed development are being carried out. These villages are also among the locations where ICRISAT's Village Level Studies (VLS) are being conducted (Jodha et al. 1977). Background information on the areas where these villages are located is given in Table 3.

Only those wells in which a VLS respondent has either a share or full ownership rights are discussed. Table 4 gives general background information on the sample wells in the three villages. The largest number of wells is found in Aurepalle where the rainfall is low, where there are many good aquifers, and where an extensive system of tanks and bunds to control and collect runoff also has the effect of recharging ground water. Many of the Aurepalle wells are old, having been dug several generations ago before diesel or electric pumps were available. In Shirapur, presumably due to the fact that rainfall is low and undependable, there is a fairly large number of wells despite the widespread presence of highly water retentive, deep Vertisols. Kanzara has the fewest wells; rainfall is higher and is relatively dependable. The shallower soils in Kanzara are underlain by rocky substrata that

Table 3. Features of Village Level Studies districts (adapted from Jodha et al. 1977:3)

	Mahbubnagar District Andhra Pradesh State Aurepalle Village	Sholapur District Maharashtra State Shirapur Village	Akola District Maharashtra State Kanzara Village
Soil types	Shallow and medium Alfisols	Deep and medium-deep Vertisols	Shallow and medium-deep Vertisols
Average annual rainfall	713 mm (bimodal rainfall)	691 mm (rains undependable and received in two distinct phases during rainy season)	817 mm (rainfall relatively dependable)
Cropped area irrigated	14.5% (tank and well irrigation)	10.7% (largely well irrigation)	1.5% (largely well irrigation)
Important crops	Sorghum, groundnut, castor, rainy season pulses, paddy on irrigated lands	Postrainy season sorghum, pearl millet, groundnut, pulses	Sorghum, cotton, groundnut, rainy season pulses
Regions represented	Alfisol tracts of the eastern Deccan plateau	'Scarcity zone' of Maharashtra and Karnataka on the western, central, and southern Deccan plateau	Vidarbha region of Maharashtra, and neighboring parts of Madhya Pradesh State

do not provide high yielding, shallow aquifers. Many Kanzara wells have been built since the 1960's when diesel or electric power for pumping began to become widely available, and when government subsidized loans began to be provided for well construction and the purchase of pumps.

Seven respondents in Aurepalle, two in Shirapur, and three in Kanzara share in or hold sole ownership of more than one well. Differences in cropping patterns, soils, and subsurface geology are likely to have influenced the patterns of well ownership in the three villages.

The high incidence of well ownership overall in these three villages is striking, reaching 48% and 43% respectively of the entire VLS sample in Aurepalle and Shirapur. At the time of the study, wells were the primary source of irrigation in these villages.

The average numbers of owners per well and the average numbers of active owners per well (who irrigated in the postrainy season of 1979-80 [Table 5]), suggest that small groups do form themselves around these organizationally independent sources of supplementary water. Many wells have been under shared ownership for several generations; most changes in ownership seem to occur through inheritance. Pumps are also owned in common. These results seem to offer examples counterfactual to our hypothesis regarding group ownership of small sources of irrigation.

The natural agricultural environment appears to be a key determinant of common well ownership. The highest number of owners per active well (4.8), and the highest number of irrigating farmers per active, shared well (4.5) are found in Shirapur, where rainfall is the least dependable. Shirapur also has the most owners per pump (3.5). Although Shirapur's deep Vertisols retain moisture well, farmers still want wells and own them in common. The second largest average numbers of owners per well and of active irrigators are in Aurepalle, where the moisture environment for plant growing is also rather undependable, due to the rainfall pattern and to shallow soils. In Kanzara there are no instances of shared ownership among the 16 sample wells. Among the three villages Kanzara has the highest and most dependable rainfall. Its soils are Vertisols, mostly shallow except along the major water courses. On the shallow soils aquifers are generally poor. Under such conditions there would seem to be less incentive for well construction. One hypothesis in line with these data from the three villages would be that although small groups of owners form and persist around these wells, shared ownership is not easy to handle organizationally and it may be uncommon unless there are no attractive alternatives.[2]

2. It is not certain whether rainfall and cropping patterns are the major factors promoting shared ownership of wells, or whether there are other more effective causes. It is possible for example, that in Kanzara poor recharge makes it difficult for a number of persons to share profitably the output of a single well. Relative to Kanzara the costs of sinking and maintaining wells could be greater in Shirapur or in Aurepalle, or in both. Our data and analyses to answer these questions are still incomplete.

Table 4. Well ownership among VLS respondents, 1979-80 agricultural season

	Aurepalle	Shirapur	Kanzara
VLS wells*	23	18	16
VLS wells used	17	12	11
% of VLS wells used	74	67	69
VLS respondents with at least a share of well ownership	19	17	13
% of VLS respondents with at least a share of well ownership	48	43	33
VLS respondents with an interest in more than one well	7	2	3
Average well share size among VLS owners**	0.67	0.46	1.00
Average cumulative well ownership among VLS well owners ..	0.81	0.49	1.23

*All wells for which a VLS respondent was a sole or part owner during the postrainy agricultural season of 1979-80. There are forty sample families in each village: 30 depending mainly on farming for their income, and 10 depending mainly on agricultural labor. The 30 farming families are drawn 10 each from large, medium, and small landholding groups. See Jodha et al. (1977) for details.

**Includes both active and inactive wells.

Table 5. Shared ownership and use of wells in VLS sample, 1979-80 agricultural season

	Aurepalle	Shirapur	Kanzara
Owners per active well	2.4	4.8	1.0
Active owners per active shared well	2.7	4.5	0
Active VLS wells with shared ownership	12	10	0
% of active VLS wells with shared ownership	71	83	0
Owners* per active pump in VLS sample	1.4	3.5	0.7

*Actual use as opposed to ownership of pumps may vary from time to time due to factors including lack of production funds on the part of some farmers, and renting out of shares by others.

Water control systems and the degrees and kinds of interaction among farmers were also investigated. These systems minimize interaction among the owners. Farmers do not meet to confer together to consider the season as a whole, and to devise ways to increase the productivity of their shared water resources. On the contrary the systems assure that the rights of each individual operate automatically by invariant principles. Several principles govern the shared use of wells in Aurepalle. First, each owner's share is fixed at a known fraction of the total capacity of the well. Second, owners are individually responsible for raising the water they intend to use. If a farmer cannot afford the electric bill or has no bullocks to use in raising water, then no one else has any obligation to help. Third, there seems to be a de facto upper limit on irrigated area in proportion to one's share in the well. This is only an upper limit. If a well owner does not own enough land within reach of the well to make full use of his share, and if he cannot purchase land near the well, he may decide to sell his rights in the well and will perhaps sell the land also. Fourth, in times of drought all owners are obliged to share proportionately; all pumps must be turned on and off at the same time. Fifth, the pump size can be limited by horsepower, being installed in at least some cases according to the size of a person's well share so that no one can realize an unfair advantage in the event that all pumps must be operated together.

It is also notable that the greatest portion of irrigation in Aurepalle is for paddy rice, which is the crop locally grown with the highest water requirement. If all use water at the maximum rate and if the other limitations noted above are observed, proportional equality can be maintained.

In Shirapur the well sharing system is based on a different set of rules. Presumably because of the drier climate and less highly yielding aquifers compared to Aurepalle, Shirapur wells are not used for paddy. Farmers assume that any irrigated crop planted in the area needs water approximately every eight days. Rights to water are therefore reckoned in terms of days with eight days' rotation a common figure. In such a system a farmer will own eight, or three, or two days' rights in a given well. For one day's share, one is entitled to as much water as the well will yield from sunset to sunset. No extension of time is possible and a fixed rotation among the farmers is set up. The practical irrigable area of a well is determined when it is built; this area is called the <u>malhā</u>. In Shirapur as in Aurepalle there seems to be a de facto irrigated land limitation on farmers in addition to prescribed rights to the well water itself: well rights are inherited or sold along with <u>malhā</u> land proportional to the number of day shares involved.

There is a greater incidence of joint ownership of pumps in Shirapur (3.5 owners per active pump) compared to Aurepalle (1.4 owners). This tendency in both areas probably has its origin in attempts by the farmers to cut their capital costs, and this tendency is probably reinforced in Shirapur by the rotational pattern of well use.

VILLAGE LEVEL EXPERIMENTS IN SMALL WATERSHED DEVELOPMENT

Since the beginning of the 1978-79 crop season, ICRISAT staff have been assisting with development, on a trial and experimental basis, of contiguous areas which in 1980-81 involved actual cultivated areas of about 14, 13, and 12 ha each in Aurepalle, Shirapur, and Kanzara respectively. Other data relating to these watersheds are given in Table 2 above. The work has been carried out in collaboration with scientists of the All India Coordinated Research Project for Dryland Agriculture, and with scientists from the Andhra Pradesh Agricultural University near Hyderabad and from Punjabrao Krishi Vidyapeeth and Mahatma Phule Krishi Vidyapeeth agricultural universities in Maharashtra. During the 1980-81 season there were 5, 8, and 5 participating farmers, respectively, on the three watersheds. The land and water management and related recommendations implemented have included the introduction of graded, broadbed and furrow based cultivation and sowing; improved crop varieties; fertilizer; and improved, bullock-drawn tool carriers for planting and for fertilizer placement. Catchment development has included improving drainage by conveying runoff along existing field boundaries as well as by channeling it through a system of waterways and concrete drop structures cutting across fields along the natural drainage patterns. In one village, small portions of adjacent fields were exchanged between their two owners for the two-year duration of the experiment, in order to simplify cultivation on the proper grade. In another case, grade line layout and planting have been simplified by being laid out across field boundaries. All of these developments have been directed and implemented by ICRISAT research staff. The farmers have agreed to the various developments and have cooperated actively with those portions of the work falling within their own field boundaries under their own control. Where work has been outside or has cut across boundaries, for example in the construction and maintenance of the drainage system, the farmers have been cooperative as well, with the important difference that in such cases of work outside their own fields their cooperation has been mainly passive.

The experiments were initiated on the basis of an understanding with the farmers in each village that although there would be subsidies initially, these would last for only two years (an initial third year in 1978-79 was limited to agronomic tests on small plots on a single farmer's field in each village). Choices of crops remained with the

individual farmers. No charges were levied for land drainage development, nor is the retention of these developments to be enforced beyond the two year period. ICRISAT agreed to pay all extraordinary costs for labor and bullocks, and to advance the seed, fertilizer and pesticide used. After the first year, when only one farmer per village was involved and no repayments were sought, it was agreed that in subsequent years repayment would be sought for material inputs only. Even this was to be only if the cooperating farmers had realized double the average net profit found in the VLS to have been realized on non-experimental fields of similar soil in the same villages. Any surplus after repayment for material inputs was to be returned to the farmer.

It was felt that since the techniques were untested under farmers' circumstances, special support of this kind was necessary in order to minimize financial risks of failure. With the end of these financial supports ICRISAT coordination is also being withdrawn, although technical advice will continue as requested. It is at this point that we will be able to observe the farmers' reaction through their own retention or rejection of the different parts of the system.

No ponds for runoff collection have been built in these villages. In Aurepalle it was decided that an existing well in the watershed area would be used for supplementary irrigation to facilitate growing a second crop if there was sufficient groundwater in any year. In Shirapur, where rainfall is low and unreliable and soils are deep Vertisols with high moisture holding capacities, a pond would be unlikely to be a sound investment. Possibilities for pond construction have been limited overall by the short duration of the experiment and the necessity to guarantee to farmers that their individual freedom of action will be minimally affected during the period of the experiment and will be completely restored when it ends.

Although the full report on these studies is still pending, at the present time it is possible to make a broad social organizational assessment of farmers' reactions to the first three years' activities. Where the system has been capable of handling runoff without overload, generally farmers did not object to an improved drainage system following both field boundaries and natural features within fields. Nevertheless they showed strong interest in maintaining boundaries, protecting individual rights, and adapting improved tillage and planting to individual, within-field patterns. Some farmers have objected to drop structures made of concrete and located within fields, but not to those on boundaries. Farmers have expressed interest in renting or in some cases in purchasing bullock-drawn tool carriers and attachments. They have shown a strong aversion, in the case of one village, to a suggestion that ownership of tool carriers be by small, cooperative groups.

In their individualism, expressed in these ways, the farmers' behavior confirms some of the predictions of our earlier studies (Doherty and Jodha 1979, Doherty 1980). Nevertheless, we have seen that in the same villages, stable small groups form around water sources, contrary to expectation. In the following section we seek to explain this contradiction, and to draw conclusions from it.

CONCLUSIONS

The behavior of the VLS sample farmers who share rights to wells in Aurepalle and in Shirapur contradicts our hypothesis that farmers would prefer individual ownership of small sources of water for supplementary irrigation. In the face of such data, we cannot simply assign short term functions to small groups and long term functions to large ones. The data can be accommodated, however, if we revise our hypothesis, taking into account decision based vs. rule based behavior, as well as the functions of small as opposed to large groups. The systems of cooperation followed by farmers who share rights to wells in Aurepalle and Shirapur are clearly rule-based. The systems governing ownership and management apply in the village as a whole. Farmers who obtain access to a well need not worry about what the rules will be. Decision-based interaction, in which one person's decisions on cropping pattern or irrigation timing might influence the wellbeing of his neighbor's crop, is carefully excluded by custom regarding shared ownership and use of wells. We suggest that such rule based activity is suitable for small or large groups, even though the larger group ultimately must sustain and sanction it. It is functionally and organizationally opposed to decision based activity.[3] Decision based activity is efficiently carried out by individuals, by short term small coalitions, or by small or large groups under a centralized management.

Thus we revise our hypothesis to state that farmers would prefer small sources of irrigation water such as runoff collection ponds on small watersheds to be individually owned, unless simple rules for the distribution of water could be specified, such that interaction and common decision-making among owners would be reduced to a very low or negligible level. To the degree our findings have crosscultural validity, we expect that it might be possible to modify the severity of these requirements in certain cultural and social contexts, but not to evade them in any case. As a supplement to the present study and its precursors, additional crosscultural comparison of cases and circumstances should be carried out. Nevertheless the revised hypothesis seems well-founded.

---

3. This latter category is discussed more fully in Doherty (1980).

In line with these findings one could explore the possibility that small ponds for runoff collection and supplementary irrigation could be installed and administered as part of an overall village water resources development project. This would present different possibilities organizationally, since large groups would be involved. Even such a system might have to be substantially rule-based however, and there would be limitations on availability and flexibility of administrative staff. The possibility exists therefore that even in a whole village development context the kind of flexibility and close attention to continually emergent and differing problems required for the maximum effective use of jointly owned ponds would not be possible. If such were the case, runoff water would still be important. Depending upon the agroclimatic, hydrological, and economic context singly owned ponds, small or large tanks for gravity irrigation, or percolation tanks to recharge aquifers might be preferred means of utilizing runoff. Ways including land consolidation and the distribution of government or "waste" land could be explored, in the right context, to make it possible for individual farmers on presently quite marginal land to engage in a type of intensive farming, based on runoff control and recycling.

The degree of necessity for such development in different SAT areas needs to be determined. What are the agricultural population levels projected for the future? At what levels will they stabilize? What will be the demand for intensification of agricultural resource use? Are some patterns preferred to others from a national point of view? Do wells and tanks, to mention only two options, suit the climate, soils, and geology of an area? Do wells and tanks offer more economical and simpler organizational options than ponds? In any particular case, these questions need to be considered in detail by physical, biological, and social scientists. Social organizational insights also need to be expanded by further study. We submit, however, that the distinctions drawn here between rule-based and decision-based behavior, and between the functions of large and small groups, will prove to be of importance in such assessments and in the design of agricultural technology to meet the needs of the SAT and other areas.

REFERENCES

Binswanger, H.P. and Ryan, J.G. 1980. Village-level studies as a locus for research and technology adaptation. Pages 121-129 in Proceedings of the International Symposium on Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer, 28 August - 1 September 1979, ICRISAT, Patancheru, A.P., India.

Binswanger, H.P., Virmani, S.M. and Kampen, J. 1980. Farming systems components for selected areas in India: evidence from ICRISAT. ICRISAT Research Bulletin No. 2, ICRISAT, Patancheru, A.P., India.

Doherty, V.S. 1980. Human nature and the design of agricultural technology. Pages 107-119 in Proceedings of the International Workshop on Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture, 19-23 February 1979, Hyderabad, India. ICRISAT, Patancheru, A.P., India.

Doherty, V.S. and Jodha, N.S. 1979. Conditions for group action among farmers. Pages 207-223 in John Wong, ed. Group Farming in Asia. Singapore:Singapore University Press.

Jodha, N.S., Asokan, M. and Ryan, J.G. 1977. Village study methodology and resource endowments of the selected villages in ICRISAT's village level studies. Economics Program Occasional Paper No. 16, ICRISAT, Patancheru, A.P., India.

Kampen, J. 1980. Farming systems research and technology for the semi-arid tropics. Pages 39-56 in Proceedings of the International Symposium on Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer, 28 August - 1 September 1979, ICRISAT, Patancheru, A.P., India.

Krantz, B.A., Kampen, J. and Virmani, S.M. 1978. Soil and water conservation and utilization for increased food production in the semi-arid tropics. ICRISAT Journal Article No.30, ICRISAT, Patancheru, A.P., India.

Ryan, J.G. 1974. Socioeconomic aspects of agricultural development in the semi-arid tropics. ICRISAT Economics Program Occasional Paper No. 6, ICRISAT, Patancheru, A.P., India.

Ryan, J.G. and Pereira, M. 1980. Derivation of empirical models to predict runoff on small agricultural watersheds in the semi-arid tropics. Pages 128-141 in Proceedings of the International Workshop on the Agroclimatological Research Needs of the Semi-Arid Tropics, 22-24 November 1978, ICRISAT, Hyderabad, India.

Ryan, J.G., Sarin, R. and Pereira, M. 1980. Assessment of prospective soil, water and crop management technologies for the semi-arid tropics of peninsular India. Pages 52-72 in Proceedings of the International Workshop on Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture, 19-23 February 1979, Hyderabad, India. ICRISAT, Patancheru, A.P., India.

Appendix 1. Land, crop, and water management improvement strategies proposed for SAT agricultural areas

Major problem area	Specific problem	Solutions proposed
Drainage	Stagnation and waterlogging	Land shaping; planting on grade; beds and furrows where appropriate; comprehensive drainage on an integrated, small watershed basis.
	Erosion	Land and water management measures as for stagnation and waterlogging; grassed waterways; permanent drop structures in waterways: fast, efficient crop establishment in the rainy season since crop cover is the most important erosion alleviator.
Moisture deficits	Timeliness and precision of operations	Use of improved, bullock drawn tool carrier for faster and more efficient land preparation and seeding; use of improved seed drills and fertilizer applicators to increase efficiency of use of water and nutrients by seedings.
	Increase rainfall storage in the soil profile	Tillage and planting on grade; broad beds and furrows where appropriate.
	Make use of runoff water for crop production	Collection and use of runoff water in ponds, for lifesaving or supplementary irrigation or both. Construction of larger reservoirs (tanks), for gravity irrigation.
	Use of groundwater	Examine potential for wells of different types in the SAT, and for improving groundwater availability.

Appendix II. Anthropological evaluation of proposals for improved agricultural land, crop, and water management in the SAT

Improvement	Group action involved	Probabilities of success
Land shaping	Decision based or rule-based agreement for an essentially one-time, short term activity.	High likelihood of organizational success for individuals or small groups. Possible high cost, relative to returns realized at a low level over a long term, may require government subsidy, or organization, or both in order to initiate such activity.
Planting on grade, with or without beds and furrows as appropriate	Decision based activity: adoption requires farmers to balance levels of labor and other factors available, against costs in time and effort of setting up and maintaining a specific land management pattern which may require long term as well as short term patience to realize results.	Best confined to within-field patterns for individual farmers at first. Minor field boundary reorganization problems may emerge; if use of the new techniques is profitable enough, individuals or small groups can be expected to adjust these on their own.
Watershed based drainage improvement with or without grassed waterways	Only rule based cooperation would be required if governments were to install the system and protects it legally thereafter.	High probability of success if imposed and then backed up by rules. Preference for systems using existing field boundaries as runoff removal areas, to the greatest extent practical.
Grassed waterways	Rule based acquiescence, at least, is required since waterways serve the watershed as a whole whether or not they cut across field boundaries.	Where the waterways could control runoff fully, little particular objection to the definition of waterways within fields was experienced in on-farm experiments carried out in southern SAT India.

(appendix II contd.)

Improvement	Group action involved	Probabilities of success
Grassed waterways (contd.)		However, these experiments revealed severe difficulties with establishment of the grass itself and this in turn made control of heavy runoff very difficult in some cases. Solution of these technological problems is probably more important than group action, if leaving waterways in grass is to prove more profitable to farmers than plowing and planting the waterway area along with the rest of the field.
Improved, bullock drawn tool carriers and attachments	Complex system involving many variable decisions.	High probability of success for individual ownership whether exclusively for own use or for hire. Little or no probability of success for joint ownership by small groups of independent farmers.
Ponds for runoff collection and use	Decision based or rule based activity by small groups of farmers or by individuals; depending on watershed size, landholding patterns, and cropping patterns.	Very low probability of unsupervised success for groups, given size of group and type of activity involved, if water were to be used in a flexible manner on a changing mix of dryland crops. Indications are that such ponds could be used by individuals where land holding size permits, or that they could be used by groups in a less flexible manner.

(appendix II contd.)

Improvement	Group action involved	Probabilities of success
Tanks for runoff collection and gravity irrigation	Rule based activity most likely.	Governments would be likely to be interested in tanks as in this case government supervision would be likely to realize a relatively high rate of return. More research needs to be done on types of area-based drainage and runoff collection, and on the types of institution required to support these both for pond and for tank irrigation.
Open wells	Both decision based and rule based use are possible.	Studies in VLS villages show that small groups of farmers who own shares in the same well are able to cooperate on the basis of simple, invariant rules. More research needs to be done on wells as an indigenous focus of group action, which could perhaps be improved for greater SAT crop production given the right institutional structure and given increased research and development on ground water recharge and use.

kms301081