RULES AND PROCESSES: DIVIDING WATER AND
NEGOTIATING ORDER
IN WO NEW IRRIGATION SYSTEMS IN NORTH SULAWESI, INDONESIA

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RULES AND PROCESSES: DIVIDING WATER AND NEGOTIATING ORDER IN TWO NEW IRRIGATION SYSTEMS IN NORTH SULAWESI, INDONESIA

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This study examines the nature of water allocation in two new farmer-managed irrigation systems in the Dumoga Valley of North Sulawesi, Indonesia. The purpose of this research is three-fold: 1) to identify the social and physical aspects of these systems which influence how water is allocated among farmers' fields; 2) to analyze the interplay between rules and processes of farmer interaction; and 3) to examine the equity and efficiency of water use by farmers.

Two Balinese subak, or irrigation associations, were selected for comparative study. The two systems differed in age, whether or not they were incorporated into a larger system, and the nature of landform and design layout.

Data collection between December 1981 and April 1983 covered two rice cropping seasons. It involved interviews with farmers, field observations, and technical measurements of water supply, demand, and allocation.

The basic rule of allocation in these systems was one of proportional shares, based upon the distribution of an equal

amount of water per unit of land area. Farmers viewed the water share rule as only a first approximation for allocating water. Through interpersonal interactions among farmers, a mutually recognized set of criteria emerged to justify temporary but repeated adjustments in the division of water.

Neither differences in system age nor in incorporation into a larger system significantly influenced water allocation. However, in both systems the topography and design of the systems had a substantial impact on the structure of water allocation; the formal roles of the subak and its officers and the interpersonal processes in water allocating were similar; and the observed patterns of adjusting the division of water were directed toward reducing variations in water adequacy, study findings indicate that the effective allocation of a collective resource in certain settings can be realized without formal or hierarchical control.

Biographical Sketch

Douglas Lynn Vermillion was born in London, England on April 21, 1952. Because his father was in the United States Air Force, he moved repeatedly between locations in the United States and the United Kingdom during his first eleven years. When his father retired from the Air Force in 1963 the family settled in Spokane, Washington. He graduated from Ferris High School in Spokane in 1970. After attending Brigham Young University in Provo Utah for one year, he went to the Philippines for two years as a missionary for the Church of Jesus Christ of Latter-Day Saints. He earned a Bachelor of Arts in Political Science from Brigham young University 1976. In 1978, he completed a Master of Arts degree in Political Science, with a major in Public Policy Analysis, at the State University of New York in Binghamton. Also in 1978, he began work on a Doctor of Philosophy at Cornell University. His major field was Development Sociology, with minors in Research Methodology and Asian Studies.

He married Mickey Paxton in Provo, Utah in 1975. They now have three children, Michael, Christopher, and Rachel.

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Kelly smurthwaite converted sketches into professional-looking maps and helped with typing and other graphics work. Caroline Rumsey did the final formatting and printing of the thesis.

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CHAPTER ONE

Introduction

This is a study about the nature of water allocation in two new irrigation systems in the Dumoga Valley transmigration area in North Sulawesi, Indonesia. The two systems are new Balinese sukak, or irrigators' associations. This study identifies the social and physical factors which are related to the processes of water allocation. It examines the processes whereby rules and rights for water allocation develop. It then analyzes the affects of such processes upon the equity and efficiency of water allocation at the level of field channels and farm intakes. This study engages two basic theoretical problems in sociology. The first of these is the question of the basis for social order. In particular, we seek to understand the nature of the interplay between rules and social interaction in the early stages of the evolution of two new social organizations, which in this case are irrigation systems. The second problem is that of cultural ecology, which is concerned with the interplay between the physical environment and social organization. In particular, we seek to understand how the physical setting and design of these irrigation systems influence the character of the water allocational rules and interactions among irrigators.

1 Evolution of this Study

In the course of graduate study at Cornell University, my studies centered on rural development and the sociology of natural resources. Partly because of the experience and expertise of faculty and graduate students, I became interested in the possibility of conducting field research on the social organization of irrigation in Indonesia. I was especially interested in participatory approaches to development which attempted to build on tradition or local knowledge. It seemed to me that the acceptance of such approaches depended upon the demonstration of farmer capabilities and the relevance of such capabilities to development.

Much of the literature on irrigation and social organization was about long-established institutions. Often social organization was depicted as relying primarily on long-established rules and structures. I detected a normative or rule-centered bias. There seemed to be a tendency for studies in cultural ecology to look at the group or community level (as opposed to the level of intra-group interaction) and to convey an image of harmony and static equilibrium.[1] It seemed to me that there was a need for more detailed analyses of the interactive processes (e.g., both between irrigators themselves and between irrigators and the environment) and the actual outcomes of irrigation (e.g., efficiency and equity of water allocation). Especially needed, I felt, were analyses which could integrate hydrological, agronomic, and sociological data in order to get a more balanced perspective of the interaction between man and the environment. Also there seemed as yet to have been little attention given to new irrigation systems, especially in relating system design to the organization of water allocation and in observing the interplay between water rights and processes of social interaction.

[1]More will be said about these biases in section two.

I became interested in research on irrigation because of its practical relevance to world food resources and its interesting sociological challenge of understanding social interaction and collective action. In the literature on world food issues there was a general assumption that urgent needs to increase world food production could be made in large part only "by the rapid expansion and modernization of irrigated agriculture" (Doorenbos, 1975:39). However, many studies of irrigation systems (especially those large in scale) in developing countries expressed concern about the poor performance of irrigation systems, especially the reported lack of efficiency and equity of water use and poor system maintenance (Steinberg, et al., 1983; Bottrall, 1981). Bottrall (ibid., p. 73) has noted the

> growing realization that much of the poor performance (in irrigation systems] steins from fundamental weaknesses in the human processes of planning and management, which no amount of investment in technological hardware is going to overcome on its own. (cited in Uphoff, et al., 1985)

The blame for poor water management has been directed toward both governments and farmers. However, officials of governments and development agencies tend to emphasize the inadequacies of farmers in water management, often basing assertions on highly general information and superficial indicators such as whether or not formal water users associations exist and whether or not they perform the tasks governments have prescribed for them (Steinberg, ibid; Colombo, et al., 1978).

In a study on irrigation in Indonesia prepared for the World Bank, Nyberg and Prabowo (1979) concluded that "the greatest potential for improved water management is at " . . . the farm level water distribution system." However, the study contained little if any information and analysis about what farmers were actually doing and why so, relative to irrigation. Policy prescriptions for irrigation performance often emphasize creating or improving canals and other physical structures at the tertiary level of irrigation systems and developing formal water users associations.'

By contrast to the image of inept, disorganized, or untrained farmers, there has been a recent profusion of social science

*See Colombo, ibid; Nyberg and Prabowo, ibid; Bottrall, ibid.

studies about farmer-managed irrigation which has suggested that farmers often may possess considerable sophistication and capacity for managing water.[1] Therefore, I became interested in conducting research on how farmers actually were organized to manage water, how they allocated it, and what were the results. Much social science literature on irrigation has focused on long-established irrigation organizations. Since substantial efforts were underway to expand the area of irrigated land in developing countries, I thought that it would be a useful complement to research on irrigation to examine farmer water management in new irrigation systems. This was at a time of increasing recognition of the importance of understanding the "learning process" of organizations in rural development (Korten, 1980).

1.1 Objectives

Given my interest in studying the capacity of farmers for managing irrigation, together with my interest in processes of social interaction in allocating resources, I decided to focus on the organization, process, and results of water allocation by farmers. I intended to examine the organization of water allocation, both its formal (i.e., more explicit, legal, impersonal) and informal (i.e., ad hoc., interpersonal) aspects. I intended to relate the organization, behavior, and results of water

[3]See for example, Coward, 1980; Siy, 1982; Duewel, 1982.

allocation to the physical setting and to local fanner conceptions about, and classifications of, the physical, technical, and social environment.

From such a study, and especially from future comparison with similar studies elsewhere, I expected that progress could be made in improving our understanding of the early development of rights, rules, and patterns of water allocation in irrigation systems.

In short, the objectives of this study are:

1) To identify the adaptive components of water allocation in the social and physical settings of irrigation systems,

2) To examine the formation of the social order of water allocation, giving special attention to the relative importance of social rules and processes of interaction, and

3) To examine the relationship between the social order of water allocation and efficiency and equity of water use. This relationship would be examined in a context of variation in water supply and demand, over time and space.

Regarding the first objective, I anticipated that both the age of irrigation systems and whether a system was an independent, community-level system or part of a large government scheme, would be two social factors which were most likely to shape the nature of water allocation in irrigation systems.

In accordance with the notion that there was a learning process which farmers in new irrigation systems might experience, I expected that the age of a system might be an important

concomitant of the nature or level of farmer organizational capacities, allocational rules and rights, and patterns of allocation (which are processes associated with objectives two and three). I had the prior expectation that a difference in the age of irrigation systems might suggest possible changes in the organizational climate through which water users associations pass in the processes of learning to irrigate in new systems.

Regarding the incorporation or not of a farmer-managed system into a large government scheme, Coward (1980:25) has noted that bureaucracies can have a profound impact on farmer water management:

> Perhaps the most serious institutional and organizational issues in irrigation development are those related to the articulation between water users and the irrigation bureaucracy.

Maass and Anderson (1978) have found that rules related to actions of water authorities of large bureaucratic systems differ from those related to actions of water users. Therefore, I had an expectation that whether a system was an independent farmer-managed system or was incorporated into a large government scheme might have an important bearing on the organization of water allocation.

I expected that topographical and soil aspects of the landform and design layout likely would constitute the most fundamental physical factors which would influence the nature of water allocation in irrigation systems. Implicit in this objective was an interest in comparing the interactions between the social and physical forces in affecting the nature of water allocation.

Therefore, with the objective of identifying the social and physical components of water allocation, I hypothesized that three particular social and physical characteristics would be important in affecting the organization and performance of water allocation: 1) the age of a system, 2) the incorporation or not of a farmer-managed system into a large government scheme, and 3) the physical setting and design layout. By the organization of water allocation, I mean the rules, rights, formal structure and sanctions, relevant ritual, factions, and relations among water users which were related to the process of water allocation. By performance I mean the efficiency and equity of water allocation.

1.2 Research Design

As a result of my expectations that the age, incorporation, and physical setting of systems might have important implications for the organization and performance of irrigation, I decided to do a comparative study of relatively new irrigation systems which differed according to these three factors. I decided to compare only two systems, partly because of limited research

By efficiency of water allocation I mean the amount of land irrigated in proportion to the amount of water supply available to a system. Fanners in the systems in this study related equity to the allocation of water supplies to farm plots proportional to their relative water demands (which demands could be related to variable landsize, soils, etc.). These terms are further defined and used in the analyses in Chapters Five and Six.

resources but mainly because of the intention of conducting an intensive study at the level of interactions among farmers.

In Indonesia the most likely places to find new irrigation systems were transmigration areas in the outer islands. Gloria Davis, an anthropologist who had done research in Parigi, in Central Sulawesi, suggested to me that the Dumoga Valley of North Sulawesi might be an ideal location to study new irrigation. Apparently the soils in the area were more fertile than those in many other transmigration sites, partly due to the proximity of active volcanoes. Moreover, there were both farmer and government-built irrigation systems in the area. After extensive inspection of numerous possible research sites, I selected two systems for intensive study. One was a twenty-eight hectare river diversion system built in 1977 by Balinese transmigrant farmers of Desa Mopugad. The second was a thirty-eight to forty hectare system originally built by Balinese transmigrant farmers of Desa Werdi Agung in 1969~70, which subsequently had been incorporated into the Kosinggolan Scheme of the Dumoga Irrigation Project as Tertiary Block Eighteen. In Mopugad the main offtake was a farmerowned concrete weir. In Werdi Agung it became Gate Eighteen. Although both systems were relatively new, the system in Mopugad was only five years old and the system in Werdi Agung was only thirteen years old at the time of my field research.

There was one characteristic which was "held constant" in the interest of simplifying the comparison. Both systems were, at least nominally, Balinese subak. I was intrigued by the question of what a new subak would be like. Much had been written about their elaborate forms which had evolved over several centuries.[5] This approach slightly resembles the approach taken by Lewis (1971) who studied irrigation among the Illocano in Northern Luzon in the Philippines. He made a comparison of irrigation in two different kinds of physical settings (e.g., upland and lowland) while keeping the cultural background in both locations the same. This approach has its limitations. We may identify certain themes in the broader Balinese cultural landscape which have an affinity or logical consistency with the observed rhetoric and styles of waterrelated social interaction. Such cultural themes may appear to be related to the process of water allocation, but the extent to which such cultural features constitute necessary or sufficient conditions for the kind of behavior and outcomes observed can only be determined, if at all, through future cross-cultural, comparative research.

The conventional rule in comparative research is to use only one comparison variable. And yet I began the research with the assumption that since I was only comparing two small systems I should be able to directly observe the relationships (and elicit farmers' perceptions of the relationships) between water allocation and system age, independence/incorporation, and landform.

[5]See Chapter Two for a discussion of the traditional subak and how they have been perceived by outsiders.

I anticipated that these respective relationships would be more visible at the micro-level of observation and therefore I would not have an unknown black box of "confounding effects" which often restricts macro-level comparative studies.

I used the three criteria of system age, incorporation into a large scheme, and the physio-technical setting for selecting the systems for an intensive case study comparison. There was some expectation that these three criteria might be related to the rules and processes of water allocation. Although the two systems were selected partially to determine the effects of age, incorporation, and physio-technical setting on the social organization of water allocation, I was not guided by, nor was I testing, a formal theory about these suspected relationships. My method was to combine the techniques of ethnographic interviewing and participant observation to gradually understand the local organization, indigenous classifications, logic, behavior, and results of water allocation.[5] Using these site selection criteria prior to field research was an effort to improve the chances of studying a setting where important and insightful phenomena related to water allocation could be examined. There was more concern with discovering the local order of water allocation than with testing preconceived hypotheses. I was attempting to discover relationships and perhaps to generate hypotheses for future comparative research.

[5]See Spradley, 1979, 1980, for descriptions of these methods.

In the contrast between "confirmatory" research (which emphasizes the testing of formal hypotheses brought to the field a. priori) and "exploratory" research (which emphasizes discovering local categories and interpretations), this study more closely resembles, although it does not fully exemplify, the latter orientation. The use of the term confirmatory here is associated with the logical positivist approach which seeks to explain causal relations through deductive, nomothetic generalizations, which are standardized, universalistic statements abstracted out of time and location. By the term exploratory, I mean analysis which seeks to generate and test "grounded theory" (theory derived from field research which uses operational definitions based on locally used or emergent categories).' In accordance with my research objectives and preliminary observations in the field, four basic research questions soon emerged in the field and directed my data collection thereafter. These were:

1) "What were the influences of system age, incorporation or not into a large scheme, and physio-technical setting on the nature of water allocation?"

2) "What was the relative importance of social rules versus processes of interaction in affecting water allocation?"

3) "What was the nature of the relationship between water scarcity and management intensity?" and

4) "Did interpersonal interaction among water users function in the direction of enhancing

'See Glaser and Strauss, 1967; Spradley, 1979.'

the equity of water allocation beyond that permitted by the proportional share system?"

The first research question (e.g., effects of age, incorporation, and physio-technical setting) grew partly out of issues raised in the literature on irrigation management (referred to above) and partly out of my preliminary observations while visiting potential research sites.

The second question (e.g., rules versus interactive processes) emerged after a brief period of interviewing farmers in the selected sites and observing them irrigate. I became aware that there were substantial differences between official rules and policies and actual processes of allocating water.

The third question (relating water scarcity and management intensity) was prompted both by an awareness of sociological and engineering literature which mentioned this relationship and by my own preliminary interviews and observations in the field. However, while other researchers had used more formal or official indicators of management intensity,• it became apparent that I would have to collect data in accordance with a different kind of operational definition of management intensity. So much of the allocation process was handled by interpersonal adjustments

•These included what this author considers to be various operational definitions of management intensity. These include policies of rotational or continuous flow (svendsen, 1983; Levine, 1982), organizational structure (Mitchell, 1977), or the imposition of standard riparian versus prior appropriation rules (Downing, 1974).

that I had to measure these adjustments as constituting a local form of management intensity.

The fourth question (e.g., whether interpersonal interaction enhances equity) also emerged from preliminary observations of water borrowing practices and through farmer explanations of the justifications for such practices (i.e., that they tended to be related to directing more water supplies to plots which had either relatively higher water demand than other plots, chronically inadequate supplies, or both). Hence, data on relative plot level water demand, supply, and supply sources was collected.

1.3 Data Collection

My period of field research was between December 1981 and April 1983. I used various methods to obtain data on what I gradually discovered to be the range of social and physical elements of water allocation in the systems. From key informants such as subak leaders or other respected and knowledgeable fanners, I obtained information on such characteristics of the irrigators as landholdings and tenure, religion, areas of origin in Bali and prior agricultural experience, and present status in village leadership roles. I also obtained information through informal interviews about the formation and organization of the two subak. Subak leaders and my assistants drew maps of the systems which were improved over time.

From interviews with fanners, either encountered in the fields or in nearby homes in the desa (village or town), I obtained data on how farmers identified and classified aspects of their physical and social environment which were related to obtaining water for their sawah (irrigated rice) fields. 1 obtained data from direct observation and discussions with farmers throughout each system about the relative water allocation practices of all irrigators. Since the systems were small especially in terms of numbers of farmers (see Chapter Four), I aimed at total enumeration instead of data from samples, with the exceptions of data on percolation and seepage, water coverage, and total landholdings, noted in the following chapters.

1.3.1 Interviewing My assistants and I regularly talked with fanners encountered in the field about farming and water-related matters, especially those related to water allocation practices, disputes, and attitudes. Most farmers were met and interviewed individually. There were numerous times however, when we discussed things as a group. In such group encounters matters were discussed of a less sensitive nature which did not require the confidentiality offered by individual conversation. We obtained views of farmers throughout the systems about which aspects of the physical environment they felt were relevant to water allocation practices and what the farmers' conceptions of "permanent" and temporary water rights were. I also asked about water borrowing practices and asked farmers to compare the fields of their channel neighbors according to these physically relevant characteristics and behavior patterns.

All discussions were in Indonesian. Nearly all farmers could speak Indonesian fluently. I used three kinds of questions when talking with farmers. First, I asked open, descriptive questions in order to encourage fanners to convey their own terms and attitudes about actions and events related to irrigation. Examples of this kind of question are, "Could you tell me how you prepare your land if there is a shortage of water?" "Could you tell me about the argument between Pak Tangkas and Pak Maning over the fish pond?" and "How do you feel about the water rotation arrangement?"

Second, I asked typological questions which were aimed at eliciting classifications. I asked such questions as: "What kinds of soils do farmers' plots have along this channel?" "what are the different ways by which farmers borrow water?" "What kinds of disagreements about water have occurred in this subak?" "What are the obligations connected with becoming a member in the subak?" "What kinds of crops do farmers grow on their other fields?" and "What are the reasons why some farmers borrow water more than others?"

Third, on the basis of what I was learning about local terms, I asked contrastive questions which were intended to clarify the differences in meaning between the categories used by farmers about physical and social factors which were related to water

allocation. Such questions were more structured than the two types just mentioned, but they were structured in locally relevant ways. Examples of this kind of question included: "What do you consider borrowing and what do you consider stealing?" "What's the difference between Pak Mekar borrowing water and Pak Pujo doing it?" "Who tends to talk with affected farmers before borrowing water from them and who doesn't?" and "Why do farmers sometimes care about their fields going dry and other times apparently they do not?"[1]

Sometimes in the field when observing something, such as the intake to a farmer's field being shut, I would test the farmers' application of these concepts by asking contrastive questions such as, "Do you consider this stealing or borrowing?" Generally such questions would elicit explanations of the meaning of the terms being contrasted, even if they did not quite fit the situation. Farmers were self-conscious about such things and were quick to correct my terms if misapplied.

I tried to not take notes, if possible, during interviews. Interviews were recorded in small notebooks which were later transcribed onto large index cards.

1.3.2 Field inspections Through two planting seasons (June to September 1982 and December 1982 to March 1983), beginning at transplanting of the rice crop, formal inspections of each of the

[1]For a detailed discussion of these kinds of interviewing techniques, see Spradley, 1979, whose work partly influenced my field method.

two systems were conducted. This was done three times weekly during the first few weeks of the first season and thereafter twice a week through the rest of the first season and the entire second season (with a few exceptions). An assistant and I inspected all channels, water division points, and plot intakes in each system." Actual depth of water coverage was measured during the inspections at selected upper-end and lower-end observation plots along different channels. This was measured by the following categories: dry, puddled, under two cms, two to four cms, four to eight cms, and over eight cms. There were ten such plots in Mopugad and fifteen in Werdi Agung. The location and method used for each observed case of altering the water division was recorded,[10] including information on who gained and who lost water from such alterations. This enabled periodic measurements of where water actually was being allocated around each of the systems, through the seasons observed. Field inspections were usually conducted early in the morning so that part of the inspection occurred before most farmers arrived at the fields. We alternated the order of inspecting different parts of the systems.

Various exceptions were made to this general pattern of inspecting the systems, usually for different logistical reasons. Nevertheless the procedure used seems to have been adequate for

[10]See Chapter Five for a detailed description of the methods used for making such alterations.

providing a representative picture of water allocation through the two seasons observed. This seems to be so because the general picture provided by this observational data is supported by the qualitative statements and descriptions of the farmers regarding soils differences, water borrowing practices, and the borrowing patterns among farmers.

By direct observation and discussions with farmers throughout each system, I identified which of the following potential sources of water were available to each farm plot: intakes from channels, neighbor's drainage, streams or ponds, or groundwater return flow. I noticed that variations in the availability of such water sources was important in the rhetoric of farmers about water allocation and it seemed to have an impact on the patterns of allocating water, as was later discovered in the analysis (see Chapters Five and Six).

I understood irrigation to be a socio-technical process of adapting to a physical environment. Therefore, I assumed that an analysis of irrigation which only examined the social aspects would be incomplete and possibly misleading. Levine (1982) and others[11] have suggested that there was a close association between the ratio of water supply to demand in a system and the intensity of management of farmers in allocating water. This relationship in turn was said to have a bearing on the efficiency and equity

"See for example Svendsen, ibid; Oad, 1982; Mitchell, ibid; Downing, ibid.

of water allocation. I assumed and eventually observed that farmer behavior of allocating water was closely influenced by the ratio of water supply and demand (as measured spatially and over time, through planting seasons). In order to calculate system water supply I measured irrigation discharge and rainfall. To calculate system water demand I measured soil percolation and seepage and evapotranspiration rates. A detailed description of the purpose and method of this water balance analysis is included in Chapter Six.

2 A Sociological Basis for Interpreting Water Allocation

In this section we will discuss a few pertinent conceptual issues in social science which relate to the sociological interpretation of water allocation and water rights. Since the allocation of water among fanners involves both rules and processes of social interaction, we will discuss how social science has conceived of the interplay between these two phenomena. Since water allocation is a process of social adaptation to the physical environment, we will discuss the sociological basis for interpreting this process. Also, water is a form of property and its allocation implies considerations about justice. We will briefly discuss the analysis of water allocation as the social disposition of property.

2.1 Rules and Processes

In searching for the basis for social order, social scientists have tended to emphasize the importance of either rules and institutions on the one side, or else the processes of social interaction, on the other. This divergence between what has been called the "rule-centered" or "normative" approach and what is called the "interactionist," "interpretive," or "process" approach constitutes a fundamental paradigmatic cleavage which reverberates across the disciplines of social science (Giddens, 1979) .

Differences between rule-centered and interactionist approaches can be contrasted, respectively, in the political science of Almond and Powell (1966) or Easton (1964) *versus* Cindblom (1965); in the theories of administration of Herton (1968) or Dror (1964) *versus* Simon (1957, 1976); in the sociology of Parsons (1964) or Coser (1956) xexsus Garfinkel (1967) or Turner (1962); and in the anthropology of Radcliffe-Brown (1952) *versus* Malinowski (1926).

The nature of the opposition between the normative and interactionist perspectives is well known, so only a brief comparison of their respective underlying assumptions will be necessary here.[12] Both the insights and the shortcomings of each perspec-

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"For a critical comparison of these two paradigms in sociology, see Wilson, 1970. For an excellent comparison of these two paradigms in anthropology, which attempts to partly integrate the two, see Comaroff and Roberts, 1981.

tive help clarify the basic issue around which this study is addressed, namely, how to explain the order and results of water allocation in the new irrigation systems.

In essence, the normative view explains social order as being grounded in commonly, and often tacitly, understood norms or precepts. Rules, values, and action are internalized through enculturation and reinforced through social institutions. Hence those in society who challenge or break social norms (which are assumed to be logically consistent), in this view, tend to be defined as deviants, rather than as innovators, or just common opportunists.

This approach has an affinity with the notion, which can be traced back to Hobbes (1968 [1651]), that society can not have order or purpose without thoroughly pervasive and comprehensive social rules. Also, society must have centralized institutions of authority and control to enforce or reinforce its norms.

If we followed the normativist or rule-centered view in interpreting the social organization of irrigation, we would be inclined to posit that a rational allocation of water (i.e., efficient and equitable, however defined) would depend upon a comprehensive set of specific rules and expectations about water rights, which is commonly understood and complied with by the water users. These rules would be understood within a more general sociocultural context of potent norms and values. And they would be reinforced by formal institutions, such as: sanctions against water theft, scheduling of water deliveries, laws

about water rights and shares, leadership roles, membership requirements, and system maintenance obligations.

Blumer has said that symbolic interactionism" has the following basic premises:

1) "human beings act toward things on the basis of the meanings that the things have for them,

2) the "meaning of such things is derived from, or arise out of, the social interaction that one has with one's fellows," and

3) "meanings are handled in, and modified through, an interpretive process used by the person dealing with the things he encounters." (1969:2; cited in Spradley, 1980:8.9)

The interactionist perspective, then, does not deny the existence of culture, but it tends to see it as a medium or a kind of grammar whereby people interact in meaningful ways. Interactionists see man as culture interpreters and creators."

The interactionist approach objects to the rule-centered view on three basic grounds. The first objection is that the rule-centered view cannot account for the regularity and profoundness of conflict and negotiating in society. Norms do not

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"In sociology and anthropology, interactions!sm most often means symbolic interactionism, which appreciates culture as a medium for interaction. However, there is some variation in the degree of importance interactionists assign to culture, from the psychologism of some game theory (Axelrod, 1984) to the near normativism of Geertz, 1973, 1983.

"Frake, using maps as a metaphor for culture, puts it: "People are not just map-readers; they are map-makers. People are cast out into imperfectly charted, continually revised sketch maps. Culture does not provide a cognitive map, but rather a set of principles for map making and navigation." (1977:6-7; cited in Spradley, 1980:9) seem to be so commonly understood within societies, nor do they appear to determine behavior in some direct or mechanistic way. Interactionists respond that social action is guided primarily by expectations about obligations, rights, and threats which develop in the exchanges of social interaction. Therefore social order is ultimately based on the process of interaction rather than on norms and institutions.

Second, interactionists tend to object to what they see as an "oversocialized" or "overdetermined" conception of human consciousness and action (See Wrong, 1961). Malinowski, a prominent critic of the rule-centered perspective, insisted that humans are highly self-conscious about the rules and institutions of their own societies. He depicted man, in everyday circumstances, as continually testing, manipulating, and exploiting (when possible) rules and institutions in his own self-interest (whether "enlightened" or not). Behavior could not be understood merely as compliance with norms.

Third, interactionists object to the static view of society imagined by the normativists. Normativists, it is said, could not adequately explain social change, which interactionists assert is a continuous reality in society and which is brought about by the diversity of interests, values, power, and strategies of social actors.

If applied to irrigation systems, the interactionist perspective would logically tend to focus on the nature of negotiation.

trading, borrowing, dispute or other forms of exchange between water users. The importance of rules about such things as water eights, water distribution schedules, or system maintenance procedures tend to be downplayed, perhaps either by considering rules as epiphenomena, arising out of social interaction (perhaps in support of powerful interests), or else as a personal resource, an exploitable rhetoric for public consumption.

And yet the compelling interactionist criticisms of the normative view involve some rather questionable, if not unrealistic, assumptions themselves. Writing about Malinowski, Hamnett (1975:7) notes,

> The Trobriander, from being an automaton enslaved by custom, becomes at a stroke a utilitarian positivist endowed with a nice sense of individual costs and benefits. This second stereotype is scarcely less implausible than the first. (Quoted in Comaroff and Roberts, 1981:16)

If one adopts the view that social order is the result of the competitive interaction of utilitarian individuals rather than the result of constraining rules, we are left with the problem of explaining why social rules are so pervasive in society and why they "sometimes constitute elaborate repertoires," as Comaroff and Roberts (ibid) have put it.

Comaroff and Roberts (ibid:17) point out that:

> Once process is linked with utility—whether utility be conceived in terms of the universalist maximization of interest or the pursuit of indigenous values—it is a short step to treating the sociocultural context as "given" and its relationship to dispute as unproblematic. Any utilitarian conception of man that does

this, whether it is clothed in substantivist or formalist analytical terms leaves the same issues tas the normativists] unresolved: wherein lies the systematic relationship between rule and process? (Clarification in brackets inserted by this author)

In as much as normativist arguments which undervalue the importance of interactive processes are inadequate, so too are interactionist views inadequate which fail to recognize the influence of social rules in shaping the style, if not also the directions, of social order. Either extreme tends to reduce the relationship between rules and processes to a simplistic depiction of reality.

It would be inaccurate to convey the impression that the criticisms of these perspectives equally fit the work of all those who are generally classified into one or the other perspective. The purpose of delineating these two paradigms in somewhat distilled condition has been to clarify the issues of a conceptual framework about the relative importance of rules and interactive processes. This framework provides a necessary sociological bearing for our evaluation of the relative accuracy of the rule-centered versus social interactionist perspective in interpreting how water is allocated in the two irrigation systems in this study.

2.2 Adaptation Through Social Interaction

2.2.l Adaptation as result or process? The static equilibrium models of adaptive societies commonly portrayed by cultural

ecologists,[15] are indicative of a tendency to focus on survival at the group level and on system-supporting functions of social institutions. These studies tend to depict rather elaborate, rational, and even ingenious adaptive responses which often present an ahistorical image of optimal and balanced resource use.[16] Such studies tend to be about social groups of a relatively small, traditional, isolated, unstratified, and stable nature.

These tendencies have three consequences. First, the possible differential, adaptive strategies and results within groups is often overlooked. Criteria of the fitness of adaptation are readily produced. They include group survival, group maximization of gene pools or group reproductive capacity, efficiency of energy use, sustainability of energy use strategies. Intra-group interaction or equity, as a criterion, usually is overlooked or else assumed (Vayda and McCay, ibid).

Second, despite Julian Steward's assertion of an adaptive culture core, there has been a tendency to assume or give the impression that the material environment is necessarily functionally related to most aspects of given societies or cultures, including technology, economics, law, politics, religion, myths,

[15]See Vayda and HcCay, 1975 for a critique and explanation of what they see as a preoccupation in ecological anthropology with static equilibrium models of adaptation.

[16]See for instance Rappaport, 1967; Conklin, 1957; or Dyson-Hudson, 1985.

ritual, and kinship. This "maximalist" tendency to link broad areas of culture to environmental adaptation can be seen either on the structural functionalist side (Evans-Pritchard, 1951) or on the materialist side (Harris, 1968) .

It is possible to define nearly all aspects of culture and social life as functionally related to the "adaptive conglomerate" of social institutions if one reifies the social system itself as an integrated, coherent, and purposive entity. This is a bit like the tautology of the "survival of the fittest" which tends to consider all species which survive as fit by definition, since they survive.

If one accepts the view that the social order is the outcome of a problematic and historically-specific interplay between social interaction and social institutions and rules, then the extent to which adaptive behavior (i.e., adaptive to the physical environment) is integrated into the total sociocultural milieu of a given society is also problematic (see Comaroff and Roberts, ibid). Furthermore, such linkages to the broader sociocultural setting could just as well be dissonant and unstable as consonant and stable. It is the assumption in this study that the extent to which specific adaptive strategies of resource management are related to the general sociocultural complex needs to be determined by observation and analysis rather than by definition.

A third consequence of the static, group-level emphasis in cultural ecology has been a failure to identify or understand the

mechanisms or processes whereby social institutions, rules, or behavior arise, become adaptive, or change. The group-level focus obscures the importance of interaction within groups and tends to create an overly-optimized view of adaptation.[17] This has prompted a wave of proposals by cultural ecologists for studies of the interactive processes among individuals within groups and to relate these processes to adaptive results, especially in terms of equity within groups (see Durham, 1974; Salisbury, ibid; and Vayda and McCay, ibid). Such a redirection is better suited to understand both the processes and results of adaptation, especially when the results are not found to be "optimal" for all members of a group.

It is the purpose of this study to contribute to the understanding of the processes involved in the evolution of adaptive rights, rules, and institutions in new irrigation systems. By our analysis of intra-group interactions among water users, we should be better able to understand how farmers learn to cope with the uncertainties and variation in new environments and to interact with those with whom they share water.

This study combines analyses of the physio-technical and social aspects of the irrigation systems at the lowest level of the systems (e.g., the individual farm-level). This is done in order to better understand the nature of water-related interac-

[17] See Salisbury, 1975, for a critique of this tendency in cultural ecology.

tion between farmers, the breadth of socio-cultural relatedness to the structure of allocation (in response to the above-mentioned "maximalist" proclivity), and the results of efficiency and equity of the observed processes of interaction.

2.2.2 Non-optimizing strategies for adaptation: bounded rationality, "satisficing," and ~~partisan mutual adjustment~~ In Weber's characterization of "rationally organized action" (1968:987), organizations seek to optimize their objectives through the systematic gathering and analysis of information, centralized decision-making, formal scheduling, and hierarchical control. Neoclassical economics similarly has assumed that decision-making involves, or should involve, complete information, objective rationality (i.e., the logical connection between means and ends), and the maximization of utilities and minimization of costs.

In reaction to what is seen as unrealistically demanding and over-rationalized conceptions of social action, Simon (1957, 1976), Cyert and March (1963), and Lindblom (1959, 1979) and others have convincingly argued that people usually do not optimize their objectives on the basis of known or assumed probabilities. Rather, they adapt to complex environments through limited information, abbreviated forms of decision-making, and incremental adjustments.

Generally speaking, despite the criticisms among ecological anthropologists and the call for greater attention to intra-group

processes, non-optimizing organizational frameworks have not been widely brought into the realm of cultural ecology." This may be because they are seen as invoking a culturally reductionist perspective. Nevertheless it seems to this author that the concepts of Simon and Lindblom are so basic as to be potentially useful within a given sociocultural context.

2.2.2.1 Bounded rationality ~~and "satisficing"~~ Herbert Simon's notion of adaptive behavior involves two basic components, what he calls "bounded rationality" and "satisficing." Simon argues that man rarely has either the knowledge or power to maximize objectives. He is faced with a complex and changing environment, information which is incomplete and not always objective, a scarcity of time, and other humans with different values and competing interests. Shorthand and subjective methods for classifying, learning about, and coping with one's environment are employed. Choice is rational in the sense that one selects a desireable alternative in accordance with one's ends. But it is a restricted kind of rationality in that it relies on shorthand and subjective methods for classifying, learning about, and coping with the environment.

The criterion for making a choice is whether or not it satisfices, or satisfies and ~~suffices~~, for decision-makers. A choice will be selected only if it satisfies a minimum, subjectively

"However, S. Kraft, 1980, an agricultural economist, has used Simon's approach to analyze the indigenous soil classifications and land use strategies of farmers in upstate New York.

acceptable level of a goal, which might be levels of profit, yield, a share of the harvest, or covering all of one's rice field with water. This criterion of satisficing works at two levels. First, a choice must satisfy consistency with a given end goal or value. Second, it must satisfy an acceptable minimum level or degree of attainment of a goal or value.

Simon asserts that the minimum threshold of acceptability for a person, or decision-making body, changes over time in response to the difficulty of finding satisfactory alternatives or obtaining satisfactory outcomes. If satisfactory alternatives and outcomes have been relatively easy to come by, then a person's minimum acceptable threshold for respective alternatives or outcomes is likely to increase. If the person experiences difficulty in finding satisfactory alternatives or outcomes, then his minimum acceptable threshold for the respective alternatives or outcomes will likely decrease." Each choice produces both immediate rewards and additional information useful for future decisions.

Relating these concepts to the example of irrigation, it might be said that levels of minimum acceptability of field water supplies (for a given crop and growth stage) would vary among farmers under conditions of scarcity. One who finds it easy to borrow water (for physical or social reasons) may be satisfied only at a higher level of farm-level supply than one who has more difficulty obtaining temporary water supplements.

"This relationship is analogous to the theory of supply, demand, and prices. However, it assumes subjective and restricted decision evaluations and is meant to apply to virtually all kinds of decisions for which time, information, control, and analytical capability are limited.

An important implication of the notions of subjective evaluation and shorthand information-processing about the environment (and in particular, the physical environment) is that man classifies his environment according to attributes which are related to adaptation. Through perception, abstraction about specifics, and generalization about particulars, humans find equivalence across particulars in the material world. Man imposes order and meaning on his relationship to a physical environment by classifying it in accordance with cultural themes and adaptive purposes (see Tyler, 1969). Such adaptive classifying can be seen as a simplifying process which shapes the way choices are posed and outcomes are evaluated.

Hence, in a new irrigation system we would expect farmers to classify aspects of their environment that relate to their adaptive purposes of acquiring and allocating water, such as soil water-retention characteristics, channel position, or variations in water sources within irrigation systems. Regarding water allocation, we may presume that farmers would classify such aspects in such a way as to make the distinctions which are needed in order to invoke, or negotiate for, environmentally discriminating behavior patterns among farmers. This may imply rankings of soil porosity or channel locations relative to other irrigators.

2.2.2.2 ~~Partisan mutual adjustment~~ Lindblom (1957, 1979) brings to the discussion of social interaction the argument that favorable or acceptable adaptive results are often obtained at the group level without centralized analysis of information and decision-making. Lindblom accepts Simon's notion of bounded rationality and addresses its implications for interpersonal or inter-group interactions.

In partisan mutual adjustment (where a rough equivalence of power is assumed to exist), organizational direction and performance evolve from the interaction of individuals, each of which has both commonly-shared and vested interests. The process of interaction may be through negotiation, verbal or non-verbal assertion of rights, bartering, deference to counterparts, or by taking actions to test the limits of tolerance of counterparts. The objectives of the contending parties are adjusted incrementally over time to determine the evolving directions of the organization as a whole. There is no centralized, authoritative, information-analyzing, and decision-making body. The interactive or incremental approach to problem solving depends less on the comprehensive and systematic uses of information than it does upon the symbolic uses of rhetoric. While such rhetoric may or may not convey accurate information, it always conveys subjective messages about explicit or implicit rights,

expectations, tolerance, or limits of tolerance. Lindblom assumes the same human limitations about information, time, and ability or disposition to analyze and optimize, as does Simon. But he emphasizes the nature and capacity of decentralized interaction, whereas Simon emphasizes the nature and limited capacity of human decision-making.

In the field of development administration it is sometimes assumed that favorable results can be achieved only by a maximization of authoritative/analytical capabilities and a restriction of interactive processes to the selection of leaders or the decision of basic policies. This attitude seems to be related to questionable presumptions about the ineffectiveness of interactive approaches to social problem solving or resource allocating. Lindblom and Cohen (1979, p. 25-26) assert that:

> What often obscures our appreciation of interaction as a method of problem solving is that interaction often—perhaps typically—produces both outcome and implementation together, as in resolving the problems of resource allocation and implementing it through the interactions of buying and selling. The problem-solving capacity of interactions is also obscured because the interactions often do not result in a decision by an official or collective authority explicitly resolving a recognized problem. Resource allocation by buying and selling requires no decision about resource allocation by anyone, nor need anyone articulate the problem of resource allocation or articulate the answer.

The process of allocating water among farmers may or may not resemble the marketplace metaphor of "buying and selling." By substituting these terms with "giving and taking," the above statement better fits the range of social interactions which occur;

in irrigation systems, such as negotiating, testing the acquiescence of others through direct assertion, bargaining, conflict, and deference. These processes may not serve to allocate resources perfectly, but perhaps "with some reduction in [the] incompetence" (ibid) of authoritative/analytical approaches which often fail to cope in complex environments.

It is conceivable that resources may be allocated relatively effectively through these varied types of interactions or partisan mutual adjustments. This may be done without a singular or authoritative understanding, decision, or schedule. Furthermore, Lindblom and Cohen imply that the interpersonal or intergroup testing of respective levels of intractability or willingness to compromise, can itself produce effective, purposive results without fully-shared or general adaptive knowledge about the environment. In other words, although respective negotiators may be asserting their demands through a common repertoire of rhetoric and classifications, agreements or adjustments may be made on the basis of the interaction alone, which do not necessarily involve exchange of information about the physical environment.

This is not to say that the often highly subjective interplay of rhetoric or assertiveness (typical of interactive approaches) is void of any beneficial kinds of information exchange, or even analysis of a sort. Interaction relies heavily on persuasion in order to make one's competitive counterparts be "converted to

allies or acquiescents" (Lindblom, 1979, p. 524). Persuasion can be considered as a form of analysis, integrating "facts," interests, and rhetoric. Hence the interactive approach recognizes that both empirical and symbolic/subjective information are used in a context where both facts and ideology may constitute forms of persuasive evidence. The important point here is that the capacity of interactive approaches to allocating resources, especially at local levels, needs to be better understood and perhaps, more accepted. Furthermore the kinds of activities, functions, and scales of organization which are appropriate for interactive approaches need to be identified.

Dror (1964) has pointed out that incrementalist or interactionist approaches seem to be best suited to relatively stable environments where fine-tuning is common and basic alterations in policy are uncommon. Under conditions of rapid change or when fundamental policy directions need to be established or redirected, more formal or authoritative approaches tend to become necessary. Hence according to Dror, interactionist methods are most appropriate where: 1) the results or performance of the basic policies are reasonably acceptable to all, 2) there is significant continuity in the nature of the problem, and 3) there is significant continuity in how the problem is dealt with.

Extending Dror's assertion to the allocation of irrigation water, we would say that interactionist approaches would be most suitable, or would be most likely to be used, where social inequalities are not severe and where allocation behavior works in the direction of counteracting the physical inequalities in irrigation systems. Also, interactionist' approaches would be suitable within a given basic policy mode of allocation (such as continuous flow or rotation) where there is continuity in the basic problem and methods of allocating water (i.e., where radical policy changes are not felt to be needed). We will now turn to a brief discussion of the property conceptions that arise as the result of interaction and adaptation in irrigation.

2.3 Water as Property

Institutions of property are based primarily upon human conceptions about rules and rights. Water may be considered as an object of property. In the formation of new irrigation systems, preliminary conceptions are forged about rights and rules pertaining to irrigation structures, land use, and water. In new systems a process begins of creating, testing, re-asserting, negotiating, and changing such rights and rules.

Following Macpherson's sociological position on property (Macpherson, 1978), we define property as both a social institution (i.e., an established practice, relationship, or organization in society) and a concept about "rights in or to things." (ibid, p. 2). Macpherson acknowledges that property both derives from and creates social relations. Property rights are created

by the negotiating, testing, and conflict of social interaction. Hence property relations are more fundamentally understood as manifestations of social relationships than as relationships between people and the material world.

The evolution of property relations has four basic components, which do not necessarily emerge consecutively. First, every property relation is based upon some overall purpose or "justifying theory" (ibid. p. 11). Second, specific rights associated with the property relation are identified and defined. Third, a recognized set of criteria evolves whereby access to rights is negotiated, permitted, or denied. For example, porous soils may become a recognized criterion or excuse for gaining access to a division of water which is larger than what is proportional to land size. Fourth, a process ensues of negotiating (i.e., creating, asserting, testing, reformulating, and integrating conceptions about rights).

Part of the process of the evolution of water rights is the development of a generally recognized range or repertoire of rhetoric about water rights. By the range of rhetoric we mean the array of criteria, rules, rationale, considerations, reasons, excuses, or objections which generally would be understood to be relevant to the property relation in question. This may be either at the level of a "justifying theory" about the overall purpose of the property relation, or else at the more specific level of what the criteria should be for permitting access to rights.

Differing interpretations at either level may cause controversy. The level and nature of controversy is influenced by both physical and social forces. One seeks to justify actions regarding water use by using elements from the locally common repertoire of rhetoric. If the criteria were not generally recognized, the negotiator would be unlikely to use it because it would not symbolically strengthen his position.

Farmers don't ask if they can borrow more water because they like to see deep water on their fields for aesthetic reasons. This would be outside of the range of generally accepted rhetoric. Even the most brazen of water thieves finds excuses from within the recognized repertoire of rhetoric, such as those of water loss rates, lack of drainage inflow, new terracing, and so on. Farmers may ignore the rules. But they cannot ignore the rhetoric, which is used to communicate to others one's interpretation or reaction to social rules. Even though rhetoric may or may not be used sincerely, it is not trivial. It is the instrument used to re-assert old conceptions or to create new conceptions about water rights.

With our notion of irrigation water as a kind of property, or a "right to a share in some common resource" (Macpherson, p. 3), the issue of equity, or distributive justice, becomes central. Levine and Coward (1985) have pointed out that the performance of irrigation systems is often misjudged by not taking into account local conceptions of equity, or the local

rhetoric of equity. However, the determination of local conceptions of equity may be more subtle and difficult than is sometimes assumed. If we take the interactionist perspective, which sees cultural norms as being more testable than determinative, and if we accept the possibility of basic intra-cultural diversity (see Pelto and Pelto, 1975), then we might expect to find that local concepts of equity of resource allocation are not necessarily clearly or homogeneously defined within many societies, communities, or even small irrigation systems.

Heath (1976, p. 134-44) has noted that social theorists have distinguished between three different concepts of justice. These are first, justice as the acceptance of "the established rights of others;" second, justice as the "distribution of benefits according to deserts;" and third, justice as the "distribution of benefits according to need." Established rights depend upon promises, agreed rules, or law. One would claim to deserve a distribution of benefits according to one's personal behavior or attributes which place one on the positive side of reciprocity relative to others. The principle of need is based on some lack, dependency, or deprived condition. The given distribution is claimed, or at least petitioned for, due to a lack of something. Access to a given share, or "extra" share, of a resource is claimed strictly on the basis of some deprivation or urgent need, regardless of one's particular standing in a pattern of reciprocal relations.

It may be assumed that as societies apply these three notions of justice, their definitions or relative importance will often be likely to come into dispute (either separately or together in competition). Regarding intra-cultural diversity and these notions of justice, Heath (ibid, p. 137) asserts that "the real world . . . so far from exhibiting the extraordinary consensus of the sociologist, is more correctly characterized by dissensus and doubt."

This framework may be applied to the question of the right-of-way of a new channel through a farmer's landholding. The members of the water users' association might argue as a body that the group has a traditionally-established right of access to direct channels, even though they may have to go through the middle of landholdings, where topography "requires" it. The few farmers who would be served by the channel may emphasize their serious need for the channel to be so located because of the need for having independent intakes; The affected landholder may protest, arguing that he deserves exemption from the right of way rule because he always drains adequate water to those below him anyway, and furthermore he needs all of his land for cultivation more acutely than do others.

In this example, the criteria for gaining access to water rights are commonly recognized. Subjectively perceived knowledge about the physical environment is communicated. Conceptions of justice and the elements of the "justifying theory" of water

rights are identified and mutually communicated. Nevertheless this rhetorical repertoire, as a local framework to establish or justify water rights, serves more as a kind of grammar for interactions than as a formula to resolve conflicts.

3 Preview of the Chapters

Chapter Two briefly describes the regional ecology of the Dumoga Valley. It includes a description of settlement, land use, and the development of irrigation in the valley. It also contains a description of the social context of the two subak in this study and a discussion of the traditional Balinese subak.

Chapter Three describes the formation and formal organization of the two irrigation systems under comparison.

Chapter Four identifies the physio-technical aspects of the two systems which are related to water allocation. This includes the nature of design layout, percolation and seepage rates, the spatial availability of different forms of water sources, and terracing and water use practices of the farmers.

Chapter Five examines the processes of interaction among water users and analyzes the social and physical components which shape the patterns of allocating water in the two systems.

Chapter Six examines the operation of the two systems through two seasons, interprets the organizational implications of the observed forms of operation and assesses their consequences for the efficiency and equity of water allocation.

Chapter Seven provides a summary of the research findings and discusses the implications of this study for future research and for the development of irrigation.

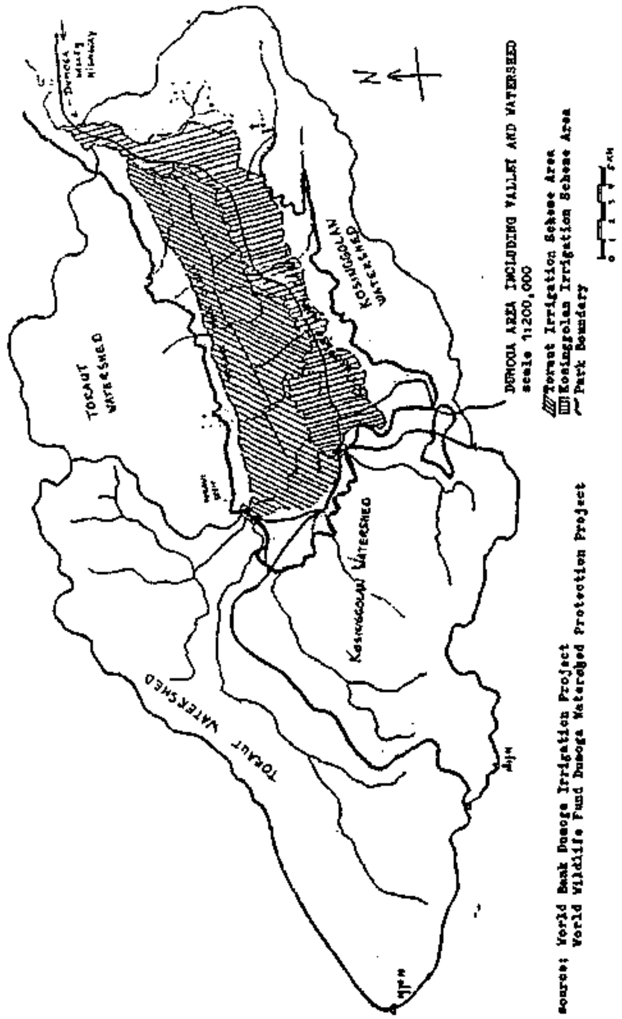
CHAPTER TWO

Physical and Social Context

1 <u>The Physical Setting</u>

The Dumoga Valley is located in the central eastern part of the province of North Sulawesi, just less than one degree above the equator. It is roughly halfway between the cities of Gnron-talo to the west and Manado to the east. Usually one can travel from Manado to the Dumoga Valley within five to six hours on a new hard-surface road. The valley is in the <u>Kabupaten</u> (Residency) of Bolaang Hongondow. The town of Doloduo, at the west side of the valley, is fifty-eight kilometers from Kotamobago. The valley floor itself is a plain of about 23,000 hectares, elongated east and west. Another 7,000 hectares of farmable, undulating land encircle the valley floor. There is a total of about 30,000 farm-able hectares, or 300 square kilometers. Steep mountains surround the valley, a few of which reach 1900 meters in elevation (see Figure 2-1). The Ongkak Dumoga River flows eastward through the center of the valley, with numerous streams flowing into it from the mountains. The elevation of the valley floor is approximately 170 meters above sea level.

Numerous extinct and active volcanoes are scattered around North Sulawesi. As a result, alluvial soils in the valley include sandy clay to clay of basaltic and volcanic origin. On the valley



Source: World Bank Dumoga Irrigation Project
World Wildlife Fund Dumoga Watershed Protection Project

Figure 2-1. Dumoga Valley and Watershed

floor they generally are fertile and well drained. Soils on the mountain slopes are shallow, medium in texture, and easily erodible.

Climatological data have been recorded by the Dumoga Irrigation Project since 1973. The average annual rainfall in Dumoga, measured over a ten-year period ending in 1982, was 1,937 millimeters (mm). Table 2-1 shows the average monthly rainfall in Dumoga.

Table 2-1

Mean Monthly Rainfall in Dumoga (mm)

Jan	142	May	155	Sep	106
Feb	163	Jun	232	Oct	69
Mar	157	Jul	155	Nov	126
Apr	229	Aug	167	Dec	210

Two annual monsoons bring rain to the area, resulting in a relatively high and stable rainfall pattern year-round. The northeast monsoon occurs between November and April. September and October are the driest months. Southeasterly winds bring rainfall between April and November. Average annual temperatures are even more constant than rainfall, varying only between 25.7 degrees centigrade in January and 26.8 degrees centigrade in August. Mean monthly relative humidity is seventy-one to seventy-two percent year-round.

2 Settlement

2.1 Orang Bolaang Mongondow

The Orang Bolaang Mongondow (i.e., people of the region of Bolaang Mongondow) have inhabited the upper peninsula of North Sulawesi for centuries. Most are Islam. They have not been influenced as much by the Portugese, Spanish, and Dutch as have the Minahasan people to the east. The Dumoga Valley itself was mostly uninhabited under the colonial period. There are only three small villages in the valley whose settlement preceded the 1930's, each of which was settled over one hundred years ago as a result of movements and interactions between the kingdoms of Kotamobagu to the east, Bintauna to the northwest, and Molibagu to the south. The oldest villages in the valley are Doloduo on the west side of the valley, and Dumoga and Pusian on the east side of the valley.

Heni Manopo, of Kotamobagu, was the last raja of the Mongondow people, reigning until 1949. He designated Dumoga as the last _totabuan_, or fertile settlement area, for the Mongondow people (especially those from the increasingly densely populated areas around Kotamobagu), including the areas of Lolayan, Kopandakan, Passi, Modayak, Mopait, and Kotamobagu. The traditional Mongondow conception of totabuan was that it was land which only could be rightfully owned by the Mongondow people. The totabuan traditionally was valued for its ability to produce a

variety of crops, spices, and herbs through shifting, rainfed cultivation. Due to traditional animistic ideas which have been mixed with the predominantly Islamic religion of the Mongondow, they considered mud to be impure and unhealthful. Even though this attitude is no longer strong, it has been a part of a traditional Mongondow aversion to working in sawah and a preference for ladang, or rainfed crop land. Even today older Mongondow people who are about to plant newly-cleared land are sometimes seen leaving food offerings in fields to ensure being on good terms with local spirits.

Traditionally, groups of Mongondow settlers were allocated land areas by the raja. Villagers were given land in blocks, as assigned, or at least as officially recognized, by the _kepala desa_, or village head. Some variation occurred between villages in the specific methods used for allocating land to villagers.

For example, Desa Doloduo had a relatively large area of land within its jurisdiction, partly because of its early settlement. Original inhabitants are reported to have come from Bintauna, on the coast to the northwest, about 150 years ago. Villagers were able to acquire land rights according to the extent of land cleared and cultivated by a nuclear or extended family, as the case may be. They tended to clear forest in skips (i.e., leaving forest-covered areas between cleared areas) so as to claim ownership over as much land as possible, claiming ownership over the forest-covered sections in between their cleared sections.

Mongondow farmers planted rainfed seasonal crops, such as sweet potatoes, cassava, beans, padi ladang, corn, and other vegetables, spices, and herbs, in one place for two or three seasons before the cultivators moved to new fields. Tree crops, especially coconut, banana, and coffee, were planted in locations where they delineated the borders of these family land blocks and also where the older family members could easily reach the locations to care for the trees, weed around them, and perhaps tend cattle grazing between them.

Desa Kinomaligan, another Mongondow village, had a different adat (traditional law) for allocating land rights. It was settled in the 1950's by Mongondow from the east. It is located in the middle part of the valley next to the present Desa Werdi Agung and had relatively less land available to it. Nuclear families and their descendants were allocated strips of land 110 meters wide, which ran from the village road to the mountain ridge on the south. Clearing and cultivation had to start at the village and progress in an adjacent, step-wise fashion toward the mountains. No skipping over forest-covered sections was allowed. Villagers said this rule was followed to make it easier to control the monkeys and wild pigs which hid in the forest. This adjacent, step-wise pattern of clearing made it easy to delineate the boundaries of a family's land. All opened land had to be under cultivation (except that which already had been cultivated) before new land could be cleared. If a family wasn't capable of clearing and cultivating new land after three or four seasons the kepala desa could assign an adjacent section of a strip to another family. If after three years a family did not clear and cultivate new land along its strip, the kepala desa had the right to give the rest of the strip, running up to the mountain, to another family. Many liked to plant tree crops because they were easier to cultivate and permitted more rapid extension of land use upwards along their strip of land, hence more readily securing the continued rights to the land for future use within the kinship group.

The Mongondow term ~~babutaan~~. means to have land taken or stolen by outsiders. Many Hongondow feel that this is what has happened in the Dumoga Valley as a result of the effects of rapid migration by non-Mongondow into the area. They express the feeling that they had traditional rights to the area as a people, but this is no longer recognized.

At first, when Minahasan or other non-government-sponsored settlers came into the area, Mongondow inhabitants, through arrangements with village heads, frequently sold their land to settlers and obtained new land themselves by clearing forest. According to local residents of the valley, many did this several times. Eventually many Mongondow found that they had given up the more valuable land in the valley floor and no longer had legal

Between 1971 and 1974, 4,500 transmigrants from Java and Bali came and settled Desa Hopuya and Mopugad. Both Javanese and Balinese were settled in each desa, but each were assigned to separate rukun <u>tetangga</u>, or neighborhood divisions. Houses were built for the settlers by the government, usually within three months after arrival. They were floorless houses, four by five meters in size, with one room and a bed. Kitchen utensils, farming implements (including saws for felling trees), and food for one year were provided. It took several months for the settlers to clear nearly all of the farm plots, using exchange labor. Soybean, corn, and rainfed rice were the first crops grown by these transmigrants. Soybean yields were roughly 1.5 metric tons per hectare. According to village leaders in Hopuya, by 1982 about fifty percent of the residents of Mopuya had purchased land. By this time 300 of the total 967 families in Mopuya were spontaneous settlers.

Many spontaneous transmigrants from Java and Bali entered into sharecropping or rental arrangements upon arrival and eventually saved enough capital to purchase land. During the 1970's resettlement and access to land could be accomplished without very much capital at the outset, as is illustrated by the experience of one young spontaneous transmigrant couple from Pujonegoro, Java, who told me of their move to Dumoga. Encouraged by news from relatives who were government transmigrants in Dumoga, they sold their motorcycle in Java for Rp. 125,000. This was their

only capital. The cost of the ship to Sulawesi and the bus to Mopuya was Rp. 65,000 altogether, leaving Rp. 60,000. They paid Rp. 50,000 to rent one hectare of abandoned sawah (owned by a Mongondow in the adjacent village of Tapodaka) for one year. This left only Rp. 10,000 for food. They had relatives who were government transmigrants and who loaned draft cattle to them for land preparation work. They were able to obtain a yield of 1.2 tons of bfiiss (milled rice) within four months, which sold for Rp. 160,000 in 1979. With this they bought one head of <u>sapi</u> immediately and continued to accumulate capital in hopes of being able to buy land within a few years.

Land rent for Mongondow fields in Desa Tapodaka was relatively low in the 1970's and early 1980's, partly because of the relative abundance of land available to residents of Tapodaka, as obtained through the bupati and camat.

The Mongondow residents were concerned with obtaining and cultivating fields in upland areas for tree crops and mixed rainfed seasonal crops. They were used to obtaining frequent but small amounts of cash for petty trading. However, they were not used to engaging in the same highly intensive cultivation practices in sawah as were the Javanese (such as plowing and harrowing repeatedly, weeding at least twice, etc.).

From the perspective of many Mongondow and Minahasan inhabitants, Balinese were especially <u>panda</u> (clever, adept) at acquiring land. One prominent Minahasan farmer leader told me that

Balinese from Desa Werdi Agung would often rent or sharecrop the land of Minahasan farmers for a few seasons. They would frequently ask to borrow tools, take grass for fodder and even some corn or coconuts, and generally make things repot (cumbersome) for the owners. After creating such a climate of bother for the owners, the Balinese would then offer more than the going rate to further coax the owners into giving up the land.

2.4 Demographic Changes

Not long ago the Dumoga Valley was nearly completely covered with primary forest. Aerial photographs taken in 1941 show only about 500 hectares of cleared land for settlements and farm land. As mentioned earlier, the original settlers were Mongondow, coming from either the east, northwest, or south.

Migration into Dumoga was very limited through the early 1960's, with settlers primarily coming from the area around Kotamobagu or from the more densely populated Kabupaten Hinahasa to the east. In 1961 there were only 8,000 inhabitants in the valley. Using the figure of 30,000 hectares, or 300 square km as the inhabitable/exploitable portion of the valley, this represents only 26.7 persons per square km.

However in 1963-64 the government sponsored transmigrants from Bali arrived and were followed by unknown numbers of relatives and former neighbors. Migration from Minahasa resumed in the 1960's after the return of calm to the region. Between

1961 and 1971, the population increased by 2.2 times, to 17,827 (Wind, 1982). This brought population density to 59.4 per square km, still no cause for concern by the government, which was intending to rapidly intensify agricultural production in the valley anyway. Between 1971 and 1974, 4,500 transmigrants were sent by the government from Java and Bali and formed the villages of Mopuya and Mopugad, respectively. Again, waves of non-government sponsored settlers followed the first set of government-sponsored transmigrants. With the completion in 1975 of the hard surface road from Manado to Dumoga, the rate of spontaneous migration accelerated, especially with an influx of Minahasans from the densely-populated sawah and ladang (rainfed crop land) areas to the east.

By 1981 the population in Dumoga Valley had grown to 48,838, an increase of 2.7 times since 1971 (ibid). By this time, the population density was already 163 persons per square km and nearly all of the primary forest in the valley floor had been cleared. Many of the hillsides around the valley floor had been deforested. Settlers from North Sulawesi now constituted roughly fifty-five percent of the valley's population, compared to being only about eleven percent in 1971. In 1981 roughly nineteen percent of the population were original inhabitants, nineteen percent were government sponsored transmigrants from Bali and Java, and about seven percent were spontaneous transmigrants from Bali and Java (ibid).

3 New Irrigation. Land Use, and the Incentive to Diversify

In the late 1930's the Dutch started to survey the valley with the intent to construct an irrigation system. The process was stopped by World War II. In 1963-64 the Indonesian government conducted a feasibility study of the area in order to implement the earlier intention of developing large-scale irrigation in the valley. Largely on the basis of the earlier design which the Dutch had partially completed, the government decided to construct two weirs, one across the Toraut River at the northwest edge of the valley and one across the Kosinggolan River at Doloduo, at the southwest edge of the valley. The main canal of the Toraut Scheme was designed to run eastward along the northern rira of the valley, with twenty-four km of main canal, 32.5 km of secondary canals and an eventual tertiary network. An estimated 7,000 hectares were to be irrigated by it. The main canal of the Kosinggolan Scheme was designed to run eastward along the southern rim of the valley, with thirty-four km of main canal, twenty-two km of secondary canals, and an eventual tertiary network. An estimated 5,500 hectares would be irrigated.

It was decided to construct the Kosinggolan Scheme first. Since construction on the Toraut weir did not begin until 1982, it will not be discussed here. Construction of the masonry weir and main canal of the Kosinggolan Scheme started in 1967. In late 1975 President Suharto dedicated the Scheme and it began

operation in 1976. Construction of secondary and tertiary canals continued until 1983. Thirteen years separated the time of the feasibility study in the early 1960s and the beginning of operation in 1976. During this time the population of Dumoga had increased by 326%, to 36,413 people. It seems that the implications of the profound changes in the population and land use in the valley which occurred during these years were not appreciated in the early planning stages of the project. The most important of these implications were the deforestation of the watershed and the profusion of farmer-built irrigation.

By 1976, when the Kosinggolan Scheme finally began operation, approximately 2,000 hectares of sawah already had been constructed by fanners within the irrigable area of the Scheme and was in continuous cultivation, generally with two crops a year. All of this was irrigated by small farmer-built structures tapping water from the numerous streams, springs, and ponds in the valley.

However, by early 1983, seven years after the scheme had been in operation, the total area of sawah within the irrigable area of the scheme had increased to only approximately 3,000 hectares. So during the twenty-year period of irrigation project identification, design, and construction by the government, only 1,000 hectares of sawah had been added by the project, whereas 2,000 hectares of sawah had been constructed and irrigated by farmers. Furthermore, by 1983 project officers finally recognized that the actual irrigable area in fact was going to be roughly 1,000 hectares less than the 5,500 hectares originally expected. This was because of there being a lower water supply than originally was expected, primarily due to deforestation.

The government tertiary development program didn't finish until 1983, but by then many fanners had already built their own temporary channels to make use of the water from main offtakes. It was unusually dry in 1982-83, but this could explain only a part of the reason for such a small increase in sawah since the scheme began operation.

There seem to be three reasons for such a small increase in sawah production generated by the project. It was not possible to quantitatively measure the impact of each factor at the time. Nevertheless they are listed in order of their estimated importance.

3.1 Farmer Irrigation

The first reason has already been mentioned. Even before the scheme began operation in 1976, 2,000 of the anticipated 5,500 hectares of the irrigable area already was sawah, due to farmer-built irrigation. Indigenous irrigation systems and the prior use of springs and streams by farmers for irrigation was virtually ignored in the design and construction of the Kosinggolan Scheme. The project either directed small rivers and streams into the main canal or, as was more common, it built underpasses to allow them to cross the main canal and be used as drains. The project defined virtually all of these natural rivers and streams as drains, straightened out many of their courses, and began regularly cleaning out the small riverbeds twice a year.

However, as it became apparent that the project's water supplies often were inadequate and unpredictable, farmers continued damming and using these small water sources for needed "supplementary" irrigation. Depending on their locations, project-hired laborers periodically would come along, weeding the small river beds and destroying the small weirs. They would tell the farmers who built them that they were "normalizing" the natural watercourses as drainageways. They told fanners that the project owned them and that they could not be blocked, or else it would obstruct proper drainage and could damage the main canal. Farmers asserted that these earth and brush weirs would collapse under high water conditions anyway, if flooding occurred.

3.2 Deforestation

The second reason for the small increase in sawah after seven years of operation of the project was the decline in the water supply to the scheme from what was originally expected, which project engineers, hydrologists, and conservationists were primarily attributing to deforestation of the water catchment area. Moreover, the dry years of 1982-83 exacerbated the water shortage in the short-term. Of the 20,500 hectares which comprise the watershed area for the Kosinggolan Scheme, more than ten percent of the forest had been cleared between 1961 and 1981. By 1981 soil erosion and siltation above the weir were becoming serious concerns to the project.

Recognizing that the conservation of the water catchment area was vital to the viability of the irrigation project, the government established a national park in 1979 to restrict encroachment and to protect flora and fauna in the mountains. A park boundary 100 km long surrounded the valley and generally was determined by steepness of terrain. At first it was set higher up the hillsides due to pressure from villagers and village heads. Later it was relocated downhill under pressure from the World Wildlife Fund, World Bank, the Indonesian forestry conservation service, and the bupati. Forest guards were hired, boundary markers were installed, and guard posts were built. Several hundred families eventually were removed to other settlement areas outside the valley and a program to reforest 750 hectares of land was begun. By the 1980s it was finally officially recognized that the irrigation project in Dumoga could not continue to be implemented apart from considerations and plans for forestry conservation and land use in the valley and hillsides. The World Bank was supporting both the irrigation and the forestry conservation projects.

In 1982 the World Wildlife Fund (WWF) , which also was involved in the development of the park, began identifying as "encroachers," those who had cleared land in the now "protected" hilly terrain within the park boundary. A representative of the WWF noted in a report that "damage of watershed forest may take several decades to recover" (Wind, 1982). Nearly all of the hillside deforestation in the park was attributed to two groups of people: original inhabitants and spontaneous migrants from elsewhere in North Sulawesi (especially Minahasa). By 1981 the latter group of hillside "encroachers" significantly outnumbered the former, due to the dramatic inmigration in the

1970s.

Settlers acquired hillside land mainly by allotment of available land by village heads or by purchase. Some gained access to land by contracting with the owner to plant, tend, and guard tree crops until maturity. Wild pigs were a serious pest and young tree crops had to be guarded constantly. The most common tree crops planted in the area are coconut, clove and coffee. During the time before the maturity of the tree crop the worker could plant rainfed seasonals (usually soybean and corn) in between the trees. When the trees began to bear fruit, an agreement usually would be made to divide the ownership of the land between the original owner and the worker. Dividing the land in half was a common term of agreement. Sometimes the owner would arrive or sell the land to the worker but retain ownership of the trees until the death of the owner or the trees.

According to a 1982 enumeration of hillside encroachers inside the park boundaries (carried out by the WWF and the forestry conservation service), only twenty-four of the 312 identified illegal farm plots (or 7.7%), had absentee owners. Of these twenty-four, thirteen had trees planted on them and eleven had rainfed seasonals only. One hundred six owner-operated plots had tree crops. Apparently then, the large majority of those clearing the forest and cultivating on the steep hillsides were settlers who acquired and worked the land themselves. Most of these were, as yet, unable to plant tree crops, either because of being unable to afford to purchase seedlings (clove seedlings were about Rp 7,000 each) or else because they lacked sufficient land to permit such diversification, and hence were dependent on seasonal crops for subsistence and more regular income. .62.5% of all so-called "encroachers" were cutting the forest just to be able to plant seasonals. The other 37.5% were cutting the forest to plant tree crops. Since only 7.7% of the "encroachers" were working for absentee landowners, this suggests that most of the 37.5% who were planting tree crops on the hillsides were doing so as part of a diversification strategy.

3.3 Reluctance to Make Sawah

A third reason for the very modest increase in sawah as a result of the government irrigation project was that some farmers preferred to plant crops other than sawah. In 1979 about 337 hectares of land within the irrigable area of the scheme were planted with coconut trees. Many farmers said that although they would prefer to plant tree crops on a plot inside the command area, the likelihood of the soil becoming too moist over time caused or would cause them not to do so.

The village of Tapodaka, on the Toraut side of the valley, was settled in 1971 with the collective intent to plant coconut trees. This group, originating from the Kotamobagu area, already had sawah, as a rule, in their village of origin fifty kilometers away. After planting 20,000 coconut seedlings, they heard about the planned Toraut Scheme and realized that their land was going to be incorporated into the system. So most of them decided to destroy the coconut trees where they existed in potentially irrigable areas. They then made over 120 hectares of sawah, in anticipation of having to make sawah sometime in the future anyway. They built two diversion structures in rivers nearby. In 1978 already 1,114 hectares of sawah existed within the proposed command area of the Toraut Scheme.

In early 1983 I and my assistants interviewed farmers in three villages (Ihwan, Wanaga Baru, Bnandi) which had land within the irrigable area of the Kosinggolan Scheme which had not yet been made into sawah. Two of the villages were in the upper part of the scheme. One was in the lower-middle section. Eighty-four farmers were identified in these villages who owned land within the irrigable area but who had not yet made sawah. Of these, we were able to complete interviews with seventy-six. Being careful not to make the respondents defensive, we asked them why their fields below the canal had not yet been made into sawah. Some mentioned more than one reason. Fifty-seven percent mentioned a lack of irrigation water, due to water shortages in the system. Twenty-six percent mentioned that they preferred tree crops on the field. Twelve percent said that they lacked the labor to make sawah and five percent said that they lacked the capital or credit. So the primary and immediate cause for not making sawah yet, according to these farmers, was insufficient water. This is not necessarily "reluctance" to make sawah. But as we will see, most farmers having non-sawah fields within the irrigation system expressed a "preference" to grow tree crops on all or part of such fields. A secondary but important cause for not making sawah yet was the desire to have tree crops, in addition to seasonals. In other words, many farmers apparently had the incentive to diversify according to both seasonal and perennial crops.

Regarding the stated preferences for land use for these fields, sixty-six percent of the farmers expressed a desire to be able to use all or part of their irrigable fields for

tree crops, aside from the question of what the water availability might actually be in the future. Of these, thirty-eight percent preferred to use all of their field for tree crops and twenty-eight percent preferred to plant both sawah and tree crops on different parts of their fields. Of the farmers who expressed the desire for tree crops on their field, seventy-two percent of them already had tree crops (predominantly coconut trees) on fields below the canal. Of the fifty farmers which expressed a desire to plant, or continue to keep tree crops on at least part of their irrigable fields, thirty-two of them, or sixty-four percent, already had sawah. Stated preferences do not necessarily indicate what the farmers will do in the future, especially if inundation of soils were to become inevitable. Nevertheless these interviews suggest that the small increase in sawah production under the irrigation project was closely associated both with water inadequacy and the desire to grow tree crops in addition to sawah.

3.4 The Incentive to Diversify

In my interviews with over 180 fanners in five desa, regardless of ethnic group, if one already had sawah, almost universally the most desired secondary crops were tree crops.[3] Tree crops were widely called the pensiun petani (farmer's pension), because

[3]Because of the constraints of time, writing space and focus, the data for these interviews were not included in this thesis.

of the security they provided in old age or if disabled. Trees demanded far less labor than seasonal crops after they matured (requiring no seasonal plowing or tilling of land and little weeding, especially if cattle grazed between trees). Farmers generally considered rainfed seasonals such as soybean and maize to be a temporary or second-best crop which was grown either until irrigation permitted sawah construction or until one could afford seedlings for tree crops.

The value of sawah was that it had high returns per hectare and was generally used both as a subsistence and commercial crop. Fanners told me that a typical "small" family of two adults and four small children consumes about 450 kilograms of rice every six months. Average reported padi yields in both Desa Mopugad and Desa Werdi Agung usually varied between 2.0 and 2.5 metric tons of betas (hulled rice). With the price in 1982 of generally Rp. 350 per kilogram of milled rice (IR varieties), a yield of 2.0 tons per hectare brought a gross income of Rp. 700,000 per harvest. However, the padi crop is more susceptible to a bad harvest, due to drought or pests, than are tree crops such as coconut or clove.

The cash earning potential of coconut trees, which is the most common tree crop in the area, is much lower per hectare of land than sawah. The typical planting density is about 120 trees per hectare. The typical yield is fifty nuts per tree every four months. At the 1982 price of Rp. 75 per nut, this

converts into a gross income of roughly Rp. 450,000 per hectare every four months.

During a bad harvest for padi, those who have tree crops, which are less susceptible to the effects of drought and are not attacked by the same pests as padi, are in a more secure position than those who do not have them. If a farmer gets disabled for a season or is too old to work anymore, he can obtain income from the tree crops, which income is not dramatically less than that of padi (if it is sharecropped). It also requires far less supervision (assuming the trees are already mature). For example, if a farmer gets disabled for a season or longer and has to use a sharecropper for the entire season, at the common rate of 50:50 shares to the owner and sharecropper, the disabled owner would get a gross income of roughly Rp. 350,000 in a good year. However the owner usually has to pay about Rp. 50,000 per hectare for the cost of fertilizer and pesticide. If a farmer uses a sharecropper for his coconut tree fields, also at the common rate of 50:50 shares, the gross income to the owner would be about Rp. 225,000, usually without any cost for fertilizer or pesticide.

Given the greater variability of yields for padi and the fact that the padi crop is limited to two crops per year in Dumoga, while coconut trees produce the above-mentioned yields about three times a year, the average difference in income between padi and coconut when using sharecroppers, is not very great.

Moreover, the timing of acquiring income with padi is limited to harvest time. With coconut trees there can be a weekly or even daily source of income, depending on the age of the trees and the schedule of work used.

This incentive to diversify, with both seasonal and perennial crops, prompts fanners to obtain land which is appropriate and available both for sawah and for tree crops. The expansion of irrigation meant that the valley floor was increasingly unsuitable for tree crops. Increasingly this meant going further and further up the hillsides for land for tree crops. Or if one had two or more fields within the command area of the irrigation system (e.g., the Kosinggolan Scheme), but had no land on the hillsides, then he may be inclined towards planting tree crops on one of the fields in an irrigable area.

4 Ralinese Socio-Cultural Context

4.1 Social Organization

Since both irrigation systems studied in this thesis are Balinese subak, it will be necessary to briefly discuss the nature of Balinese society and the subak. The subak in Bali exists within a complex social structure. In Bali there is a profusion of elaborate institutions, such as the banjar (hamlet or neighborhood association), the subak, various sorts of

voluntary associations, temple groups, and patrilineal and caste-related kinship networks.

The caste system does not take on the implications of occupational functions or ritual purity, as in India, Instead, the caste rankings imply only a modest variation in prestige and, as Geertz (1959) has asserted, it is better understood as a "title system," whereby titles are passed on patrilineally as names and identifiers of prestige. The system is made even less significant, in terms of affecting a generalized social stratification, by the fact that of the four main groups (branmana, satria, vesia, and sudra), over ninety per cent of the population are sudra, the traditional peasantry group.

What makes the whole structure characteristically Balinese, according to Geertz (1959, 1967), Boon (1977), and Hobart (1975), is that membership in these various institutions tends to be territorially and organizationally cross-cutting. Typically, members of a subak come from more than one banjar, members of a banjar belong to different kinship groups and voluntary associa-tions, and so on. Balinese society, according to Hobart (1975:-72), is "distinguished by the organized ranking of groups and social roles on the one hand, and by the values of corporate-ness and equality within groups on the other." In reference to this sense of corporateness, the metaphor of the family is often applied by Balinese to the banjar, subak, or other associations, though not imputing the element of parent-child relations.

Farmers in the subak I studied noted that the group was like a family and so they had to be sabar (patient) with one another until sejnua sudah sasiar. (all had a common understanding about group expectations and purposes). This combination of cross-cutting ties andthe general Balinese values of equality and rukun (or solidarity) within groups invokes a set of rather functionally specific social institutions, which Geertz (1967, 1972) has characterized as "mutually independent," "self-contained," "strictly defined," and "autonomous."

In such an organizationally diffused but functionally-focused climate, formal leaders of any institutions tend not to be repositories of much discretionary authority.[1] The klian, or head of either the banjar or subak, tends to act less as a ruler than as an intermediary, arbitrator, or communicator. He usually is in the role of a facilitator for forging generally acceptable decisions out of interpersonal interactions. As Geertz has noted (1959:995):

> In line with the general Balinese tendency to disperse power very thinly, to dislike and distrust people who project themselves above the group as a whole, and to be very jealous of the rights of the public as a corporate group, the klian are in a very literal sense more servants of the bandjar than its masters, and most of them are extraordinarily cautious about taking any action not previously approved in the hamlet meeting.

[1]Even the raja of traditional Bali was severely restricted in discretionary powers by his often unruly "subjects" (see Liefrinck, 1969; Geertz, 1980).

One of my informants at the subak in Mopugad noted the general lack of aspiration of members to become leaders of the subak. Members usually feel obliged to accept an office, he said, if elected by their friends. They do not see such leadership positions as opportunities either for political advancement or pecuniary reward. In fact no such opportunities are connected with such positions. Noting this, he referred to the Balinese saying that being a leader of the subak is like caring for male ducks; they make a lot of noise, but no eggs.

Also in line with this way of doing things is the Balinese (and also Javanese) tendency to use formal bodies and meetings as forums for announcing, rather than forging, policies. Regarding village council meetings in Java, Koentjaraningrat (1967:274) writes that ". . . at the official meeting his (the village head's) announcements are nothing but the final resolution of preliminary discussions. . . ."

Arguments can break out and be fully articulated in formal gatherings. But the Balinese (also like the Javanese) strongly emphasize a self-effacing appearance in public, which exhibits a refined (halus)[5] and patient (sabar) countenance. They have a pronounced aversion to becoming main (or lek in Balinese, meaning embarrassed or ashamed) in public, by having heated or kasar (rude, course) confrontations. Balinese prefer first

[5]A11 non-English terms used in this study are Indonesian, except where otherwise identified.

to formulate arrangements or resolutions interpersonally between neighbors or households, before addressing an issue in a larger, and more formal, group.[6] Hence in the subak, if there are disagreements over scheduling a rotation of water or a planting date, subak leaders tend to try to work things out interpersonally in small encounters when possible, rather than in public or formal meetings.

It is the position of this writer that such diffuse and general cultural orientations determine more the *style* of social interaction than the *content* or *outcome* of it. The choices for actions which are posed and selected, and their results, certainly are not unrelated to such sociocultural themes. But *decisions* and *behavior* are more problematic and indeterminate (relative to basic social rules), than is the social *style* of interaction (which style is used to further one's position or interests).[7] There is a difficulty in imputing causality or behavioral prediction from broad notions such as halus or malu, with their multiple, subjective meanings and even more multiple uses.

'See Covarrubias (1956) and Geertz (1973, chapter fourteen) for discussions of lek or malu in Balinese society. See Anderson (1972) or Hobart (1975) for discussions of the notions of kasar and halus in Javanese and Balinese society.'

'On this point, see Comaroff and Roberts (ibid). Referring to Bali in particular, see Hobart (ibid) and Boon (ibid). This is essentially an interactionist perspective, but one which is cautious not to undervalue, a *priori*, the importance of social rules.

Balinese society is not without contending factions and factional leaders. Hobart (ibid) analyzed patron-client relations in Bali and has shown that factions generally are backed by patrons who tend to exercise their influence through informal and often anonymous manipulations. They tend not to hold positions of formal leadership since their assertive and surreptitious role would too brazenly conflict with the culturally-favored mediator role of public office.' Instead the influence of factional leaders is founded upon "ascribed circumstance," usually as a result of "inherited wealth or extensive social networks" (p. 86) .

4.2 Balinese Society Transmigrated

What happens to Balinese society when it is transmigrated? In short, it tends to become simplified and more homogeneous. As transmigrants left Bali and settled in Desa Mopugad and Desa Werdi Agung, they broke away from more extensive kinship networks. They now lived together, in a new desa, with more people who were unrelated and who came from various parts of Bali (because of the kabupaten quota system of selection used). Now kinship groups tended to be considerably decreased in size,

'Birkelbach's (1973) survey of Balinese subak tends to support this assertion about formal leaders not being loci of wealth or high social status, at least in the subak. In his study he found an almost normal distribution across all landholding size categories owned by klian subak (with only 10.9% owning more than one hectare); 78.4% were of the sudra, or lowest, caste.

more numerous, and more equal and modest in influence. Ritual and artistic activity becomes less extravagant than in Bali. There is only one gamelan orchestra in each desa, which usually plays only once every several months, for the new year or other important events. Houses are nearly uniform, especially during the first several years after settlement, and are in open yards, not enclosed by stone walls, tall shrubs and trees, as in Bali.

The variety of voluntary organizations depicted in the literature on Bali is limited in resettlement areas, especially in the early years of settlement. Settlers in these desa had been extremely busy in pursuing the common tasks of clearing land, planting crops, obtaining cattle and additional land, and building more tolerable housing than that provided by the government.

Transmigration villages are under the jurisdiction of the Transmigration Department for several years after settlement. Land sales of transmigration lands are prohibited, generally for ten years. Numerous national public works, agricultural, health, population, education, and research programs seem to give added attention to transmigration areas. In short, transmigration towns obtain more national attention, are less autonomous, and generally are more subject to the standardizing effects of national bureaucratization than are towns in Bali. Prior to the presidential election in 1977, Golkar (the national

political party in power), in collaboration with the agricultural ministry, formally established all of the kelompok tani (farmer organizations) in the Dumoga Valley, requiring each to have a head, secretary, and treasurer. This was necessary for the farmers in order to obtain agricultural credit and extension services. In the process, all of the farmers nominally became Golkar members.

Neither in Desa Mopugad nor in Desa Werdi Agung (the towns within which the two irrigation systems of this study are located) are the <u>kepala desa</u> (village heads) elected by villagers or are they especially popular leaders. They were selected by the samat (district head) and in both desa were not widely respected by the townspeople. They had the stigma of being opportunists rather than citizen advocates. In Werdi Agung the kepala desa was an alchoholic and commonly had difficulty summoning people to his residence for official purposes. Moreover, he had married a Mongondow woman and had, at least "statistically," converted to Islam. The kepala desa in Mopugad was widely accused of being corrupt and of, among other things, selling off people's inheritance land parcels to those who paid the right price. His house had been attacked by a large group of villagers who were angered by corruption and land disputes and smashed all of his windows with stones.

However, except for those who unluckily had gotten particularly poor quality land assigned to them, most transmigrants

I knew or spoke with were generally thankful for what assistance the national government had given them in resettling and they felt that their standard of living had improved markedly over what it had been in Bali. Nevertheless, there was a widespread sentiment of suspicion and distrust, especially of the local and regional echelons of government. Rumors were regularly told of neighbors who were exploited by corrupt officials in such diverse areas as the program to extend credit to farmers to make sawah terraces, land ownership certificates, the construction of irrigation channels, the reimbursement to farmers whose fields were traversed by main or secondary canals, road construction projects, liabilities in civil disputes, and so on. The transmigrants said that in Bali corruption occurred on a relatively limited scale, but in North Sulawesi it was hebat. tremendous or dreadful.

The sense of polity or community, to the extent that it is felt by these villagers, is more present at the level of the banjar or subak than at the level of the desa. And banjar and subak affairs are of more immediate importance to the townspeople. It is in the banjar that marriages and cremations or funerals are administered, village public works projects are organized, and individual land taxes are specified and recorded. In both Mopugad and Werdl Agung, the transmigrants' land allocations were assigned first in large blocks to the banjar. Within these blocks individual parcels were randomly assigned to families

by lottery. Hence, unlike what is typical in Bali, in Dumoga field neighbors are also residential neighbors. Furthermore, the minority of transmigrants who were Christians in these desa were assigned to separate banjar than the Hindu. So there was substantial overlap in religion and banjar in the subak in the desa.

In the early stages of resettlement in these desa, socio-economic inequality was radically reduced, compared with conditions in Bali. In both desa, as is the case in most other transmigration sites in Indonesia, government transmigrants arrive with very little capital (Davis, 1977) . Families are given two hectares of land, plus three-quarter hectare inheritance plots for teenage children. Over time, differences in soil fertility, the arrival of spontaneous settlers, and differences in capacities and dispositions of transmigrants lead to inequalities in amounts of landholdings and wealth. And yet such inequalities do not necessarily quickly lead to the rise of exploitative or even patron-client relationships. Government-sponsored transmigrants of unequal landholdings have relatively little leverage over one another, in comparison with the landed/landless patron-client relationships in Bali, because they are all relatively independent landholders with at least two hectares. Landless spontaneous settlers who arrive either tend to bring more capital than government transmigrants (and hence tend to soon buy land)' or else they are close relatives or friends of government transmigrants (and hence are less subjects of exploitation than of sympathetic favors). Often land is loaned free of charge to relatives or friends who were spontaneous arrivals, The typical shortage of labor in transmigration areas tends to work in the direction of better leverage for the landless, than is the case in more labor-abundant areas, such as Bali (see Scott, 1976).

5 The Traditional Balinese Subak

Since the two systems examined in this study are, at least nominally, Balinese subak, and in order to make clear some points of reference, a brief description of the subak and a critique of the prominent writings about it are included here. Only a brief description is needed here because of the extensive descriptions of the subak which are already available.[10] Also, the main purpose of this section is to see how the subak has been characterized to date and to see what the limitations of such characterizations are for understanding, at least in the subak, the order and process of allocating water.

[3]For a comparison of the socioeconomic characteristics of spontaneous transmigrants, see TTRC (1974).

[10]See for example, Liefrinck, 1969; Grader, 1960; Geertz, 1967, 1972, and 1980; Birkelbach, 1973; and Boon, 1977.

5.1 Description of the Subak

In the sawah regions of Bali, scores of subak manage irrigation along whole watersheds, from the mountains to the sea. Although ancient inscriptions as early as 896 A.D. refer to Balinese irrigation (Goris, 1954), there is no account of how the rights and institutions of the subak emerged and changed over time. In modern times the subak is known to be identified as a contiguous area of sawah which receives irrigation water from a unique weir and main delivery canal. In the Balinese landscape of steep to level terrain, frequently segmented by deep gorges running downslope, delivery canals often run for several kilometers, connecting the sawah of the subak with its weir above. Depending on the size and landform of the subak, the water is divided into distributary channels which may constitute up to three tiers of organization: the subak as a whole, the <u>tempek</u> (main subak subsections), and the <u>kecoran</u> (the tempek subsections)...

Traditionally, there were, and are, klian (elected leaders) at each level and <u>seka yeh</u> (water teams) at the two subsection levels—to organize maintenance and water deliveries, and when needed, to settle disputes. Fines are used for those stealing water, failing to attend to maintenance duties, or otherwise failing to comply with subak rules or decisions. Funds are raised from members for system maintenance and periodic ritual services and offerings which link the rice-goddess cult of Dewi

Sri to stages in the cultivation season. All those owning land in the subak are members and are given single votes in subak decisions, regardless of their caste, kinship position, village, or amount of landholdings (Grader, 1960:271; Geertz, 1972:27).

The tenah is the basic water share which according to the literature on the subak, is based on the amount of land irrigated. But it is also used as a measure of seed and rice as well (Geertz, 1967). Geertz notes that in theory and "pretty much in fact as well," the tenah represents "exactly the same share of water supply"—throughout a given subak (Geertz, 1972:28).

In Bali, the rice growing season is divided into nine stages, each of which involves some act of ritual ceremony, offering, or prayer. These ares 1) the water opening to the subak, 2) field or terrace opening (often concurrent with stage one, unless staggered delivery occurs within the subak), 3) planting, 4) purifying the water, 5) giving offerings of holy water, flowers, and fruit to the gods, 6) reproductive or budding phase, 7) maturation or yellowing, 8) harvesting, and 9) storing the rice in the granaries. In order to spread out water demand over time, water delivery to different subak often was staggered down a given watershed, on the basis of this nine-stage cycle.

There were no centralized water authorities higher than the subak, although according to Geertz (1980, pp. 68-86), through the nineteenth century the sedahan (rent and tax collector for the lords) irregularly assisted subaks "in certain auxiliary functions of coordination, arbitration, and adjudication"—at the occasional request of subak members (ibid, p. 69). Nevertheless this official was related to the subak in a peripheral, ad hoc way, not in an authoritative, hierarchical manner. According to Geertz (1972) the subak was completely autonomous from village or other organizations and had only the specialized function of irrigating. The entire membership was the highest decision-making authority.

Hence the subak or series of subaks along watersheds have not been "hydraulic bureaucracies" requiring centralized planning, decision-making, and control. Apparently traditionally they have been decentralized, relatively autonomous, differentiated, and specialized organizations. And yet apparently they achieved region-wide and year-round stability and seemingly highly equitable coordination of water allocation (Geertz, ibid; Boon, 1977).

5.2 Critique of How the Subak Has Been Characterized

This study assumes that a perception of the interplay between rules and social interaction is fundamental in understanding the process of allocating water. We will now evaluate the prominent characterizations of the subak in light of this assumption.

This will help provide a sense of the limitations of earlier studies and the challenges for this current one.

~~5.2.1 Colonial ethnographies~~ Both F. A. Liefrinck and C. J. Grader, while under the service of the Dutch colonial government, wrote descriptions of the Balinese subak. Liefrinck (1969) served intermittently in Bali between 1874 and 1906 and wrote a description of subak in Buleleng, in north Bali. In 1938, Grader (1960) wrote a description of a subak in the region of Jembrana, in west Bali.

Both accounts offer graphic detail about the structures and functions of the subak. They present useful legal descriptions of subak offices, tasks, regulations, fees and fines, ritual obligations, and meetings. And yet in these descriptions of rules and formal institutional structure, there is no discussion of how subak rules or policies emerged or how their interpretations may have been negotiated in practice. Liefrinck describes the formal style of the subak meeting and how all significant decisions are made unanimously. Subak leaders try to achieve a consensus among members by informal, personal discussions in advance. And yet intra-group diversity or tension is only referred to in the context of violations and fines. A reader does not sense that disputes or tensions can be legitimate or reflective of ongoing processes of adaptation.

Since these studies were mostly limited to descriptions of formal structure, we do not learn much about processes of

allocating water or maintaining the systems from these accounts, either the process of interaction among members or, more abstractly, the interplay between rules and social interaction itself, or the relationship between subak processes and their physical environments.

5.2.2 Rule-centered culture core ecology The most extensive and influential writer about the subak is Clifford Geertz, who has gone beyond legal description to cultural ecology. His studies characterize the subak as an integrated technological, physical, social and religious unit. Geertz published two articles on the subak (1967; 1972) which can be described as a kind of "rule-centered, culture core ecology." These studies relate particular aspects of the physical and social environment to the formal rules and structure of the subak. They describe certain affinities among limited aspects of the socio-political, cultural, ritual, technological, and physical environment, which altogether constitute "the whole, marvelously intricate ecological system the subak represents" (1967:233).

~~5.2.2.1 Rule-centered orientation~~ Geertz's two studies are rule-centered in the sense that what is discussed are institutional forms and rules. Usually these are formal aspects rather than informal patterns or structures of behavior. Geertz depicts the subak as "differentiated, corporate, self-contained" and "completely autonomous" (1972:27). And yet he does so by referring to rules and institutions, not processes of social interaction.

The institution of water allocation by tempek and tenah is described as a "fixed pattern," as "fixed and unchanging," and as being "embodied in hallowed custom" (1967:321; 1972:28). Work groups at the tempek and kecoran levels do not function in an ad hoc manner, but as "official arms of the subak," which together are tiered to form a hierarchical "grid." He mentions the ritual "encasement" which is one of the major "regulating mechanisms" which directs the staggered order of planting. It does so in a way which is "firmly established and strictly observed" (1967:233). Where reference is made to "collective bargaining" between subak, it is done by noting that this process operates "under the governance of an explicit code of customary law (adafc) to which all in one drainage adhere" (ibid, emphasis added).

There is no discussion of farmers negotiating, testing, interacting, changing rules, or interpreting them differently. The overall impression conveyed is that of a rather mechanistic, social system where order is essentially rule-imposed. Geertz's essays on interpretive anthropology to the contrary,[11] these

"See Geertz (1973; 1983). In either work, it can be seen that interpretive anthropology for Geertz is overwhelmingly the interpretation of social interaction in light of culture. I agree with Geertz's consideration of social interaction as being culturally stylized, and hence, as being a component of culture. However, Geertz tends to emphasize how symbols, meanings, or rules shape social interaction, not the reverse. We see little interplay between social processes and rules.

studies of the subak, as with some of his other studies, show an implicit Parsonian normative influence (Rice, 1980).

5.2.2.2 Culture core perspective It has been said that these two articles by Geertz (1967, 1972) are culture core ecology. This can be said both because Geertz presents them as such and because of their methodology. In the first sense, Geertz refers to Julian Steward's (1955) idea of the culture core and adaptation in the 1972 article, "The Wet and the Dry," which compares Balinese and Moroccan irrigation. In this article he refers the reader to his book. Agricultural Involution (1963), for a more detailed description of the culture core concept, in which Geertz (1963:10) says that ecosystems

> are bounded; they do not include everything. And, so bounded, the processes by which they develop, maintain their identity, transform themselves or deteriorate, can be specified—as can the influence of the external, parametric conditions which most significantly play upon them. Cultural ecology, like ecology generally, forms an explicitly delimited field of inquiry, not a comprehensive master science.

Geertz says that cultural ecology involves both "the discrimination of the culture core (i.e., those limited aspects of culture which are adaptively relevant) and "the definition of the relevant environment" (i.e., aspects of the environment which affect or are affected by the given adaptive behavior, ibid:8). In his 1972 comparative study, he rejects "geographical determinism" or "reductive materialism" and notes that,

> environment is but one variable among many—or, better, one set of variables among many. And it is one whose

actual force must be empirically determined, not a priori declaimed. (p. 37)

It may be added that not only the force of the environmental variable, but the relative force of each of the cultural, social, political, ritual, and technological variables are to be determined empirically and locally, not assumed in advance.

In the second sense of the assertion that these studies are culture-core ecology—the methodological sense, we can see Geertz's method of using the culture core concept by the extent to which he draws the technological, physical, social, and religious variables into his analysis. He delimits what is adaptively relevant from what is not.

Regarding the physical environment, Geertz refers to the highly segmented landform of ravines and watersheds and the stable rainfall, temperature, and sunshine in Bali. He notes that the topography and climatic -constancy, regularity, and homogeneity" (1972:25) provide a setting whereby the highly intricate, organizationally segmented, densely populated, and ritually complex social order can produce a tightly coordinated ecosystem.

In the technological dimension of adaptation, Geertz specifies the array of small-scale techniques which permit a high degree of allocational control down to sub-hec|are levels, despite the irregular terrain: brush and stone weirs, tunnels, long conveyance canals, aquaducts, small distributory channels and precisely-measured proportioning blocks (or temuku).

For the physical dimension of adaptation, Geertz makes general comments about the stability of the climate, the abundance of rainfall, and the slope and irregularity of topography. He does not analytically relate actual variations in rainfall, soils or water supplies to actual subak or inter-subak decisions or disputes.

The adaptively relevant part of the social dimension which Geertz mentions is the "passion" the Balinese have for:

> organizing everything into specifically focused, highly corporate, structurally articulate, mutually independent, autonomous groups and then seeking to adjust relations among them in terms of a highly developed ritual system. (1972:37)

It is this "way of doing things" throughout the society that Geertz says is congruous with the stable climate and segmented landscape. Geertz notes that this pattern of social organization pervades all aspects of the social life, including the subak. Regarding the ritual dimension, only the part of Hindu Bali which deals with the ceremonial sequences in the cultivation stages of the rice crop is brought into the analysis. This aspect is related to the Balinese form of irrigation because of its role in establishing a mechanism whereby staggered water delivery can be ordered within and between subak, thereby spreading out over time the peak water demand periods among subak.

In many of his other writings Geertz presents a rather "maximilist" perspective of cultural interpretation (i.e., that in order to understand behavior one must know about virtually all aspects of the sociocultural context, see Geertz, 1973). However, when examining the adaptive nature of the subak, he employs more of a "minimalist" method by identifying only a core of related physical and social components. This is a useful and parsimonious approach to relating a broad range of adaptively relevant forces.

And yet these studies have the same limitations as do many group-level, ahistorical studies of cultural ecology. They describe a contemporary, harmonious equilibrium, and long-established adaptive form. There is little sense of change, interaction, conflicting interpretations of rules, or the formation of new rules.

5.2.3 A Revised rule-centered approach In his more recent book on the nineteenth century Balinese polity, *Negara*. Geertz (1980) demonstrates a noticeably more flexible and dynamic perspective of Balinese irrigation. This study can be considered as a revisionist rule-centered approach because in this work reference is now made to processes of informal or ad hoc negotiating and competition within subak and between them. However, since the book does not examine specifically any such processes in his analysis of the subak, it can not be considered as a fully interactionist perspective.

Geertz notes the prevalence of "day-to-day problems of adjustment" which arose due to local ecological variations and needs for coordinating water deliveries and cultivation

activities. The often informal and ad hoc system of "case-by-case adjustment" was functional because of the stability and form (or "continuity," to hack back to Dror) which was provided by ritual and customary law. As Geertz (1980, p. 83) describes this,

> Just as, in a particular subak, a particular cultivator had to adjust his activities to those of his immediate neighbors, either personally or through the mechanisms of subak government; so also, among subaks, each subak had to adjust its activities to those of its immediate neighbors. Indeed, it was only because the mechanisms for such subregional adjustment were so well developed, and, an exception now and then aside, so effective, that regional coordination could be accomplished through the agency of a ceremonial system which was only minimally reinforced by superordinate political authority.

Regarding conflict, Geertz (ibid., p. 82) says that it, was absorbed in parochial, case-by-case, ad hoc [sic] settlements between the subaks themselves, rather than rising to more exalted, and more explosive, levels. . . ."

There were no centralized water authorities higher than the subak, although Geertz mentions that throughout the nineteenth century the *sedahan* (rent and tax collector for the lords) irregularly assisted subaks "in certain auxiliary functions of coordination, arbitration, and adjudication"—at the occasional request of subak members (ibid., p. 69) . Part of the reason we now get a more interactionist image, than in the earlier studies, is because Geertz is referring to relations between the nineteenth century state apparatus and localities.

It is asserted that this more recent treatment by Geertz of the subak is only partially, rather than fully, interactionist because all of these references to ad hoc adjustment, negotiating, and conflictual interaction are only qualifications of the institutional analysis. They are abstract asides, apparently intended to convey more of a dynamic and flexible image than his earlier writings. There is no specific examination of actual disputes, negotiations, experimentation or other processes of interaction which occurred and shaped the social order.[12]

In summary, these studies of the subak have three common limitations: 1) they do not examine interactive social processes within the subak; 2) they do not examine the organizational implications of physical variations within subak lands or between them; and 3) they do not examine the observed results of irrigating for equity and efficiency of water use within subak. This has created an image of a static, long-established, tightly cohesive, formal and elaborate organization which can be understood primarily by reference to its rules, cultural norms, and general environmental setting. Rules appear to be logically consistent and determinative. Such images convey the impression that there is little independence, tension, or mutual causality between rules and processes of social interaction.

[12]This is perhaps partly because of the limited nature of the historical materials with which Geertz had to work.

By contrast this present research focuses on water-related interactions, physical variations, and equity and efficiency within the subak. It is hoped that this study, in combination with the earlier writings, will help to provide a fuller understanding of the subak, and more generally, of the nature of allocating a collective resource.

6 Summary

This chapter has discussed the physical and social setting and cultural background of the two farmer-managed irrigation systems in this research. The two systems exist in a location of intense government efforts to intensify agriculture. One might ask whether or not the government's large-scale approach to irrigation development in the Dumoga Valley was apropriate, when judged from the criteria of the high costs involved, ecological considerations, existence of natural and diverse small-scale water sources, farmer principles of land use, the relatively extensive farmer-developed irrigation and sawah which had come about spontaneously and prior to project completion, and finally, the relatively small increase in the current and expected area of sawah within the command area since the irrigation system had been in operation. No doubt there were some improvements to the existing farmer-built systems, but they were at a heavy cost.

Referring to the opening of Dumoga Valley for rapid agricultural intensification through large-scale irrigation development, a World Wildlife Fund report (Wind, 1982, p. 9) noted that:

> A gradual growth and small-scale development are much preferrable to fast developments under large-scale investment projects in order to plan a development based on ecological principles.

With the decision to develop the valley primarily via a large-scale irrigation project, an assumption was made that converting most of the valley floor into sawah would be a transition uniformly desirable to local fanners. Originally the project was conceived as an engineering effort requiring little more than information about the physical environment. It wasn't until 1979 that the park was established for watershed protection. Finally the project participated in an integrated development plan in 1982 and a land tenure/land use study in 1983. By then it was apparent that the independence of fanner settlement and land use priorities were having a profound impact on the project and the valley. Hence the project missed the opportunity of adapting its plans, in the early stages, to local cropping and land use strategies. Yet it is quite possible that if there had been no large-scale development of irrigation in the valley that the forestry conservation project might not have been developed at the same time.

In designing and constructing the irrigation system, a conventional non-participatory approach was followed. This meant both the neglect of integrating prior farmer-built structures into the design and the neglect of local knowledge in designing and constructing the tertiary network.

Concerning the distribution of water, in 1982-83 project officers of the Dumoga Irrigation Project were debating the issue of what the long-term response should be to the fact of having less water available than anticipated in the original design. One proposition was to stagger water deliveries and planting seasons in three or four large blocks across the system. It was assumed that staggering at a high level in the system would permit continuous flow irrigation at the tertiary level. The other proposition was to have continuous flow at the main system level and let the farmers stagger and rotate water deliveries within tertiary units. The latter proposition implied more faith in the capacity of fanners to allocate water than did the former proposition. The former proposition had more support by the time I left the field.

The capacity and methods of farmers for allocating water at the tertiary block level, and their implications for efficiency and equity, are the issues addressed in the following chapters of this study. Two small systems are compared in order to analyze the relationships between the systems' physical, agronomic, and social components. Finally, the actual efficiency and equity of irrigation in these systems is related to the interaction of these components.

This chapter has provided a brief overview of the salient physical, historical, and social context of Dumoga Valley, with added emphasis on the two transmigration towns within which our two irrigation systems exist. The valley itself has a rapidly increasing population, a diversified agriculture, and numerous kinds of settlers, varying in the recentness of settlement and in the nature of their prior agricultural experience.

However, as we have seen and as should become more apparent in the remaining chapters, the immediate social settings of the two subak in this study are relatively homogeneous and simple ones. The subak are closely associated with their respective residential and religious communities. We will see that the Balinese aversion to strong formal authority, the sense of rukun or solidarity, and malu or public shame, are consistent with the style of interactions observed among water users. Also these characteristics provide a social context within which particular equitable patterns of water allocation rights and behavior evolve.

CHAPTER THREE

Formation and Organization of the Two Systems

1 Introduction

This chapter has two purposes. The first is to describe the formation of the two systems under comparison, including reference to the nature of the landform and the corresponding layout of the hydraulic design of the two systems. The second is to discuss the nature of the formal organization of the two systems, giving attention to the interplay between rules and processes of interaction among irrigators. This will provide us with a sense of the context within which the process of water allocation occurs in these systems.

2 <u>Formation of the Subak in Mopugad</u>

2.1 Beginnings

In 1973 government-sponsored transmigrants from Bali began to arrive in the area north of the village of Doloduo and formed the village of Mopugad. They came from most of the twenty-six kabupaten (or residencies) of Bali, in accordance with the regional quota system being used at that time. Each settler family was allocated a block of 1.75 hectares of land in addition to a household plot of one-quarter of a hectare. The locations of the farm plots were selected by a lottery run by transmigration project officers. Hence, farmers who obtained agricultural plots at the site of the present irrigation system in Mopugad were not farmers who originated from the same regions or kin groups in Bali. These transmigrants came from the areas of Tabanan, Den Pasar, Klungkung, and Karangasem. Most had been sawah cultivators, but a few had not known wet rice cultivation and irrigation until they learned it from their field neighbors during and after the formation of the irrigation system. However, most farmers in the system (with the exception of a few share-croppers and new members) belonged to the same newly established banjar and all were Hindu Bali.

Three months after arrival, the settlers began the cumbersome work of cutting and burning the primary forest which covered most of the prospective agricultural land allotted to the Mopugad transmigrants. Virtually all of the settlers soon began cultivating soybean, after clearing their land. Soybeans were often intercropped with corn and were planted three times a year. The land proved to be well-suited for soybean cultivation and farmers obtained average yields of fifteen karung. i.e., 100 kilogram sacks, or 1.5 metric tons, per hectare.

In July 1975, farmers who held land below the site of the present weir and on the west side of the small Mopugad River met together as a group of thirty to discuss the implications of an expected imminent decline in soybean yields. On the west a steep ravine ran diagonally southwestward. This was

met by the village residential boundary on the far west and southwest sides of the area. To the southeast was the boundary with the Javanese village of Mopuya and to the east was the river. Farmers in Mopugad were still getting approximately fifteen karung of soybeans per hectare, but they knew such intensive and successive plantings would soon deplete soil fertility. Furthermore, the burgeoning influx of governmentsponsored and spontaneous transmigrants was rapidly expanding the area planted in soybean cultivation. Local prices for soybean were sure to drop eventually.

The group decided to attempt to build a weir across the Mopugad River and build irrigation channels to serve the area. Given the depth of the gorge and the estimated range of depth of the river, it was decided that the weir would have to be built of concrete. They agreed each to donate Rp. 15,000 to purchase fifteen sacks of cement each, for a total of 150 sacks. Two leaders were selected, Pak Sulawa as the head, and Pak Maning as the secretary. Both were very energetic and strong-willed. The former had had long experience in sawah cultivation in one of Bali's most agriculturally sophisticated and intensively irrigated areas near Den Pasar. Pak Maning, who was in his early twenties at the time, lacked prior experience in either sawah cultivation or irrigation, since he originated from a vegetable and tree crop area near Karangasem, in eastern Bali. But he was the only member of the group who had attended and was graduated from high school. Thus he could keep records and serve as a liaison between the group and the local and outside officials who would eventually want to extract information from, or extend it to, the fanner group. He was one of the few who spoke Indonesian upon arrival in North Sulawesi. Together, the two men represented different age groups, regions of origin, and modes of expertise.

It was agreed that one more soybean crop would be planted before they would begin to make sawah terraces. In the meantime, they would construct the dam and the first set of channels. As surely as predicted, the yield of this very next soybean crop did drop, down to between eight and nine karung per hectare. (By 1983 average reported soybean yields in the area were only about seven karung per hectare.)

2.2 The landform and the Designing of the System The fields which were to be served by the new farmer-built irrigation system lay at the mouth of a small canyon, where the waters of the Mopugad River rushed out onto the valley floor and shortly thereafter converged with the main river in the center of the valley, the Ongkak Dumoga River. At this time only dense forest covered the steep walls of the canyon. The soils had been formed from volcanic as well as sedimentary parent rock and were a medium-textured, sandy loam or loam. The fields were part of a small, alluvial fan which was spread out in a

double cone-shaped fashion and was rippled with four slight, well-rounded ridges. Two of the ridges were prominent and were at about forty-five degree angles to one another. Each ridge had minor ridges that branched out from the center of the system going in opposite directions. The slope of the land was roughly two to six percent, being steeper in the upper reaches. If an observer stood in the lower middle of the present system and looked northward toward the canyon and the abrupt mountain ridge on either side, one would see the river moving diagonally to the right, about three hundred meters away, in a gully. To the left were four hundred meters of fields. A steep and deep gorge, about thirty to forty meters wide, separated the first row of village houses from where the observer stood. This gorge extended about a third of the way up into the system, cutting between the lower reaches of the two more prominent ridges. The terrain was one of divergence and convexity.

Just before the weir was constructed, the secretary of the subak, Pak Maning, approached some engineers from the Dumoga Irrigation Project and asked that one of them visit the site and offer advice about how the fanners could build their dam. The engineers, busily completing the Kosinggolan Main Canal on the southern side of the valley, declined the invitation. It was understood that in a few more years another large weir and canal would eventually be built by the government to serve Mopugad on the north side of the valley. So they decided, as

Pak Maning said, to Pakai otak kami sendiri, "use our own brains." During the dry season of 1977, twenty-five farmers worked for one month (in between the work of soybean cultivation) to build the concrete dam. A brush dam was built temporarily, to divert the river water to one side while half of the dam was going up on the other side. Upon completion, the dam was one-and-a-half meters tall and ten meters across.

It took another two months for the members of the group to build the main canal and secondary canals A, C, D, and E (see Figure 3-D,[1] in addition to cultivating the soybean crop. All members worked together on the main canal and channel C, taking three days to build the main canal up to where it runs into channel C. Channels D, E, and A were each only 200 to 250 meters long and so were built by only the users of these channels. Even though not all subak members were to use channel C, they all built it together because, as Pak Maning said, "It was so long" and it would have been "too great a hardship" for the few users to work alone. The main canal was dug running diagonally downward and away from the river to the west. After four hundred meters, it met the top part of the present system (Plots Ml and M2 were not terraced until two to four years later).

[1]The plot and channel codes on the map were arbitrarily assigned by the author.

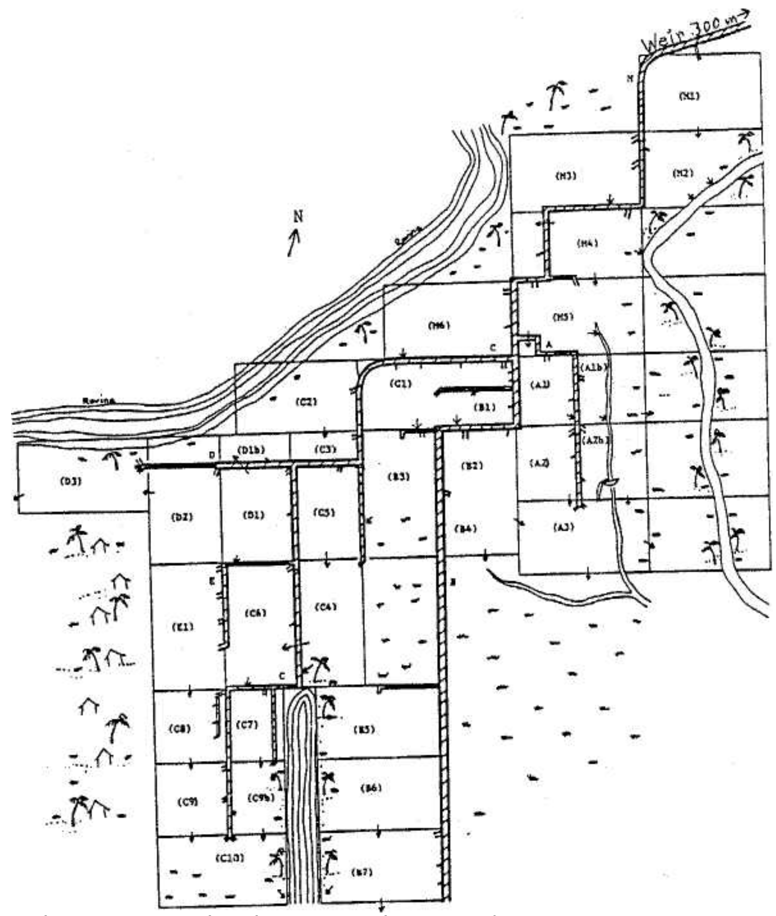


Figure 3-1. Irrigation System in Mopugad

Channel C was built branching out to the left (as one faces uphill) to follow the prominent ridge in that direction. It then turned southward where channel D broke off due westward to follow a minor ridge to meet plots D2 and D3. Originally channel D had an offtake channel which reached plot El. But after trying this, the owner of plot El decided the flow wasn't adequate (due to high water loss along channel D, which runs close to the ravine to the north). *So* he built channel E and gave up the other route. Channel A was built following another ridge running to the east and south. Channel B wasn't built until 1981, when there were finally at least two farmers below plots B2 and B4 (B3 and B5) who were ready to give up soybean for sawah and requested a channel. Since channel B was to be six hundred meters long, its construction was considered too burdensome for users and so the entire subak membership worked together to build it in two days. Within two seasons after its completion, two more farmers (at B6 and B7) began using the channel as well. While most of the basic channel layout was constructed at once, it should be kept in mind that the amount of land actually irrigated grew more gradually. By 1978, there were only eight hectares of sawah in the system. There were numerous other minor design modifications> and additions which were made between the original construction in 1977 and 1982-83.

During the initial channel construction, greater priority was given to follow the high ground and avoid depressions than was given to follow landholding boundaries. This expedited construction of the channels. It was understood that if a farmer later wanted to shift a channel over to his landholding boundary, he could do so, if he used his own labor and did not create any new problems with the channel slope or with water access for other users. For instance, at first the main canal cut through the middle of plot M3, which was still mostly forest then. The following year, when the owner was ready to make sawah, he moved the canal over to follow the right-side boundary. In another case, the main canal originally cut through the middle of plot H5 but was moved to the boundary by the owner after the first season.

According to what is typical in Bali, land tax deductions have been given to farmers having fields which were transversed by subak channels. The subak itself did not reimburse farmers for the channel rights of way through the middle of landholdings. No land tax adjustments are made in North Sulawesi for landholdings transversed by farmer-built irrigation channels. The subak opted not to provide any reimbursement to such fanners. However as we will see, there are subtler forms of reimbursement for such farmers, which are tolerated. These include the existence of additional intakes or intakes which are wider than the standard division or share of water. By the term "standard division of water," we mean the configuration of water proportions which are formally or officially established throughout the system, at each level, based on land size.

The water was divided at channel division points and field intakes by small proportioning weirs called tem*uku*. These were made by putting flat-bottomed notches in wooden logs. Notch widths for field intakes nominally were set at ten centimeters per standard field size of 1.75 hectares. Those who had channels cutting through the middle of their fields, such as plots Al, A2, C5 and D2, were permitted two intakes, one for each side of the channel. However, the intake notch width for these intakes generally were set at six or seven centimeters. This allowed the combined intake notch widths of these plots to reach about twelve to fourteen centimeters, as compared with the ten-centimeter standard. The one exception to those who had channels cutting through their fields was M4, a top-ender. H4 only had one intake, but the inflow was larger than the others because of being at the top. Furthermore, the main canal cut deeply through his land and the left side was nearly too high to be served by an intake without building a rather large stick and stone drop structure. So he used a wooden aquaduct over the main canal to connect the two portions of his field.

All of the terracing was done individually, using one pair of sapi (cattle, not water buffalo) per field. (Sapi were in good supply in Dumoga by this time.) An informant told me that

the terracing was done individually instead of collectively, using gotong royong or exchange labor, because prior to each season all the terracing had to be done at the same time. Terracing by the use of exchange labor would have caused too wide a range in planting times, causing some fields to be too late for land preparation, since the usual high rainy period would have passed. Although the flow of water from the main weir was usually large and fast, the terracing process used very large amounts of water, so rainfall was a necessary supplement. High rainy periods generally occurred twice a year, in Hay and June and in November and December. Hence it became the norm to plant two padi crops per year. This pattern was also related to the use of a local rice variety called MR, which took nearly five months from broadcasting to the harvest. Each season a farmer usually was able to make no more than three or four terraces, or up to one-quarter of a hectare of new sawah. At this rate a field of 1.75 hectares took about seven seasons, or three and a half years, for terraces to be made over the whole field.

2.3 Landholdings and Tenure

As one might expect in a resettlement area, the average amounts of land held by farmers in the system is rather high, compared to the typical amount of landholdlngs which they had had in Bali, which generally-were on the order of between oneeighth and one-fourth of a hectare per family.* The average total amount of land owned by the members of the subak in Mopugad was approximately 3.7 hectares.[1] Forty-three percent owned two hectares or less and forty-three percent owned between 2.1 and 4.0 hectares. Fourteen percent had more than six hectares of land. Nearly all of the land owned outside of the irrigation system is a mixture of land planted with rainfed seasonals (especially soybean and corn) and tree crops (especially coconut and some clove).

Differences in landholding amounts did not represent different factions of power or interests in the newly-settled village. Nearly all of the members of either subak were owner-operators. The few who were renting water were either sharecroppers, land renters, or new owners of the farms who were not yet ready to pay membership fees. Hy informants and I identified four irrigated farm plots (out of thirty-four plots in the system) which were not cultivated by the immediate families of owner-operators during at least one of the seasons observed.

'Landowners in the village of Tihingan (near Klungkung), which was studied by Geertz (1967), had average landholdings which were higher than those in surrounding towns. And yet the largest landholder in the village had only 3.3 hectares. In Birkelbach's (ibid.) survey of subak in Bali, ,*eighty-nine percent of the klian subak held one hectare of land or less.

[3]These data are based on a fifty percent random sample in Mopugad. Figures on the landholdings of the subak members were supplied by subak leaders.

These were at plots M2, C3, B6, and D3. Of these, sharecroppers at M2 and C3 were relatives of the owners. Those who owned more land than their family could cultivate usually preferred to work in the sawah themselves and have sharecroppers or tenants work on their rainfed land. However, a few other plots sometimes had sharecroppers to help work a small portion of an owner's field, while the owners worked the rest.

We will see that water allocation in these systems is largely a process of personal interactions and that the formal organization of the two systems function less to program behavior to achieve results than to provide a stable setting whereby adjustments can be made with more or less generally acceptable, rather than exploitative, results.

A definition of the use of the term "formal" is in order here. By formal, we mean laws of the subak and procedures which are based on subak offices or meetings. The established rules and rights of members and leaders, decisions made by the subak membership as a whole, or decisions or actions taken by a subak

[1]After leaving the field I discovered some discrepancies in my notes about these data which mean that it is possible that there were a few more than four plots with sharecroppers on them. Based on what I knew about who was operating most of the other plots, I have concluded that there could have been no more than eight plots which used sharecroppers.

leader by virtue of the authority of his position as such, are all formal aspects of the subak because they involve subak laws, offices, or meetings. Interpersonal actions taken which are not based on subak laws, offices, or meetings are not considered herein as part of the formal structure or function of the subak.

3.1 Leadership

When I came to Mopugad in early 1982 to conduct this research, the leadership positions of the subak in Mopugad were the same as when it was first organized. These were the Kepala (head), sekritaris (secretary), juru pengairan (water master) , and bendahara (treasurer), to use the Indonesian terms which were locally used.

This simple structure was commensurate both with traditional subak organization and with the nominal government stipulations of the structure of kelompok tani. This system had not yet been made into a P3A (Perkumpulan Petani Pemakai Air), which means "water users association," and so it did not have any of the standardized rules for sanctions or maintenance which the government was attempting to impose on irrigation systems.[3]

The role of sekritaris in this subak involved a much more active and prominent role than that usually implied in the western

[5]The P3A is a nation-wide designation for water users associations which have been formally established by local government authorities and whose by-laws are written and authorized at the provincial level, by the governors.

notion of a scribe or secretary. He was just as likely as the head (the klian in Balinese, or kepala in Indonesian) to be consulted by water users in case of complaints or occasional requests for official permission to borrow water or formally schedule a water turn (usually when the water supply was severely limited). In fact, due to the abrasive personality of the head, several members preferred to deal with the sekritaris. The sekritaris was just as likely to conduct subak meetings as was the head and was even more likely than the head to meet with outside officials or disseminate information to the members. This nearly equal status of the two roles was partly due to the fact that the head was hot-tempered and was less well-liked than the secretary, and that either one was so busy as frequently to be absent from the area.

Pak Maning, the sekritaris, owned six hectares of land besides his sawah field (three hectares planted with soybean and corn and three hectares planted with coconut). He also owned and often drove a mini-bus between Mopugad and the city of

'Literature which refers to officers in the traditional Balinese subak other than the klian or head, depicts them as fulfilling more subordinate roles than that of the sekretaris in this subak. Geertz (1980:186) refers to the assistants of the klian as "messengers" or "policemen." Grader (ibid.) refers to the "helpers" of the klian as assistants or "criers," whose number depend on the size of the subak and how many tempek, or sub-sections, there are. He notes that the general term used for subak functionaries was penyarikan unbali, which he translates as "a person who makes notes." No mention is made of an officer who is strictly a scribe (in the western sense) nor of one who roughly equals the klian in authority (as was the case in this subak) .

Kotamobagu (the headquarters of the kabupaten, or residency, sixty kilometers away). The head of the subak had been able to acquire ten hectares of land besides his sawah field, and this was planted with soybean and corn and tree crops. While both of these men used sharecroppers on some of their rainfed land, they still worked parts of it and frequently were present on those fields to supervise. The presence of either man at the irrigation system often was unpredictable, except at periods of peak labor demand, such as at land preparation, transplanting, and harvest. During periods of off-labor demand they would go to the sawah, at least to inspect the water flows, about three to five times a week.

The juru pengairan in this small subak served a latent function of being the third person to contact, if one could not reach the head or secretary. The system was small enough that the head or secretary could fulfill the roles of communicator, mediator, and occasional permission-granter. The members contacted the secretary or head when official sanction was sought, but this was infrequent. The users preferred, whenever possible, to work things out informally to avoid the embarrassment of being perceived as soliciting favoritism, pulling rank, or presuming that one's modest problems merited official action.

The subak had five rather amorphous sub-sections, referred to by the farmers as "sub-kelompok," which constituted the most common level at which water borrowing tended to occur.

The phrase "tended to" is used because this configuration changes to different groupings, as will be seen, in response to different degrees of water stress and different periods in the planting season. Each group had a nominal kepala, or head. These individuals acted to coordinate, not sanction, arrangements made among channel neighbors. They had no discretionary authority above that of the channel neighbors. Hence, for definitional clarity we will consider actions at this level to be informal and interpersonal since they do not involve subak offices or meetings.

These five sub-kelompok were constituted as follows (with the sub-group plot code of the "heads" being underlined): 1) Ml, M2, M3, M4, M5 (the subak secretary), M6; 2) A1, A2, A3; Bl/Cl (the head), B2, B3, B4,B5, B6, B7; 4) C2, C3, El, D2, D3; and 5) C5, C6, El, C7, C8, C9, C10. (See Figure 3-2 for a map of the locations of these groups).

Although the secretary told me where the groups were and who the leaders were, other members at different times identified different groupings. I came to realize that this was because they perceived these groupings as dependent on the nature of the particular need for staggering planting dates or rotating water. Usually they would form each time as a result of informal arrangements made by any of a number of channel neighbors. When the members of the subak referred to any of these leaders and what function they served, it was often done with the

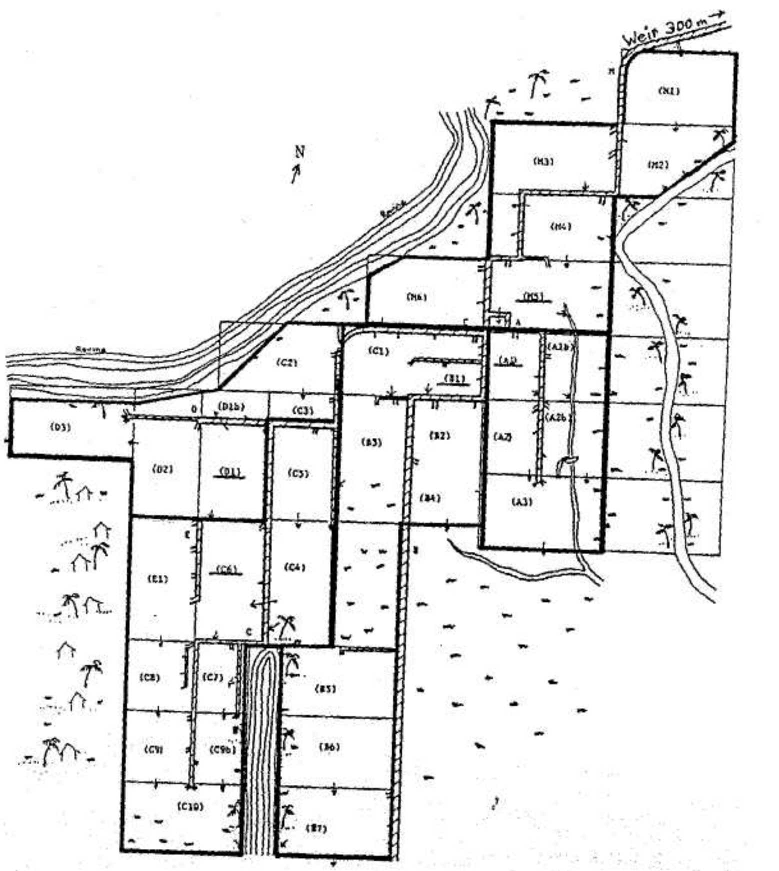


Figure 3-2. System in Mopugad with Sub-Sections Delineated

implication that they represented channels of communication or points of contact which could perhaps lend some legitimacy to personal requests to borrow water. Even the lead role of the leaders was perceived as one of clarifying and implementing group policies, not making them. The members themselves proposed and decided upon planting dates, the necessity for water rotation, what the lines and periods of rotation should be, and so on. Such decisions involve a complex array of considerations such as individual labor constraints, soil differences, credit constraints, family problems, different sizes of plots and differing terracing designs.

3.2 Water Distribution, Planting Dates, and Sanctions At those times when formal rotations of water turns were requested and/or implemented, the particular arrangements were often controversial. For instance, there was a tendency for those having larger irrigated plots to prefer to have rotation turns of twenty-four hours each, in order to ensure that the whole plot would be reached by water during a single turn. Fanners with smaller irrigated plots tended to prefer rotation turns of twelve hours each because they knew their fields would be completely soaked during the turn and so that the next turn would come sooner. Twelve-hour turns were the norm, since more frequent turns was a positive thing tor all-users and since, there was a generally expressed principle of needing to defer to the needs of the smaller plot holders. Even when a system- wide rotational arrangement was set, I observed so many "sub-rotations" among immediate neighbors, exceptions to the arrangements which were worked out interpersonally in the fields, and outright tampering, that the formal arrangements were often modified to the point of being barely recognizable in the field.

Until 1982 there had always been enough water after transplanting for continuous irrigation. When the dry weather of 1982 came, the subak began rotating water. Two levels of rotation were used. The first level, which was at a moderate level of scarcity, gave a turn to all users of channel C, D, and E. They got the turn at nights because, according to the sekritaris, they were at the lower part of the system and so deserved to have their water turns at night, "when the evaporation rate was lower." The sekritaris also said that at night there weren't as many people around who would bother the water division. Most members lived about two kilometers away. The upper part of the system and channels A and B received turns in the daytime. The second level, which was used during a more serious degree of water shortage, gave twelve-hour turns to each 1.75-hectare plot. Smaller plots were grouped together for the same turn. Sometimes when the water shortage was not most severe, rotation was scheduled only at night so that continuous irrigation was practiced during daytime. This occurred, as will be shown in Chapter Six, at either of these levels of rotation.

water from him. However, he said that no fine would be applied against the owner of Al, who obviously had done it, since the "victim" had not formally complained about it. These Balinese fanners usually were not of the disposition to unilaterally assert authority or to exercise formal authority until the most local, interpersonal levels had failed to diffuse tensions and formal petitions for subak intervention had been received. In this case, no fine was imposed for checking another's intake. This revealed the local concept that farmers held of the prior and basic obligation of individual water users to monitor their own plot water supplies and to try to resolve difficulties inter-personally. Only after these obligations had been met were subak authorities usually willing to intervene beyond merely restoring an alteration in the division of water to normal.

Occasionally, when staggered planting was needed due to water shortage at the first of a season, it was arranged by the subak, by dividing the system into two or three sections. Staggering had first become necessary during the drought of 1982 and 1983. During the first season I observed, running from June through September 1982, the subak decided to stagger by one week the transplanting dates of the top half versus the lower half of the system. During the second season, running from December through March 1983, the system was split into three groups and planting was officially staggered by one week between each group. In practice, during both seasons which I

observed, numerous exceptions to the formal arrangements occurred. Some planted early, (including the subak head), some took water during two turns, and some missed their turns and joined a later one. I heard excuses expressed such as, "I had work elsewhere at that time," or "I was making new terraces and needed more time," or "My soils had cracked and were harder so I had to take longer to plow," or "My family couldn't help me at that time." No sanctions were applied against these actions.

The standard maximum water division for a 1.75-hectare plot was ten centimeters. The smallest division officially allotted was five centimeters for plots irrigating one-half hectare or less. Standard intakes between five and ten centimeters were nominally assigned according to size of the plot, and in two cases (C3, C4) were also assigned according to whether or not the plot received drainage. If one wanted water beyond the ten centimeter maximum, he was supposed to personally arrange with one's channel neighbors to borrow water temporarily. Bow-ever, so many were temporarily doing this that many were obviously widening their intakes without permission and in some locations it became difficult to distinguish in practice temporary from permanent augmentations of the standard division of water. At plots C7 and C8, which are owned by the same person but cultivated by different sons, the ten centimeter division was divided into halves, one for each plot. Plots C9, A1 and A2 likewise had their ten-centimeter allotments divided proportionately into two portions on either side of the channel.

The head of the Mopugad subak told me that in Bali his subak always controlled water very tightly, so he had to be tricky to steal water there. In Bali he would syphon water by implanting a hose underground which ran from the middle of the channel to a point three meters inside his field. When the water became low in the channel he had to run quickly to the field and cover up the end of the hose in the channel or else his arrangement would become visible and the fine would be certain and heavy. Here it was easy to steal water, he admitted.

An example of the kind of informality imposed by this demanding and rather scattered labor situation occurred in Mopugad during ray first season there. A formal rotation had been established during the reproductive phase of the plant growth period. The subak met and decided to give twelve-hour turns to each of the five quarternary sub-groups. The dry weather had already caused a one-month postponement of the normal planting time for soybean and corn. Two and one-half days after the rotation began, after each sub-group had gotten one turn, it began to rain and everyone left the sawah to work in the ladang (non-irrigated fields). The rotation ceased abruptly and the sawah fields were deserted. After three days of sporadic rainfall, the weather turned dry again. The informal water division altering started again but the formal rotation did not resume,

allegedly because the new work in the ladang interfered with the management requirements of formal water rotation.'

Even actions to acquire more water above the main turnout generally were carried out informally and in an ad hoc way. In Mopugad leaks in the concrete weir were frequently stopped in a makeshift manner, using logs or branches, by farmers who came to do so on their own accord. I was told that those who most often went up to stop up leaks in the weir were the farmers of plots 03, C9, El, C8, and C7 (those with the most water stress). None of these were leaders of the subak.

Fines or sanctions had never been applied for water theft until the second season of my observation. Nevertheless a rate had been set at Rp. 5,000 for the first infraction. This was given only after a first formal warning by the head or secretary. In fact the first fines ever given for tampering (given in 1982) were set at only Rp. 2,500 each, due to the hardship of the drought and to the fact that tampering was so prevalent. In theory, repeated and reported infractions during the same season could invoke cutting off the water supply of the offender's plot for an, as yet, undetermined period. Farmers were reluctant to make formal complaints however. Nearly everyone modified the standard division of water at one time or another. Farmers

'Rain came for a few days at this time and virtually all of the members of the subak were preoccupied with plowing and planting soybean and corn on their ladang, which they either owned or sharecropped.

expressed a need for tolerance and give and take. Implicitly the formal sanction was understood as a last resort, to be used only when and if things became too heated or chaotic.

3.3 Membership

Those who were not original members who had participated in constructing the system could pay Rp. 80,000 per quarter hectare to join the subak and obtain life-time water rights, or they could rent water seasonally.

Those who had purchased land within the system after its formation (C4, C4b, B5, B6) could rent water by the season at the rate of Rp. 5,000 per five centimeter-wide intake, instead of formally joining the subak. For water renters, channel cleaning duties and selamatan duties were the same as for members, but they could not vote in subak meetings until they paid the membership fee and became full members. Sharecroppers obtained access to the water through the land they cultivated temporarily. The owners of these plots were members of the subak. Nevertheless the water rent was established and counted separately from the terms of the shares of the harvest. Water rent for such sharecroppers was generally set at Rp. 5,000 per season for fields of about one quarter of a hectare.

A few exceptions were made to these official policies and to the standard share size. They are identified as cases one through six.

Case One The non-member cultivator of the quarter-hectare plot C3 was given a seven-centimeter division (instead of the five-centimeter share based strictly on land size) because he received no drainage from C2 and his terraces were new. He paid Rp. 5,000 per season to "rent water" in addition to the terms of obtaining land use itself. He had contracted with the owner (the kepala desa) to make terraces on the plot.

Case Two The farmer of the upper part of plot C4, who irrigated 1.25 hectares, paid only Rp. 5,000 per season for his division. He had purchased the land and was not yet a member of the subak. This rate was considered to be enough because he obtained considerable drainage from C5 as well as apparent groundwater recharge.

Case Three In another case, a sharecropper on the left side of plot M4 often opened a temporary intake. However, he was able to avoid paying rent for an official intake because he usually obtained enough water via a wooden aquaduct over the channel from the main side of the field. The main intake of M4 was usually wider than ten centimeters by two or three centimeters, apparently to help compensate, but nobody contested it.

Case Four Another farmer who recently had bought a quarter-hectare field in the lower right corner of plot C4, had originally participated in constructing the system but then stopped during the process because he thought his land wouldn't be irrigated after all. After buying this small plot and wanting to irrigate it, he still had to pay Rp. 80,000 because he hadn't owned land originally, nor had he participated in the entire construction process or in other subak projects such as the later construction of channel B. Furthermore, he hadn't continuously helped clean channels since the creation of the system. As an informant said, he had "stopped belonging to the subak."

Case Five The operator of the 1.25-hectare portion of plot C4, Pak Gusti Ngurah, was not yet a formal member of the subak, even though he had acquired the land of the original owner who had been an original member. In this case subak membership was not concurrently transferred with land ownership. The original owner had borrowed Rp. 300,000 from Pak Gusti and had given his land as security on the loan. Since the loan hadn't been paid back after several years, it was generally considered that the land now belonged to Pak Gusti, who had been cultivating it ever since and renting water.

Case Six In a contrasting example, the owner of plot C10 had joined the subak at the beginning and had continued to help clean channels, attend meetings, and contribute to the credit fund. Therefore he was considered to be an official member, despite the fact that he had never made sawah nor irrigated his field until 1982. He had preferred to plant soybean until then.

From the preceding cases we can see that the criteria for membership were that one had to: own land in the subak, have

contributed labor and materials during the original construction, to have continued to do channel maintenance work, to pay fees, and to help with additional system modifications. If one had not participated in these activities, one had to pay the membership fee to join the subak, regardless of the nature of one's land acquisitions in the system. As was seen with the case of Pak Gusti (C4), the purchase of land from a subak member did not make one a new subak member. The membership fee had to be paid. And so subak membership, and thus water rights, were kept separate (at least in this one case where this kind of purchase occurred), from land ownership rights.

In 1979, there was an additional investment made by original members. At that time all members contributed Rp. 5,000 to start a rotating credit fund, which was used mainly for meeting personal temporary cash needs or food shortages or for subak expenses, to be paid back at five percent interest by harvest time. From the original contributions, payments for new subak membership, and interest from short-term loans, the fund had grown to Rp. 400,000 by December 1982.

3.4 System Maintenance

Regarding channel maintenance, the rule was that everyone was responsible to clean the channel where it ran alongside one's own plot. This was to be done at the outset of land preparation. Bottom-enders at D3, C10, and A3 informally arranged to assist upper-enders in cleaning, for a roughly equal amount of time.

There was a Rp. 1,000 fine for neglecting at the beginning of a season to clean channels which ran along one's land boundary. It had rarely been used. Those sharing field boundaries with channels running along them were naturally responsible for maintenance of the channel segment. What disadvantage this arrangement seemed to have as far as slightly unequal channel segment lengths was made up by the clear understanding about who was supposed to clean which sections. One could tell by inspection who hadn't done their part. This arrangement also provided some flexibility for members to choose the time and day of work so that they didn't have to arrange to do it together.

3.5 Ritual and Water

Each season, the subak holds three modest selaroatan (ritual meals) next to the weir. Each selamatan costs about Rp. 50,000 and is paid for by equal donations from all members or water renters. Selamatan occur just prior to land preparation, at the outset of the reproductive phase, and at harvest.

The nine-stage ritual cycle of padi cultivation in Hindu Bali was not brought into the process of staggering water deliveries and planting dates, as Geertz (1967) and Boon (1977) have mentioned to have been the case in Bali. There was no inter-subak

staggering here and all staggering occurred within one or two week stages within the subak. Exceptions to scheduled planting dates frequently occurred because of labor constraints.

4 Formation of the Subak in Werdi Aguna

4.1 Beginnings

Residents of Desa Werdi Agung came in groups from various parts of Bali. They were settled in residential neighborhoods and in blocks of agricultural land according to point of origin as well as religion. This encouraged social integration and the use of exchange labor with field neighbors in the cumbersome work of clearing forest. Host of the settlers who obtained land on the site of the subak under study came from the sawah regions around Den Pasar and were Christians. A few were from Karangasem to the east and were Hindu. Most of the Christians were members of the Gereja Kema Injil, a conservative Protestant church. A minority were Roman Catholic.

At the time of settlement, the valley was still largely forest-covered, with no paved roads. It took a two days' walk to get over the mountains to the city of Kotamobagu, fifty-five kilometers away. In Werdi Agung virtually all farmers grew peanuts and corn for four years as they continued the tedious work of cutting, digging, burning, and hauling away timber and roots.

Several factors prolonged the clearing process. One of these was the fact that many settlers wanted to use much of the wood for housing or for future sale. Thus much of the timber was felled, dried, and cut into boards in the fields, rather than being quickly burned and hauled away. Secondly, there was the problem of babi hutan, wild pigs. The primary forest immediately bordered the fields and wild pigs were numerous, always trying to "attack" the peanuts and corn. Fanners produced about 150 kaleng (1.5 metric tons) of groundnuts per hectare and were selling the crop at the nearby Mongondow village of Ibolian for Rp. 120 per kaleng. They planted three times a year and after the first harvest, the yield declined three times successively. They said that this was primarily because of the pigs. They started having to watch their fields continuously from planting to harvest. A third reason for the prolongation of land clearing was the relative scarcity of cattle for traction, compared to their relative abundance later on in the 1970s, when the Mopugad transmigrants arrived. Land was prepared by hoeing because of the amount of felled timber still present on the ground and the lack of draft cattle. Gstons rpyong, cooperative exchange labor, was commonly used in forest clearing, hoeing, guarding fields against wild pigs, and harvesting.

By 1968, most of the felled timber was removed from the fields and most farmers were able to acquire at least one sapi.

Farmers frequently borrowed draft animals from one another. They were ready and willing to make sawah.

On the steep hillside to the south a large, fast-flowing stream came down from the mountain range on the south and flowed over to the west of the site of the present subak. Some of the fanners followed the river up to a point where the river came onto a natural terrace and turned westward. They proposed this as the site of a weir. The group estimated that about seventy hectares could be irrigated by the diversion and invited seventy farmers who owned one-hectare plots which were below the site of the dam (all in the transmigration area) to come to a meeting in 1969 and form a subak. Sixty-three farmers joined the subak and a head, secretary and treasurer were selected.

4.2 The Landform and the Designing of the System If an observer were to stand in the lower middle part of the fields of the present system, one would see a line of rounded mountains forming the southern border of the valley. The fields are situated on the valley floor just below and between two curving extensions of the mountains. The slope of the fields is only about two percent and is a bowl-shaped formation which flattens out to a plain but still maintains a subtle concavity. Upon the formation of the new subak in 1968, the members held several field inspections and meetings to deliberate on the proper placement of the channels. First, the site of the weir was determined, then the membership composition of the subak, and finally, the layout of the channels. The channels were dug before the weir was built, so that the water "would have a place to go," as one farmer put it. A main channel was dug out from the weir site to feed three secondary canals, which in turn fed six tertiary channels. Since the fields were divided into square one-hectare plots, the tertiary channels were built to run straight down between plots. Temuku, or wooden micro propor- tioning weirs, were used at channel division points and at field intakes, just as in Mopugad.

At this stage the width of each offtake was determined solely on the basis of the amount of land being irrigated, supaya adil, "so that it would be fair," as an informant recounted. Differences in soil permeability could not be a criterion for setting the field intake widths at this time, because they were not yet known. Only after several seasons of irrigating, gradu- ally compacting the soil during land preparation and comparing fields, did certain farmers, such as those at fields El, E3, Zl and ci (See Figure 3-3), successfully petition to the subak to have their intake widths permanently widened by the additional amount of what normally would be permitted for plots of the size of one-quarter or one-half of a hectare. Permission for the farmer at field E2 to set a wider intake was granted only after he demonstrated an improved compaction technique by plowing deeper and more frequently. After demonstrating proper land

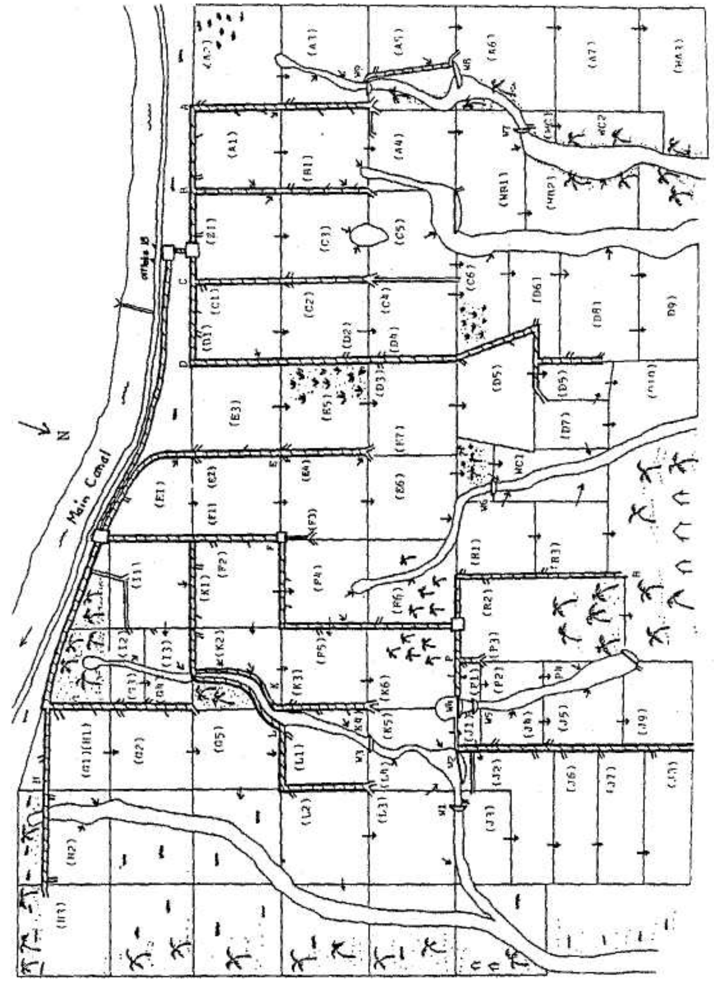


Figure 3-3. Irrigation System in Werdi Agung After Incorporation Into Kosinggolan Scheme

preparation techniques and still demonstrating an obviously higher infiltration rate than average, the fanner was granted the adjustment. Whether the petitioning fanner drained his water back into the system or not was relevant to subak deliberations about such adjustments. Because of the nature of the terrain and the channel configuration, it was difficult for farmers not to drain water back into the system. This was not the case in Hopugad.

Before the main canal of the Kosinggolan Scheme was built, a farmer-built channel came down a slight ridge between where channels A and B presently are located. Although the channel passed through the middle of three landholdings (Al, Bl, A4), the farmers recognized that this location was necessary at the time. But after several seasons of land preparation and gradually cutting away at the ridge, the terraces were lengthened and the ridge disappeared. After this gradual levelling process was completed in all three landholdings, the channel was filled in and relocated along the boundaries. Besides not wanting the channel cutting through their own land, the farmers in the lower two plots did not want the channel first going through the middle of their neighbors' fields above them. All three were in agreement about the change, which led to the construction of channels A and B along the east and west boundaries of these plots. In this case incremental terracing changed topography enough to permit a later relocating of channels and intakes. '

In 1975 the main canal of the Kosinggolan Scheme was dug through the fields of the subak, which at that time included irrigated fields above the canal. The lower part of the subak was incorporated into the larger government network. Fields which were above the canal later were converted to rainfed cultivation. This conversion happened along with the decline in water available from the farmer weir and the availability of sawah elsewhere to owners of these fields.

Being linked to the government canal caused a few changes in channel configurations, some of which were unsatisfactory from the farmers' points of view. Padi cultivation was disrupted for two seasons until water began flowing into the new main canal offtake at Gate .Eighteen. A new, long, lateral canal was built by the project to move water to feed channels E, F, K, L, G, and H. A separate secondary canal formerly came straight down from several hundred meters above to feed channel E. The division box for the turnouts for channels E and F was built by the project, as was channel F itself. Farmers complained that now too much water went straight down into F and too little went into E and on towards G and H. Channel E came out of the box at a near reverse angle to the secondary channel feeding it, further compounding the problem. In addition, the long lateral secondary channel had so little slope that at low water supply periods, water sometimes flowed in reverse away from channels G and H and back to the E/F division box. I noticed this happening on two occasions. Thereafter farmers adjusted to the problem by regularly placing obstructions in front of the channel F offtake gate.

Farmers recognized that the project did not want to make too many offtakes from the main canal. But they complained that having tertiary channels like this one, which ran lateral to the slope for so long, lost too much head. They recognized the cost and difficulty of building too many concrete division boxes, but they complained that the first offtake channel, which ran to the left over high ground, usually did not receive enough water flowing into it. The center offtake received too much, unless it was checked. The right offtake also had a chronic allocation shortage. I observed this area for two seasons and found this to be true.

Fanners said their principle was that the water should first flow in one body to the high ground and then branch out to the lower areas, rather than be divided above as is the case now where the first channel goes to the high ground and the second immediately drops down to low ground.

There were additional channels which were made shortly after the Kosinggolan main canal came into operation. Some were made under the Kosinggolan system tertiary development project and others were made by the fanners. Channels G, H, L, P, R, and extensions of channels C and D were all built after incorporation into the Kosinggolan Scheme.

Channel J was built by farmers shortly before channels P and R were built by contractors. This location was at the convergence of a bowl-like landform at the lower sections of channel L and F. Two small embankments were built by channel J users along the lower boundaries of plots L4, K5, and K6, forming two small ponds to collect water from drainage and seepage from above and use as supplements to water supplied by channels F and P. The fanners linked Channel P (which was built by the government) with Channel J (which was built by the fanners) by directing it first into these two small ponds and then out to channel J.

At channel J farmers advised contractors for the Kosinggolan Scheme tertiary development project not to bother building an aquaduct over the stream on the right side of channel J to convey water to the plots along channel J on the other side of the stream. They told them that this stream flowed into another one and that those plots were already getting water from both sources. They wanted the channel to enter the small marshy area supplied by the stream and then be directed out of it again to serve fields on the other side. In this way farmers thought they could take advantage of both sources without disrupting the prior channel network. The laborers said that they had to complete the work quickly; so they built it according to specifications. The farmers later moved the channel to direct the water into the upper stream as their supplementary water source. The stream was then tapped in four places downstream and served nine farm plots. The aquaduct was never used. Farmers preferred to combine in this stream both conveyance and drainage functions. The project's tertiary design criteria consistently kept the two functions separate in other tertiary blocks as well.

After a harvest in 1983 the subak finally altered the relative levels of the offtake doors of three division boxes in the subak to make the relative allocations more equitable. In each case the locations with the worst water supplies were getting their divisions enlarged. This was done with the agreement of the entire group. It cost them Rp. 15,000 (about US $24) for the cost of labor and two sacks of cement and Rp. 1,500 for sand. The farmers had spoken to project personnel a number of times about this and had been told that the construction had been done scientifically. A farmer told me that the project probably was right in theory, but in practice the allocations were really unfair. Farmers even had gone so far as to propose to a project staff member that they would be willing to buy the concrete if a project engineer would advise them on how to alter the boxes. They were told that there was no budget for redesigning structures.

After having waited for several seasons, the farmers decided to go ahead and alter the division boxes themselves; The farmers recognized the division boxes as government property, because the government had built them. So the farmers were particularly

slow and reluctant in taking independent action to redesign them.

4.3 Landholdings and Tenure

From an enumeration of all subak members, as reported by the head of the subak, the average amount of total land owned by subak members was 3.0 hectares. Twenty-four percent owned two hectares or less, fifty-eight percent owned between 2.1 and 4.0 hectares, thirteen percent owned 4.1 to 6.0 hectares, and five percent owned more than six hectares. Hence, eighty-two percent of the membership owned between one and four hectares.

Of the few non-members who were renting water in the system as sharecroppers, the owners (who were members) usually managed the water supply obtained by the plots. My informants and I identified only five plots which were not cultivated by the family of their owners during either of the. two seasons observed in 1982-83. These were at plots D6, E5, E7, K4, and G2."

5 Formal Organization and Process in Werdi Aaung

Unlike the subak in Mopugad, this subak at Gate Eighteen of the Kosinggolan Scheme had been recently formally established

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[1]Because of some discrepancies which were discovered in field notes, the exact number of sharecroppers in the system can not be specified. On the basis of my observations and acquaintances in the field I conclude that there were no more than eleven plots which had sharecroppers, out of the seventy-eight plots in the system.

as a P3A. To the fanners, this was merely another abstraction imposed on their affairs by the government for its own reporting purposes. There were no changes in leadership or in rules. For example, the P3A by-laws established at the provincial level specified that those stealing water or failing to join channel cleaning teams should be required to perform certain extra work for the P3A, the length of work time being related to how many infractions per season the person had made. However, in this subak fines had never been applied against water theft and those which were applied for non-participation in channel maintenance work were monetary fines.

5.1 Leadership

The formal organization of the subak in Werdi Agung is very much like that in Mopugad. It has a head (who is the owner of plots L3, J6, P3 and R2), a secretary (owner of plots E4 and WC1), and treasurer (owner of plot Zl). It has semi-formal, sub-group coordinators for arranging channel maintenance and occasional water rotation within quarternary channels. These sub-group coordinators operate plots Zl, E4, K3/F5, G3, L2 and J2. Initiative for proposing rotation arrangements tends to come from any of a number of channel neighbors. These coordinators, like those in Mopugad, served more of a function of communicating and mediating than of decision making.. Planting

dates, rice varieties, rotation dates, and even sanctions are deliberated upon and decided by the entire subak membership.

Subak leaders were frequently occupied at other field locations than at the subak, as was the case in Mopugad. The head of the subak owned and operated with his family four hectares, three hectares of which were sawah. The secretary owned and operated with his family 4.5 hectares, all of which were sawah. In this subak the head was a rather passive figure. Some complained that he was not aggressive enough in acting on complaints and applying sanctions. The secretary tended to be the liaison with government officials who came to seek data or extend information.

5.2 Water Distribution, Planting Dates, and Sanctions

The subak required all members to broadcast seed at the same time, mainly to spread out the effects of plant pests, such as field mice and stem borer, both of which were common in the area. In Werdi Agung, since all broadcast seed at the same time, a limit was placed on the extent to which fanners could stagger transplanting dates. The limit was roughly one week difference among members in transplanting time. The farmers said that the stem borer prefers to attack the padi of those who plant later. There was a Rp. 10,000 fine for broadcasting seed before the scheduled date. Two members were fined for broadcasting too early during the two seasons I was present.

I was told that this infraction was rare. In the two cases the farmers wanted to plant early in order to avoid a later conflict of labor demands on other fields.

Each one-hectare plot is given a ten centimeter-wide intake, regardless of porosity of soils or the availability of a neighbor's drainage as a supplementary supply. The subak secretary, Pak Mustika, explained the rationale for having standard division sizes as necessary to help prevent farmers from being lazy during land preparation and making water loss rates go up. If plots with clearly higher-than-average water loss rates were given permanently wider intakes, then their operators would not be inclined to prepare their land carefully to reduce water loss rates. So the divisions are always fixed. When wanting to use additional water, those who did have water loss rates higher than their field neighbors are supposed to arrange directly, on a temporary basis, with those who would be affected. If the channel neighbors should refuse to let the petitioner obtain water from them, then he may request from subak authorities to have a temporary water supplement. Referring to this kind of a supplement, Pak Mustika used the term penyusuan (a nursing or a suckling), which is a pejorative and condescending term designed to invoke a feeling of rasa malu (embarrassment,) and reluctance in the would-be supplicant.

Upon getting a formal request to borrow water (which occurred only rarely, he said), he or the head of the subak would determine

whether or not the farmer had prepared his land properly and whether or not he had a serious temporary need for additional water. If the request were granted, then the head or secretary would either personally notify all parties involved or would see that at least a stick and flag was placed at the point of water borrowing. In my field inspections I saw such signs only three or four times per season throughout the system. I observed such signs at the intakes of plots H1, El, and F5, which were locations of common and relatively intense competition among neighbors.

Actions to acquire more water from the main turnout generally were arranged informally, in an ad hoc way. In Werdi Agung farmers occasionally approached the gate tender of the main Kosinggolan Canal to complain or ask about scheduled water deliveries to the block. On two occasions of water shortage, I saw different farmers who had been plowing at the time place large rocks in the main canal just below Gate Eighteen, in order to increase the total flow into the system.

There were more complaints about cattle getting loose and grazing on someone's padi than there were complaints about stealing water or broadcasting seed too early. In fact one of the subak leaders said that a fine for stealing water had never been given. But if it were to occur, it would be a monetary fine and not a suspension of water to the offender's plot, because, he said, that would be too severe and would cut off part of the supply of water to those who rely significantly on drainage from the offender.

5.3 Membership

Each season the subak collects Rp. 6,000 per hectare from the membership to pay for the construction of the sangcrar tanj (farmers' meeting place), and for food supplied at meetings or maintenance work parties. Rp. 1,000 is deducted from the Rp. 6,000 fee for participation in the channel maintenance work (mentioned below), which is required twice each season (at land preparation and at the reproductive stage). This leaves a normal actual fee of Rp. 5,000 per hectare.

Regarding the requirements for obtaining membership, some controversy developed over the issue of including as members in the subak in Werdi Agung the irrigated plots which were below and outside of the transmigration tract. The head of the subak, Pak Polos, wanted to include all of these plots in the subak, since they also obtained water from Gate Eighteen. He himself owned four small plots below the boundary of the tract, which boundary constituted the lower boundary of the subak. These lower fields were not made into sawah until after the coming of the government canal. Hence the subak boundaries were defined by the fields served by the original investment of members in constructing the system. The subak continued to operate after its incorporation into the large government system to manage

water and its own field channels, which were now below Gate Eighteen.

Below this gate the farmers managed irrigation with little interference from the outside. Officials from the government scheme rarely inspected the field channels or communicated with the subak, except to inform the farmers about scheduled water deliveries for planting dates. Now, five years after the main canal had been in operation, there were pressures from some of those in the subak, and those with new sawah fields just below the boundary of the original subak, to enlarge the subak to formally include as members all those receiving water from Gate Eighteen of the Kosinggolan Scheme.

Sentiments were expressed by some members in a subak meeting that water should be shut off, insofar as possible, to lower-enders if they did not join in cleaning the channels. This meant Channels D and F in particular. At the meeting it was decided to invite the owners of these lower plots to include their plots in the subak. New members would have to pay the seasonal membership dues, help clean the channels which served their plots, and help pay for the recently-built sanaaar tani (the farmer's meeting building, which was next to Gate Eighteen). But several of the owners of these lower plots expressed an aversion to paying these fees until they got assurances of equal water divisions, not just sisa-sisa (leftovers). Such assurance could only be given over time, after the fees were paid. Some of the members expressed a reluctance to assure equal channel water divisions since, they argued, the lower plots obtained drainage and groundwater from percolation and seepage above, anyway. The holders of lower plots considered this to be an exaggeration. By virtue of modern water law statutes, they were entitled to equal rights to the water since it now came from the gate of the government system.

There were two reasons why no large retroactive membership fee was charged to new members, such as was the case in Mopu-gad. Several of the channels had been built by the government and so the costs of construction could not be attributed solely to the efforts of the original subak members. Furthermore, the water was now all being supplied by the government-built Kosing-golan Scheme—not the original farmer-built weir and feeder canals. Secondly, nineteen of the twenty-eight plots below the transmigration tract were owned and operated by members of the subak who, of course, owned land above and already had voting rights in subak policy. This put them on a different footing from other lower-enders who had not participated in the original construction and ongoing channel maintenance. Some of the latter were not even of the same village and so it would make conflict arbitration at the village level difficult. The other nine of the twenty-eight were inclined to join the subak in order to be able to vote in group decisions and be assured equal division, or rotational turns, of water. The reality of water recharge

decreased the leverage of the upper-enders. It also distinguished those owners of upper and lower plots from other members who did not own plots below, in that those who owned sawah both within and outside the subak had less incentive than other members to take on the additional costs and maintenance work associated with the lower plots.

Finally, at the root of this issue of whether or not to formally include these lower plots into the subak were inequalities associated with two problems. First, the differences between lower-enders who received both water from channels and other forms of return flow versus those who relied solely on water from channels, complicated the issue of why the lower-enders should receive equal channel divisions if they received other sources of water as well. Those lower-enders who received other sources of return flows (e.g., drainage, ponds, or groundwater recharge) had less incentive to clean the channels than those who were solely dependent upon them. Upper-enders wanted these lower-enders to commit themselves to join in the channel cleaning tasks. Lower-enders expressed concern about whether or not they would be guaranteed equal divisions of water. Second, those who owned more than one plot in the proposed broader area of the subak (under the proposed organizational enlargement) would be burdened with new maintenance duties and fees for each plot owned.' This controversy was still unresolved when I left the field.

5.4 System Maintenance

The cleaning of channels is required twice each season, just prior to land preparation and at the reproductive stage. Fines of Rp. 1000 are made for not attending the work parties, unless one has an excuse such as being sick or being out of town on business. Work parties are arranged within quarternary channel sub-sections.

Fines are applied only rarely for not joining work teams. All members work equal time on channel maintenance, regardless of the size of their irrigated plot. They work separately in small groups of usually five to seven, except when cleaning the 350-meter secondary canal running to the left side of the system (as one looks at Figure 3-2). This is cleaned by the entire group jointly. Regarding the quarternary channels, an informant said that, "If we all worked together in a big group, there would be too many members sitting around and joking too much."

[1]Spatial differences in sources of access to water and their implications for water allocation will be discussed in Chapters Four and Five.

In discussions about any of these subak regulations, farmers were prone to emphasize their flexibility. They stressed the situationally specific, ad hoc, and flexible nature of such rules or sanctions. Even the compliance with group policies of staggering or rotating water deliveries was largely assumed to be negotiable, within limits, in individual cases. The usual reaction to my occasional legalistic questions about formal organization was to downplay the idea of rigidity or impersonal-ness. The newness and variability of the environment seemed to invoke a tentative and flexible approach to subak affairs.

Perhaps after a few generations the formal organization would begin to look as well-defined and elaborate as the subak in Bali did to western administrators and anthropologists. However, in Dumoga, neither subak was operating under the superor-dinate institutions of the kera-jaan (the traditional kingdoms of Bali). And yet based upon Geertz's historical study (1980) of nineteenth century Bali and this field research, it seems certain that negotiating and testing the order of these subak, as they evolve, will continue to be inherent aspects of their organization.

The use of the stick and flag, in both systems, as an organizational shorthand for warning members not to tamper with certain allocational arrangements, is an illustration of the fact that in both systems it is difficult for the leadership frequently to be in communication with all the members of even guarternary groups. The heads and secretaries of both systems explained that would-be water borrowers should always try to arrange directly with channel neighbors to borrow water, if possible. This was because such borrowing, or altering of the standard division of water, was so frequent and often so localized that there was no way it could be handled through formal channels. The task would overwhelm the subak leaders, even during periods of general water adequacy.

Farmers in both systems liked to compare agriculture and irrigation in North Sulawesi with what it was like in Bali. Such comparisons had common themes—the greater diversity in agricultural work and greater flexibility in the subak in North Sulawesi. In Bali a farmer had only one field and it was small. Farmers used the saying "Ei Bali *satu* kali pasang" ("In Bali, you put the yoke on only once"). This meant that in Bali the fields were so small that one could finish all the plowing or harrowing before resting for lunch, so that one needn't yoke the cattle again for the afternoon. But here farmers were always going from one field to another, if not working on one's own land then working on the land of someone else. Farmers often said that here there was too much work, even just in agriculture. Even spontaneous settlers regularly made and cultivated sawah on someone else's land, cultivated rainfed crops while

guarding young tree crops on someone else's land, or accepted short-term work as a contracted or daily-hired laborer.

Regarding allocating water in the subak, when a formally scheduled rotation is in place and subak leaders begin to inspect the channels more often, farmers are more reluctant to alter the specified division of water. Otherwise there is considerable give and take. In Bali, things were more tightly controlled. When I talked with farmers about subak rules, schedules, or sanctions, they would often imply that I shouldn't take these things too seriously. "Dasarnya musyawarah. beajtulah" as they would sometimes say. This meant, "It's all based on just talking it out, that's all." To these farmers, the basis for formulating, interpreting, and applying procedures was through talking it out, negotiating, and often testing the acceptability of one's preferred borrowing plans by simply adjusting the division of water in their favor, to see what the reactions of others would be.

Farmers felt that although a subak policy might have been agreed upon formally, putting it into practice might call forth further deliberations and adjustments at each step in the direction toward local, specific activities. The formal organization and rules of both these subak occasionally are used in an assertive way, to achieve direct and specific results (such as to formally invoke staggered or rotated water delivery, or to apply fines). But usually they serve a more passive function of establishing general, flexible standards around which farmers obtain specific results through interpersonal interaction.

In this chapter we have discussed the formation and organization of two subak and their flexible organizational climates. With this information about the organizational context of water allocation, we can now turn to the core physical and social elements which constitute the adaptive process of water allocation.

In the introductory chapter it was stated that the two subak were selected based on differences in age, topography, and incorporation into (or independence from) a larger government irrigation network. So far we have only described some of the historical, social, and physical contexts of the two systems. Hence the implications of such differences for water allocation in these systems is not yet clear. However, we have seen here that the two subak are very similar both in the organization and the nature and extent of organizational flexibility.

However, we also have seen in this chapter that the incorporation of the subak in Werdi Agung into the government scheme did result in there being no substantial, initial joining fee for new members who would obtain permanent water rights. After this incorporation, the water supply came from the government scheme. Several channels were built by the government tertiary development program of the large scheme. This had the effect of rendering the prior farmer construction investments

irrelevant to the current benefits. A fee to make up for such prior investments was not required of new members as was the case in Mopugad, where farmers were still independently using the original farmer-built system.

In the next chapter we will identify the physical elements of these systems which the farmers indicated are relevant to rights and patterns of water allocation in the systems. As we focus on water allocation in these two subak over the next three chapters, we will discover the effects of the above-mentioned differences between the two subak on the process and results of water allocation.

CHAPTER FOUR Physio-Technical Aspects of the Two Systems

1 Design Configurations of the Two Systems

Through observation and interviews with farmers, I discovered that the basic features of the hydraulic design configuration, sources of water supplies to farm plots, and soil permeability strongly influenced the nature of relations among water users as they allocated water. The kinds of physical aspects described in this chapter and the manner in which they are classified (especially regarding soil permeability and plot water sources) tend to follow the means of classifying which farmers used, as these aspects were related to water allocation. For example, farmers in both systems compare channel neighbors by making simple rankings about one another's plot distances from the main offtake and water loss rates according to three categories (e.g., high, medium, and low).

As will be seen in the next chapter, basic physical characteristics of the systems shape the nature of interpersonal water allocating behavior. Such behavior affects water use efficiency and equity. The design configuration and the landform in which it is embedded constitute both important influences on behavior and the media through which behavior brings about system-wide results for water use.

We have already noted the more narrow, sloping, and elongated nature of the system in Mopugad. By comparison, Werdi Agung is flatter and more spread out, lateral to the slope. Mopugad is crossed with numerous slight but diverging ridges. In Werdi Agung the expanse of concavity in the landform exceeds that of convexity. In Mopugad only one natural drainageway, on the right edge of the system, is used below for recharge into the system. In Werdi Agung there are numerous small drainageways and ponds within the system which are used below as alternative water sources to the channels. However, these dry up after the water supply for the system is cut off at the main offtake.

The different types of landforas of the two systems shape the basic characteristics of the system designs. The system in Mopugad was approximately 27.5 hectares of sawah in the first season observed and 28.5 hectares of sawah in the second season. The system in Werdi Agung was about 38.5 hectares in both seasons. Table 4-1 summarizes the nature of spatial density of the three most basic physical structures: channels, channel division points, and plots intakes. One might be surprised to see that the total number of channel meters per hectare of irrigated area (or farm ditch density) coincidentally is virtually the same in each system, 129.0 and 129.1. However, when we use a different measure of ditch density—the number of channel meters divided by the -number of irrigated plots, we see a significant difference. Our definition of an irrigated plot identifies each plot as a parcel of land which is a unique water management unit with a unique supply point. A field is defined as a single farm which has a single operator (or operator household) . It is possible by these definitions then, for a farmer to have a field which may constitute two distinct plots. This may be the case where two sections of the same field obtain water from different channel supply points, each section thus relying for its primary source of water upon two separate lines of access to water.

Table 4-1 Spatial Density of Irrigation Structures

	Mopugad			Werdi Agung		
	Total	Per Hectare	Per Plot	Total	Per Plot	Per Hectare
No. of Channel Meters	3,675	129.0	111.4	4,970	129.1	64.5
No. of Channel Division Points	4	.14	.12	13	.34	.17
No. of Permanent Plot Intakes	36	1.26	1.09	74	1.92	.96

There are three reasons why the channel density <u>per hectare</u> between the two systems is the same but the channel density <u>per irrigated plot</u> is seventy-three percent higher in Mopugad than in Werdi Agung (111.4 m/ha. versus 64.5 m/ha). First, the

standard transmigration landholding field allotment size in Mopugad was 1.75 hectare. In Werdi Agung it was also 1.75 hectare, but this was divided into two locations of 1.0 and .75 hectare each. The fields in the subak in Werdi Agung were those which were 1.0 hectare in size. Second, there were proportionately more fields in Werdi Agung which obtained water from two different channels. Such fields constitute two irrigated plots because each section relies on a unique line of access to water and therefore, a unique set of channel neighbors. In Werdi Agung there are ten fields (thirteen percent of the total) which each constitute two irrigated plots. In Mopugad there are two fields (six percent of all farms) which each constitute two irrigated plots. The third reason is the above-mentioned prevalence of streams and natural depressions in Werdi Agung which sometimes topographically divide farms into two distinctly irrigated plots. These three factors make the average irrigated plot size in Mopugad .86 hectares while in Werdi Agung it is only .5 hectares.

Looking at Table 4-1 again, we see that the number of channel division points per hectare is nearly twice as high in Werdi Agung as in Mopugad. The difference in channel division point density <u>per plot</u> is less dramatic but is in the same direction (forty-two percent higher in Werdi Agung). Also the density of permanent plot intakes per hectare is fifty-six percent higher in Werdi Agung than in Mopugad. However, the level of plot intake density

<u>per plot</u> is slightly lower in Werdi Agung than in Mopugad. The slight difference in intake density per plot is due to several plots in the lower portion of the Werdi Agung system which do not have a direct intake from a channel. Hence in Mopugad there is more potential channel length per plot from which to temporarily divert extra water. To put it another way, in Werdi Agung there are proportionately more plots drawing water on a given length of channel than in Mopugad. This means that based purely on the nature of the architecture of the two systems, a greater pressure is placed on allocation along <u>channels</u> in Werdi Agung (where plots are more concentrated along generally shorter channels). In Mopugad relatively more pressure is directed at the <u>channel division points</u> for water allocation, because of the fewer division points per plot and the generally longer channels. As will be seen, such aspects of system design are offset by other physical features such as differences in soils, modes of access to water, and the amount of water available over time.

Farmers in Werdi Agung are dependent upon more channel division points per hectare, or per plot, than is the case in Mopugad. The system in Werdi Agung is more dendritic in its architecture, than in Mopugad. There are 2.0 distinctly irrigated plots per hectare in Werdi Agung and only 1.46 plots per hectare in Mopugad.

We can draw one other figure from Table 4-1. In Mopugad there are nine plot intakes per channel division point. Except

for the two short channels A and D in Mopugad, the rest of the plots are located along only three channels: the main channel up to where it divides into channels B and C and channels B and C. In Werdi Agung there are 5.7 plot intakes per channel division point. Therefore in Werdi Agung, generally speaking, there are fewer potential locations per plot for a farmer to borrow water from a neighbor's plot. But there are more potential channel division locations per plot from which a farmer may borrow water.

So while the system architecture in Werdi Agung is more complex overall, it is also generally more segmented into small units, than the system in Mopugad. And yet the notion of complexity is a relative one. in this case we mean it relative to water management. In this sense whether or not this design configuration is more complex relative to water management depends largely on how the lines of borrowing and adjustment are drawn across the system. For example, to the extent to which most of this activity occurs within these small units the system is not very complex, relative to the process of water allocation. The design configuration serves to localize and simplify the process of allocating water. But to the extent to which the most profound physical inequalities and regular patterns of adjustment cut across these system subsections and channel division points, the system architecture is more complex, relative to the process of water allocation.

One final note will be made regarding the spread of plots along the channels. The average plot distance to the main system offtake (i.e., the weir in Mopugad and the gate in Werdi Agung) is 1,020 channel meters in Mopugad and 612 channel meters in Werdi Agung. The standard deviation of this plot distance to the main offtake is 455 meters in Mopugad and 285 meters in Werdi Agung. Therefore, in Mopugad the plots are spread farther away from the main offtake than they are on the average in Werdi Agung. Moreover, the inequality in plot-to-main-offtake distance is significantly greater in Mopugad than in Werdi Agung. This suggests that distance from the main offtake would be a more important factor in Mopugad than in Werdi Agung. This more elongated feature in Mopugad relates to the generally steeper gradient of the channels. All channels are dirt-lined in both systems.

2 Water Sources and Water Losses

2.1 Plot sources of Water

There are some fundamental differences between the two systems in the spacial variation of water sources available to plots. Such differences in the physical components of these systems must be identified before we can understand the behavior of the irrigators. The physical aspects of the system which farmers related to water allocation were: the nature of water sources accessible to each plot, the degree to which one

depended directly on the channel, the distance from the main offtake, and percolation and seepage rates.

There are four kinds of water sources upon which a given irrigated plot might depend: water directly from the channel, neighbor's drainage, groundwater recharge, and streams or ponds. By groundwater recharge, I mean water from shallow percolation or seepage from above, which surfaces in sawah fields below and has a negative impact on the percolation and seepage rates of the lower fields. Some streams or ponds are located in the middle and lower parts of both systems. In both systems these sources go dry after one or two days after the water from the main offtake in either system is totally cut off. The latter three kinds of sources (neighbor's drainage, groundwater recharge, and streams or ponds) are indirectly dependent upon the main delivery channels. Some of the groundwater coming into some of the lower plots in the systems may come from outside the system. But this seems to have been an insignificant amount during these relatively dry seasons. When water was cut off at the main offtake of either system, no plots were able to maintain standing water, although some fields remained moist for several days.

Table 4-2 summarizes the number and percentage of plots having each type of water source. It is possible for a plot to have either one or two primary sources and either none, one, or two secondary sources. A source is defined as <u>secondary</u> if it is clearly less in quantity and only supplemental to the primary source. Two sources may be designated as primary sources if they are vital in order to irrigate and are both roughly equal in quantity of water supply.[1]

Table 4-2

Primary and Secondary Plot Mater Sources

---Number of Plots ---

Types of Water Sources	As a Primary Source		As a a	
	Mopugad	Werdi Agung	Mopugad	werdi Agung
Channel	28 (82%)	42 (54%)	1 (3%)	6 (8%)
Drainage	1 (3%)	6 (8%)	10 (29%)	17 (22%)
Groundwater	0	0	5 (15%)	4 (5%)
Stream	0	1 (1%)	1 (3%)	5 (6%)
Channel/Drain	3 (9%)	11 (14%)	0	1 (1%)
Channel/Grdwtr	1 (3%)	1 (1%)	0	2 (3%)
Channel/Stream	0	2 (3%)	0	7 (9%)
Drain/Grdwtr	1 (3%)	12 (15%)	0	0
Drain/Stream	0	3 (4%)	0	3 (4%)
Grdwtr/Stream	0	0	0	3 (4%)
TOTAL*	34 (100%)	78 (100%)		
No 2nd Source	—	-	17 (50%)	29 (37%)
			34 (100%)	78 (100%)

*Percentages may actually not add up to 100% due to rounding error.

We can see from Table 4-2 that by far most of the plots in Mopugad had the channels as their primary source of water (twenty-eight out of thirty-four, or eighty-two percent). In Werdi Agung only a little over half of the plots had a channel as their primary source of water (forty-two out of seventy-eight,

[1]These data were obtained by direct observation over two planting seasons and by interviews with informants along each of the quarternary channels in each system.

or fifty-four percent). By adding the row figures, we can see from this table that in Mopugad only two plots did not include a channel as their primary water source. In Werdi Agung twenty-two plots (twenty-eight percent) did not have a channel as their primary source of water.

Regarding secondary water sources, fifty percent of the plots in Mopugad did not have any secondary sources, compared with thirty-seven percent of the plots in Werdi Agung. in Mopugad the most common secondary sources are neighbor's drainage and ground-water recharge. In Werdi Agung the types of secondary sources and combinations of secondary sources are much more varied and diffused among the plots. However, neighbor's drainage is the most common, single, secondary source in Werdi Agung. By adding up some of the rows in the table, we find that only six plots (eighteen percent) in Mopugad have either groundwater recharge or streams or ponds as a secondary source. In Werdi Agung twenty-four plots (thirty-one percent) have either groundwater or streams or ponds as a secondary source.

Therefore regarding sources of water at the plot level, there is a clear and dramatic difference between the two systems. Mopugad has a preponderance of plots which primarily obtain water directly from the system channels. Half of the plots in the system have no secondary water sources at all. In Werdi Agung a smaller proportion of plots are primarily reliant upon water taken directly from channels. By comparison, in Werdi Agung a much greater proportion of plots obtain water by combinations of either two primary or secondary sources.

Another useful way of summarizing this comparison of plot-level water sources is to compare the numbers of plots in each system which have different levels of diversity of water sources. We will spatially identify plots with different levels of diversity of water sources. Table 4-3 indicates the number of irrigated plots in each site which have one, two, three, or four different sources of water. (This includes both primary and secondary sources). From this table we see that while nearly half of Mopugad's plots have only one source of water, only twenty-four percent of the plots in Werdi Agung have only one source of water. Contrastingly, in Werdi Agung, twenty-nine percent of the plots have either three or four water sources, compared to only three plots (or nine percent) in Mopugad.

Table 4-3

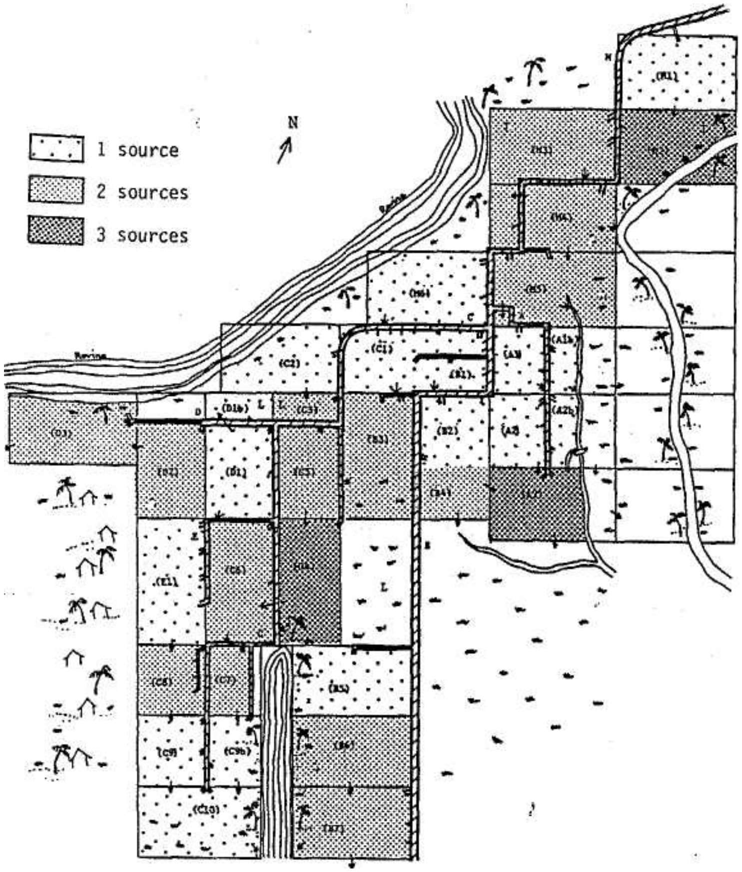
Diversity of Water Sources of Plots Number of

Sources	Mopugad	Werdi Agung
1 source	15 (44%)	19 (24%)
2 sources	16 (47%)	37 (47%)
3 sources	3 (9%)	9 (12%)
4 sources	0	13 (17%)

In Figures 4-1 and 4-2 we can see the configuration of plots in each system which have different levels of water source

diversity. The darkest shaded plots have four sources (as can be seen in the lower left hand portion of the map of the system in Werdi Agung). There are only three moderately darkly-shaded plots in Mopugad, representing the three plots which have three sources. The other plots have either one or two sources. The lightest shading represents those plots which have only one source of water. In either system, when there is only one source of water, that source is a channel, in all cases.

In Mopugad each of the three darkly shaded plots obtain water from the channel and from drainage of a field neighbor. In addition to these sources, plot M2 receives groundwater recharge from the steep, new terraces in plot Ml. Plot A3 receives water by tapping the small drainage stream just above in plot A2b. And plot C4 receives groundwater recharge from the relatively elevated terraces of plot B3 (see Figures 3-1 and 3-3 for plot code locations) . In Werdi Agung the more darkly shaded plots in the lower portions of the system are those which are either receiving groundwater recharge or water from tapping the small streams or ponds which cut through the system—in addition to receiving water from the channels or drainage from neighbors. In Mopugad there is not a concentrated grouping of plots with high or low diversity of water sources. In Werdi Agung those which have either three or four sources together have a mean channel distance of 342 meters from the main offtake. Plots having only one or two sources have a mean channel distance of 526 meters from the



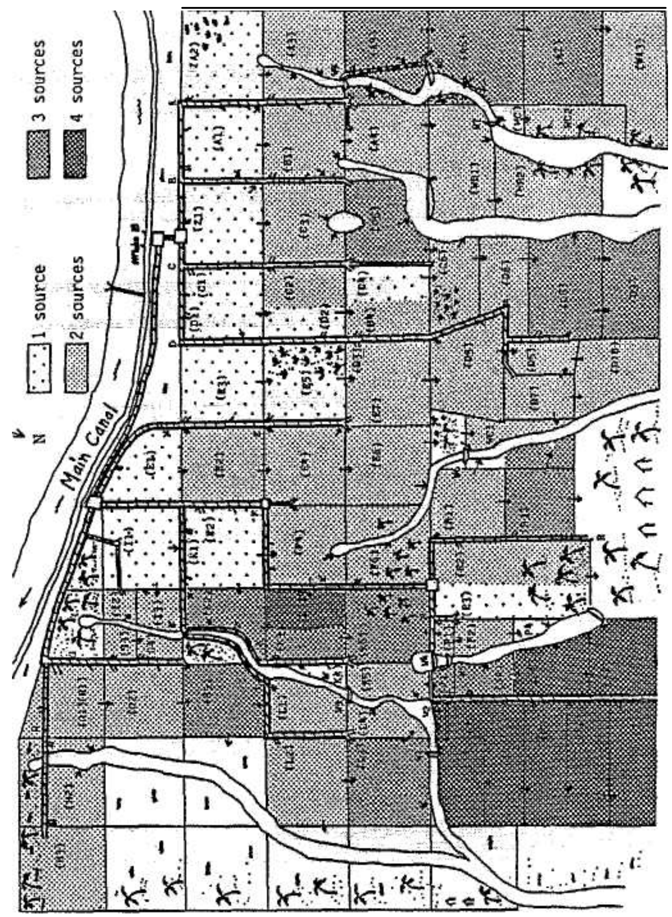


Figure 4-1. Diversity of Plot Water Sources, Mopugad

main offtake. Therefore, the plots with greater diversity of water sources are lower in the system in Werdi Agung.

With the data about the primary and secondary plot water sources, we can construct a simple index which describes a plot as having low, medium, or high channel dependency.[2] Low channel dependence means that the plot either does not obtain any water directly from the channel or that it does so only as a secondary source in combination with some other source. Medium channel dependence means that a plot has the channel either as a single, secondary source or as a primary source in combination with another primary source. High channel dependence means that a plot obtains water from the channel as a single, primary source.

Figures 4-3 and 4-4 show the spatial configuration of plots having differing levels of direct dependence on the channels. The dark shading indicates low channel dependency. The light shading indicates high dependency. Mopugad only has one plot with low channel dependency and four plots with medium dependency. Thirty of the thirty-four plots are solely dependent on a channel as their primary water source, and these are spread evenly top to bottom in the system. In Werdi Agung plots with medium or low channel dependence are nearly all located either in the lower part of the system or at the ends of quarternary

[2]This is my own categorizing of course, not that of the farmers. Nevertheless, it is based on the four kinds of water sources which farmers relate to water allocation practices, as will be seen.

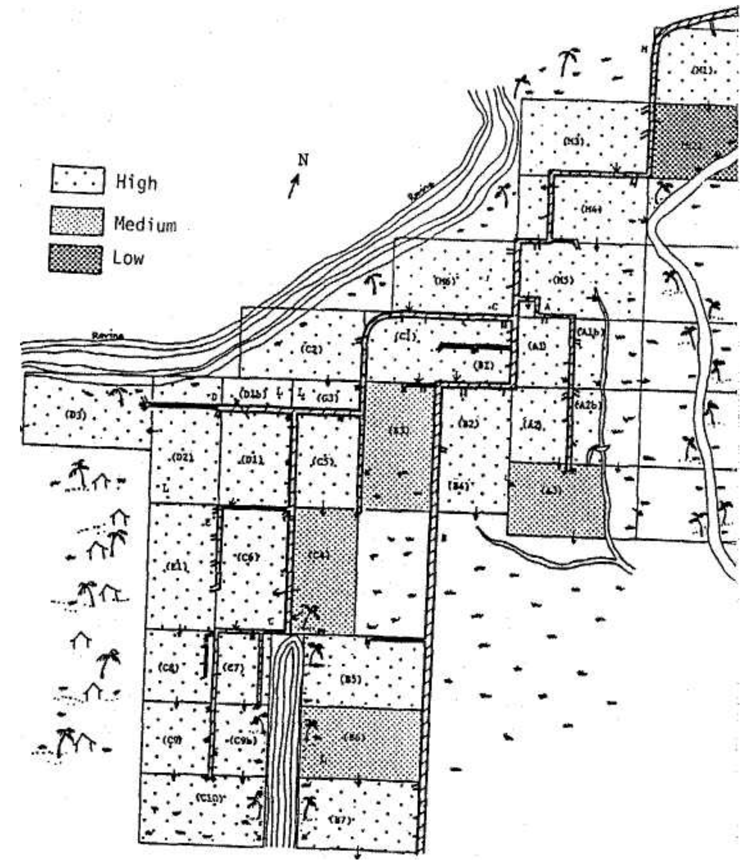


Figure 4-3. channel Dependency Index, Mopugad

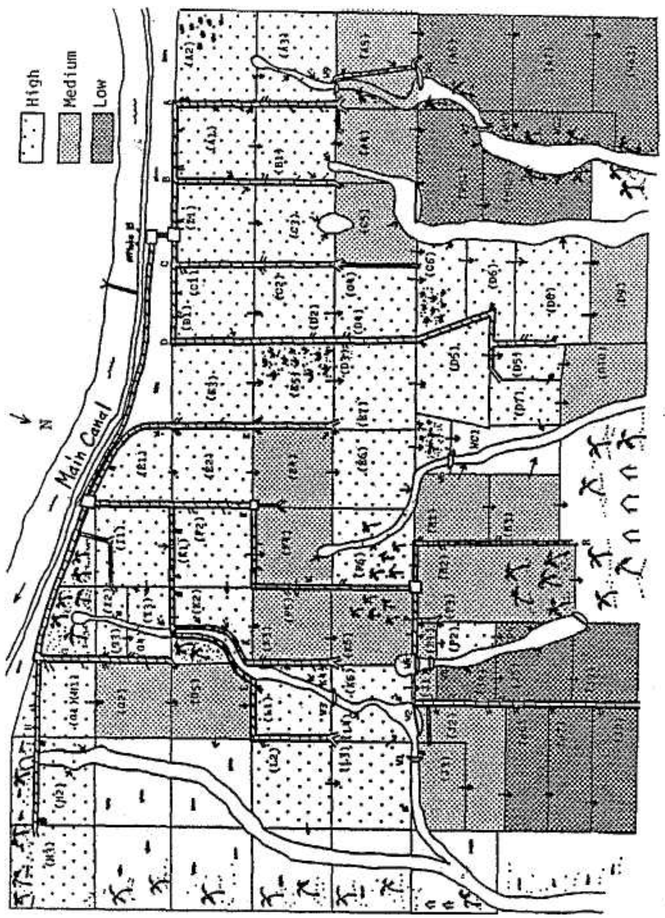


Figure 4-4. Channel Dependency Index, Werdi Agung

channels. All of the plots in the upper portions of the system have high channel dependence. Some of the plots in the lower portions of the channels in the middle part of the system, as well as those along channels K and L, also have high channel dependence. These latter plots are highly dependent on channels because they tend not to receive water from groundwater recharge or streams or ponds. The neighbor's drainage which most of them do receive generally is only of occasional and marginal importance. The level of channel dependence is not associated with plot channel distance from the main offtake in Mopugad. In Werdi Agung however, plots with high channel dependence have a mean channel distance from the main offtake of 364 meters, compared to a mean distance of 481 meters for the plots with low dependence.

Having low direct dependence on the channels is not necessarily a good or bad condition. The adequacy of a plot's water supply depends on both the amount and regularity of its water supply, whatever the source or sources happen to be. However low channel dependence may mean that altering channels to borrow water would not be effective. Of course the regularity and adequacy of water supplies may be associated with the nature of the source. We will examine the implications of these patterns of physical inequality in Chapters Five and Six. It is the purpose of this chapter only to identify them.

We can see in Figure 4-5 the overall relative proportion of plots per system which have each level of channel dependency. This chart shows the relative preponderance of plots with high channel dependence in Mopugad. We have just seen that this preponderence of plots is spread roughly evenly through the system. However, in Werdi Agung, while the distribution of levels of channel dependency is much more varied, this variation is not spread uniformly. Plots with lower dependence tend to occur in the lower reaches of the system.

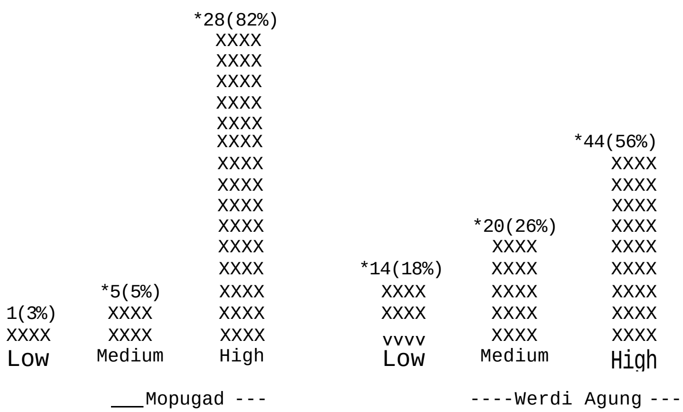


Figure 4-5. Proportion of Plots, by Level of Channel Dependency

Where all this detailed description takes us is to the conclusion that the system in Werdi Agung is endowed with certain physical characteristics which by themselves tend to counteract

the inequality of distance of the plots from the main offtake. The prevalence of groundwater recharge and tapping of drainage streams and ponds in lower areas provides supplemental water supplies (or at least lower percolation and seepage rates) to fields which otherwise would tend often to be with less-than-equal supplies of water from the channels, due to their bottom-end position. Given the physical characteristics and the slightly concave topography in Werdi Agung, when water is in short supply, the relative dependence of lower fields on non-channel sources shifts even more in the direction of these alternatives. Observation through two seasons showed that when the supply of water is inadequate in the channels, some middle and upper-enders tend to be worse off than lower-enders who have access to these alternative sources (which usually take longer to dry up than do the channels). The availability of more sources itself does not mean better water adequacy, especially if a given single source for other plots happens to be a reliable source.[3]

In Mopugad however, no such natural equalizing features appear on the landscape. While the elongated nature of the system accentuates the difference between top and bottom-enders, the bifurcation of the system at its middle into two long channels (B and C) exacerbates a tension between the bottom-enders on either side. Though the lines of inequality are more sharply

[3]The actual patterns of difference in plot water adequacies and their relation to the spatial variations in these physical inequalities are addressed in Chapters Five and six.

drawn in Mopugad, they are more simply constituted. One might expect that this simplicity would help in the development of common understandings among irrigators and in negotiating for water rights. However, in Mopugad, the basic division in the middle of the system, the relatively large numbers of plots below channel division points and below the upper-plot intakes, and the larger average plot sizes all complicate the above-mentioned relative simplicity of the physical setting because of their social implications, which we will examine in the next chapter.

2.2 Percolation and Seepage Rates

Often I found farmers comparing the permeability of soils on each other's plots. The soil of a given plot would boros yak air ("waste a lot of water"). That of another would tahan air Lama ("hold water a long time"). Especially in Werdi Agung varying permeability was said to be a prominent reason why certain farmers borrowed water more often than others or why some plots were officially allowed to take extra water and others were not. usually farmers would relate the permeability to the texture of the soils. The most common classification mentioned was that of "berpasir. biasa, lilin." (sandy, loamy, clayey). Farmers often compared the low percolation and seepage rates in Bali with the very high rates in their land here in North Sulawesi.

I decided that in order to be able to compare percolation and seepage rates between plots and between the two systems, it would be necessary to have roughly one measurement per two hectares. I used a single sloping gauge to measure change in depth of standing water in selected terraces. Generally three or four measurements were taken per location and an average rate was derived. Depth of standing water was measured morning and evening and in some cases at midday. Surface flow into and out of the terrace being measured was stopped during the measurement period. This was done so that change in the level of water in the terraces could be attributed only to rainfall, evapotranspiration, or percolation and seepage. By measuring rainfall and evapotranspiration rates nearby, I was able to determine how much of the decline in standing water was caused by percolation and seepage. Change in water depth was compared to evapotranspiration and rainfall rates, measured nearby, in order to estimate percolation and seepage rates.[5]

I assumed that for my purposes, percolation and seepage rates were roughly constant over time, after transplanting. With help from assistants, I made sixteen measurements in Mopugad and twenty-three measurements in Werdi Agung. This was an average of one measurement per 1.78 hectares in Mopugad and one

*For a description of this instrument and method, see IRRI, 1981.

[5]See Chapter Six for a more detailed description of this water balance method.

measurement per 1.67 hectares in Werdi Agung. The measurements were not uniformly spread around the system but were more concentrated where greater local differences were thought to exist because of topography and where there were fanner reports about variations in permeability. The location and average rate estimated for each measurement are identified in Figures A4-1 and A4-2 in Appendix One.

Based on what I knew about plot sources of access to water, topography, and farmer rank comparisons of plot porosity, I estimated percolation and seepage rates for all of the plots in each system and calculated a system-wide mean percolation and seepage rate.' The mean rate in the Mopugad system was 12.9 millimeters (mms) per twenty-four hour day, with a standard deviation of 9.0 mms. The mean rate calculated for the Werdi Agung system was 32.9 mms per 24-hour day, with a standard deviation of 30.7 mms. The range from the lowest to highest value was thirty-four mms in Mopugad and 103 mms in Werdi Agung. Thus, not only is the average percolation and seepage rate two and a half times higher in Werdi Agung than in Mopugad, but the variability is far more pronounced. In a sense, differences in percolation

'Each plot which was measured represented one or more neighboring plots which were not measured and estimates were made for the adjacent plots, which generally were the same as or close to the measured rate nearby. In some cases the estimate was lowered or raised a bit from the nearby measurement according to observed differences in percolation and seepage rates, due to topography or soils, as observed by myself or as ranked by farmers. This form of estimation was recommended to me by Gilbert Levine in a personal communication, 1982c.

and seepage rates within Werdi Agung are more extreme, and hence are more easily visible to the farmers.

Relative to other wet rice lands in Asia, these rates are rather high (see Kung, 1971, p. 36-38). This can be explained not only by the rather sandy texture of the soils, especially in Werdi Agung, but also by the fact that the sawah terraces are relatively new and not fully compacted.

To approximate the categories farmers used, I grouped each plot into one of three categories: high, medium, and low rates of percolation and seepage. Plots were defined as having medium rates if the estimated rates were within plus or minus thirty-five percent of the system mean rate. Plots below this range were designated as low. Those above it were designated as high. Figures 4-6 and 4-7 illustrate for each system the locations of plots having high, medium, and low percolation and seepage rates. The dark shadings represent high rates and the light shadings represent low rates. Highly permeable, sandy land runs along the upper portion of the Werdi Agung system and comes down through the middle of it along channels C, D, and E. In Werdi Agung (Figure 4-7) most low rankings occur in middle and lower portions of the site, where this occurs, it helps counteract the effects of being in the lower portions of the system. If the differences in percolation and seepage rates in werdi Agung tend to have a net equalizing influence, in Mopugad they slightly exacerbate the inequalities of differences in channel position which already exist, especially along channels A and D.

In Mopugad all but one plot with a low percolation and seepage ranking are in the upper third of the system. Plots with medium porosity occur in upper, middle, and lower parts of the system. Plots with high porosity are located at the lower section of channel Al, all of channel D (which runs close to a ravine), and at the lower middle part of channel C. We must remember however, that these differences in percolation and seepage in Mopugad are relatively minor, in comparison with those in Werdi Agung.

There is no significant association between percolation and seepage ranking and channel dependency in Mopugad. However, as one can see by comparing the maps of Werdi Agung in Figures 4-4 and 4-7, those areas which tend to have higher channel dependency (eg. the upper and middle sections) are also roughly those areas which tend to have higher percolation and seepage rates.

Thus in Werdi Agung, the spatial configurations of both percolation and seepage rates and the relative dependence on channels tend to work together to counteract the advantage of being closer to the main offtake. On the other hand, since low percolation and seepage rates are common among lower plots, and since low rates are just as likely to have high as low channel dependence, these two features tend not to work together to counteract the disadvantage of being farther from the main offtake.[1]

[1]Evidence of this will be examined in Chapter Six.

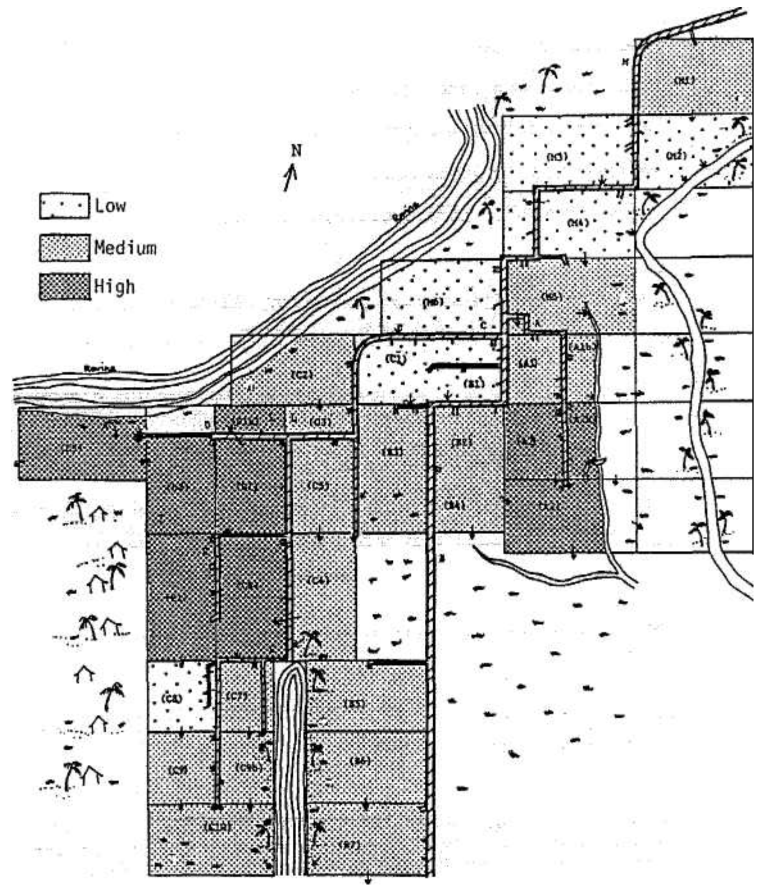


Figure 4-6. Infiltration Rate Index Relative to System Average, Mopugad

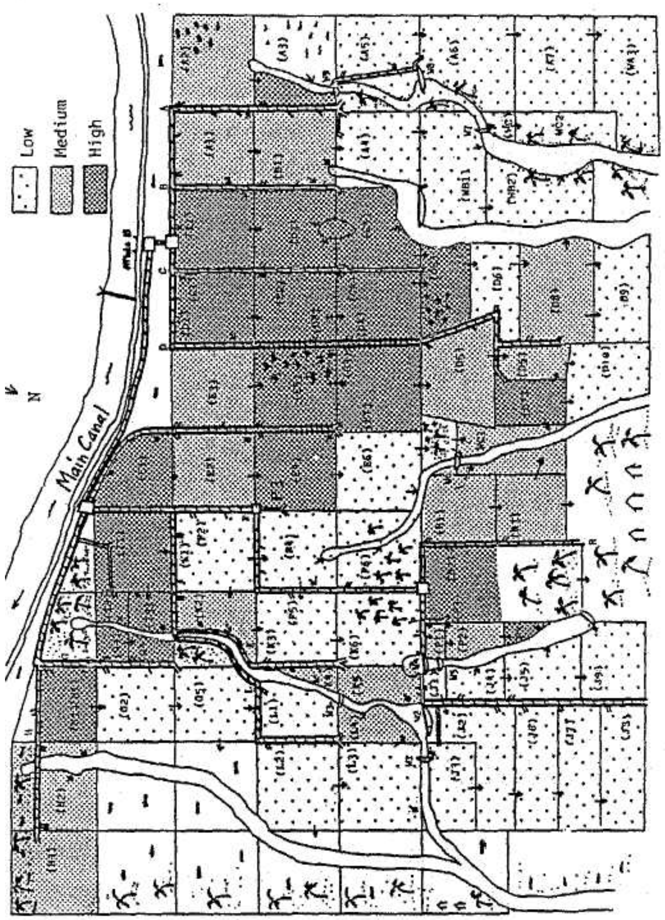


Figure 4-7. Infiltration Rate Index Relative to System Average, Werdi Agung

However, almost all of the lower-enders have either low percolation and seepage or else low dependence on the channels.

3 Terrace Making and Land Preparation

3.1 Terrace Making

The farmers' own theory of levelling land and making terraces, as my informants described it, is a standard one among farmers. It prescribes a method where all of the relevant constraints to terrace size and form are commonly understood and agreed upon by sawah cultivators. Even those settlers who make terraces without having the advantage of prior experience nearly always learn the theory while working alongside experienced farmers. The difficulty or ease of preparing land, as well as of managing water, is noticeably related to the way the terraces are constructed in a given terrain.

According to farmers in both systems who explained terrace-making to me, terraces should be built with a size, shape, and quality that will create level fields, conserve and gradually enhance topsoils, and permit even and rapid irrigating or drying. Differences in practice occur according to differences in degrees of experience or according to conscious decisions about tradeoffs between short-term and long-term labor constraints, rather than according to basic disagreements about how terraces should be constructed ideally.

The first requirement is that a terrace must be level, or else the water will be too deep in one place and perhaps too shallow, if present at all, in another place. The wider a terrace is in the direction of the slope, the more difficult it becomes to approximate a level condition and the more cumbersome is the work of moving earth. Generally speaking, the greater the slope the more careful one has to be not to remove the topsoil while in the process of pushing topsoil downslope while terracing. If a terrace is too wide (more than fifteen meters to these Balinese farmers), then the yield and height of the padi will not be uniform. This is because the topsoil and decomposing organic matter cannot be spread from one side of the terrace to the other if the terrace is wider than fifteen meters. Cattle can only pull a comb-tooth harrow which is no wider than three meters. An informant in Mopugad said that in the system in Mopugad at least, topsoil can be drawn and spread from one side of the terrace to the other not more than the width of five turns and passes with the harrow (assuming there is only one fanner and pair of cattle involved). Within a fifteen-meter limit, decaying matter and fertile topsoil can be spread and mixed with less fertile soil anywhere in the terrace. Over a four to five-year period, decomposing organic matter from padi stubble and from weeding fields and bunds can be evenly spread to gradually create uniformly fertile soil conditions within terraces.

If the topography permits, it is thought best to have long terraces (perpendicular to the slope) of up to fifty meters or more in order to avoid having to turn around too often while plowing or harrowing. Long and narrow terraces facilitate rapid and precise adjustments in water levels. Terraces that are small and square inhibit rapid water level adjustments through the field (including drying) and require the farmer and draft animal to circle around and around and cross over bunds too often while preparing land. Of course, steeply sloping land with ridges may force such a terrace design. It is easier and faster to make smaller and more square terraces under sloping conditions, because the levelling does not require soil to be moved too far. Hence short-sighted farmers or those who are in a special hurry to finish terracing may opt to build such terraces despite the long-term consequences of more cumbersome land preparation. It was for this reason, I was told, that farmers who obtain contracted laborers for terrace construction often obtain terraces that are too small and square, unless they personally supervise the work.

On the other hand, terraces which are too large can have disadvantages for labor. Farmers generally prefer terraces which are not too large for a given task, such as plowing, transplanting, or weeding to be completed within the terrace within a normal half day's work. Farmers said that it is preferable to have a discrete and well-definable perimeter, like a terrace, upon which to base work expectations, especially when hiring labor.

This helps maintain morale under tedious working conditions and makes it easy to relate payment of contract laborers to discrete, and if need be, small sections of land. Having terraces which are not too large, i.e., over fifteen by fifty meters, helps to minimize the frequency of need for laborers and draft animals to leave and re-enter a terrace after stopping for lunch or night-time. It is also easier for farmers to inspect the quality of transplanting or weeding work done by laborers. Contracted laborers tend to transplant seedlings at a lower density or tend to be less thorough at weeding in the less visible, middle portions of large terraces.

Because of the heavy demands on labor in the early stage of resettlement, terraces are often built quickly at first and are enlarged or re-shaped later on. Ridges running down the middle of a landholding may eventually be levelled out, permitting the later relocation of a channel to the plot boundaries. This was done with the main channel in Mopugad, at plot M5 and with channel B in Werdi Agung at fields Al and Bl. In these cases then, incremental terrace construction led to incremental irrigation system designing.

A farmer may choose to invest time in clearing or working upland fields even if it might mean that he or she doesn't make the effort to level all the ridges in the sawati field and opts to make small, square terraces. This tends to increase the extent to which water is divided in different directions among the more

numerous terraces, making more problematic the equitable distribution of water between terraces within the plot. What may seem to be negligence in the quality of terrace making may in fact be the result of a considered choice by a farmer. One farmer in Mopugad admitted that the lower, slightly-ridged portion of his field had terraces that were too short and square but, he said, he wasn't capable of doing it right at the time and hoped eventually to hire someone with a bulldozer to do the terracing over again, when the Toraut main canal construction would come through the area the following year.

Besides questions of size, shape, and relative levels of terraces, there are other aspects of terrace-making which farmers say effect the nature of water management. These are the processes of making bunds and improving the layer of topsoil. It has been asserted that farmers use bunds to store water in anticipation of temporary water shortage (see Seckler, draft). One irrigation engineer suggested that I determine whether lower-end fields have higher bunds than upper-end fields. He said that the lower-end fields would more frequently experience serious and prolonged water shortage and therefore they should be inclined to have higher bunds to permit the storing of more water in terraces.

Upon looking for such a correlation during my field inspections I found none. Bund heights were roughly the same height throughout either system. Only occasionally did I observe fields where flow between some terraces was stopped by temporarily damming up the points of flow-through with mud and grass. This was done sometimes for two or three days during a time when water was severely scarce or during plowing when flow-through points in terraces were blocked. However, the scarcity itself made it difficult or impossible to obtain enough depth of standing water to last in the terraces long enough to prevent or eliminate water stress, especially given the relatively high percolation and seepage rates in both systems. I never saw any evidence that farmers actually stored water—in the sense of saving it long enough to make a difference with plant water stress. Whenever I asked about it, farmers always said that stagnant water was not good, it led to bad chemical reactions, and made the water "too hot." What they cared about was that there be a steady flow of water. Even when anticipating a shortage, fanners knew that the infiltration rates were generally too high in either system to permit storage for more than a day or two anyway. Furthermore, it has been shown that percolation and seepage rates tend to increase with water depth, where deep percolation and seepage occur (Kung, 1971; Yoder, 1986).

Farmers explained that they always wanted to make their bunds rise about twelve to fifteen centimeters above the floor of the terrace in order to be able to get as much as ten to twelve centimeters of water in the terrace (for land preparation or in case too much water comes into the field) and still have three to five

centimeters to the top of the bund. Bunds should have three to five centimeters which are always above water so that they remain hard. If the bunds were built higher than this, it would be more likely that during heavy rains or when there is excessive water entering the field, water in the terraces could become unintentionally too deep for the well-being of the high yielding varieties. Moreover, if the bunds are too high above the top of the water in the terraces, serious cracking may occur right down to the water level, causing leaks.

Farmers quickly become aware of the natural limitations of their soils and try to make terraces appropriate to them. Where the subsoil is rocky or heavy in texture, one must avoid exposing too much .of it while levelling. In such conditions terraces usually would be made smaller than otherwise would be the case. If infertile subsoil is exposed while levelling, then fanners are inclined to make a special effort to mix it with fertile soil and decomposing organic matter over the next few years to build up both uniform fertility and water holding capacity. Bunds with light-textured soils have to be made thicker in order to help decrease seepage. Farmers recognize that having too many bunds for a given field size will cause too much water loss. Put another way, the higher the ratio of terrace perimeter to terrace area, the higher the seepage rate. Farmers in Werdi Agung now regret having introduced a small fish from Bali, called the taint, to their sawah fields in North Sulawesi. Fanners catch the tiny fish after drying their fields. In North Sulawesi the topsoil is much shallower and the soils are lighter-textured than in Bali. The bulut multiplied rapidly in these new fields and were continually burrowing holes in the bunds, increasing seepage rates dramatically.

In Werdi Agung there are several fields which farmers said had a significant amount of small gravel, even in the topsoil. This presented a special challenge while terracing, both in terms of work and water requirements. One day in Werdi Agung I observed a farmer levelling land to make a terrace. It was at the edge of the field next to a short embankment by a small stream (see plot A5 in Figure 4-3). Besides obtaining water from a significant groundwater flow into the field, he was "borrowing" additional water from the channel. Since there was a considerable amount of gravel in the soil, he made a small, fifteen centimeter-wide ditch running through the middle of the prospective terrace and began piling up topsoil on each side, thereby directing water through the middle to carry away gravel which he dislodged with a hoe. Water velocity had to be fast in order to help move the gravel which he was working loose with his hoe. After doing this in one location, he would make another small ditch one meter to the side and' do the same thing. This was repeated across the area of the prospective terrace. He claimed that this got rid of about ten percent of the gravel. After this process he levelled the ground and

picked out by hoe or by hand the remaining gravel in the top soil, collecting it in baskets. He said that in his experience with plowing the neighboring terraces, each time he plowed, the gravel sank slightly lower and the topsoil became slightly deeper. There were several fields like this at the top of the system and next to the small marshy streams which cut through the system in Werdi Agung.

In summary, terrace making is a complex and incremental process. The requirements for labor and terrace design are closely related, at least in these two systems, to highly variable, microlevel aspects of the landform. Farmers believe that the quality of terrace-making affects the rate of percolation and seepage in the soil.

3.2 Land Preparation

Farmers said that by plowing deeply enough, making more passes over the field when plowing and harrowing, and digging by hand in corners of terraces (where plows and harrows can not reach) they can help reduce percolation and seepage rates because of the plastering and compaction effect.' They also recognize that the high percolation and seepage rates decline to a lower and relatively constant level after five or six years of proper

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•Martin (1986:167) reported that farmers in Nepal who had extremely well-drained soils said that thorough land preparation could reduce the percolation and seepage rate by as much as fifty percent.

land preparation. If the levelling and terrace making is not done correctly on a given plot and other farmers are aware of this fact, the farmer will lack credibility in the future when borrowing or asking to borrow additional water for his or her field.

The land preparation techniques of the farmers in these two irrigation systems are virtually the same as those reported elsewhere throughout Asia. (See Rung, 1971, IREI, 1970.) When water and labor are not serious constraints, the period of time for land preparation is roughly twenty-five days from initial land soaking to transplanting, depending partly on the nature of the soils. Heavy textured soils are more difficult to plow. After introducing a large flow of water over the fields for a day or two, the first plowing is done. This takes roughly two to three days per hectare, depending on soils, the nature of the terraces, and the supply of water. This is followed by harrowing, which takes roughly one to two days per hectare. The land generally is soaked for about one week to allow for the decomposition of organic matter and for a mud plastering effect to take place around the bunds. Then comes the second plowing, which should take less time than the first time if the water supply has been regular. This is followed by a second harrowing, which always takes about the same amount of time as the first one. Then comes another soaking period. The land is harrowed again just before transplanting.

Generally, deeper than average water is desired for soaking. Farmers usually start plowing and harrowing in the top terrace and proceed downwards. If the water was adequate for soaking, farmers tend to restrict somewhat the normal amount of flow into and out of the given terrace so that the high and low spots are easily seen and levelled according to the surface of the water. When moving down to the next terrace, the water depth in the terrace just plowed or harrowed is increased, in order to break up clods. Usually farmers leave the terrace outtake open slightly while plowing for the first or second time, or while harrowing for the first time, so as not to dry out the rest of the field. During the second and third harrowing however, the terrace outtakes generally are shut because the clods are broken up enough by then so that the erosion would be high if water were draining out of the terrace during harrowing. These tasks require less water than the earlier ones. Many farmers prefer to close the terrace outtakes whenever harrowing.

Depending on the seriousness of water or labor constraints, the actual kind of land preparation will vary anywhere from a single plowing and harrowing with no soaking period (under a condition of water shortage) to something like the "ideal" scenario described above. Short-cutting the land preparation work may lead to less fertile soils, more weeds, and higher infiltration rates (due to less compaction and less of a plastering effect on the bunds).

One fanner I knew who seemed to have ulcers and a back problem said he was too worn out and muscle-sore to harrow twice and so he just transplanted the padi after harrowing only once in part of his field. Because of this he had more weeds in those terraces which were harrowed only once.

4 Padi Cultivation and Irrigation

The basic functions of padi irrigation are well known to these fanners. Irrigation brings water to the plant, brings fertile silt to the fields, permits the dissolution of decaying organic matter, reduces water loss by permitting plastering or soil filling in terraces, and discourages weed growth. Over-irrigation, or the failure to drain or periodically dry the fields, can lead to anaerobic soil conditions which cause root rot, toxic reactions, lodging, inhibited plant maturation, and difficulties in doing the harvesting, it also inhibits root penetration. Each of these factors was mentioned to me by farmers. Since neither salinity nor alkalinity are problems in the two systems, the farmers did not mention the function of irrigation in keeping these conditions from affecting the root zone of the plant.

There did not seem to be any disagreement among fanners over the basic principles for how to manage water during the padi season. During the seedling nursery stage, less water is needed

but it must be carefully controlled so that it does not wash away the seeds or submerge them for too long, causing oxygen depletion during the germination stage. It was felt also that continuous flow was important during the early part of the nursery stage, since the water level was so low and yet so crucial for germination. The seedling nurseries generally took up about five percent of the total sawah land (see Dumoga Irrigation Project, 1980, p. 21). In Werdi Agung, nursery broadcasting was done nearly simultaneously throughout the system so that pests would be spread out more and spraying could occur at the same time. Family labor is virtually always used for this.

While transplanting, farmers prefer to lower the water level to near the soil level so that the field will not be too wet and muddy, making stepping in it difficult. This also makes it easier to estimate the distance between plants, in order to set the spacing appropriately. The water level has to be near zero to prevent the dislodging of the newly transplanted seedlings whose roots haven't taken hold of the soil. Exchange labor, in groups of six to eight is commonly used in both systems for the transplanting, although hired labor is also now commonly used in Werdi Agung. Women, men, and older children all help with transplanting.

Through the first fifteen to twenty days of the vegetative growth period, farmers tend to keep the water shallow, (at two to four centimeters). From twenty days after transplanting up to the reproductive period, the water depth preferably is kept above four centimeters. Fertilizer generally is applied two or three weeks after transplanting and then again at the outset of the reproductive period. Pesticide typically is sprayed twice, or more often, depending on the threat. This is done generally within two weeks after the first fertilizer application and then at least once more after flowering. When fertilizing, fanners lower water to a near dry or puddled level for one or two days and then fertilize. Water is restored within a day or two of fertilization. When spraying pesticide or herbicide (which was just becoming commonly used) farmers lower the water level to a slightly puddled condition. Applying chemicals is virtually always done by men.

About forty days after transplanting, the fields are dried again for about three days to encourage root penetration just before weeding. Farmers usually tug and shake the weeds just enough to displace the roots. This causes them to die, without having to pull them out completely. If weeds are too numerous, farmers are likely to use herbicide. So farmers take advantage of the fertilizer application and weeding times to dry the fields temporarily so as to introduce air into the soil. They know that such temporary drying not only enhances root development at these stages, but also inhibits the formation of ineffective tillers.

Farmers recognize that it is more important to have a steady water supply during the reproductive stage than at any other

period. As a rule, fields which have padi at the reproductive stage have more of a right to steady water supply than fields which have not yet reached the stage, or have just passed it. While it is well known that plant consumptive use of water is higher during the reproductive stage than at any other time, the farmers did not emphasize this, undoubtedly because any variations in transpiration rates in either system are dwarfed by the high percolation and seepage rates (as will be seen in Chapter Seven).

Following the reproductive stage, water coverage gradually becomes less important to the farmers and the fields generally are drained entirely by ten days before harvest. Harvesting usually is done by supplementing family labor with laborers which are given one-fifth of a share of the harvest.

Continuous flow irrigation, with the occasional drying mentioned above, is the universally preferred method of irrigating, except when water shortage forces rotation. Continuous flow requires less management than either rotation or continuous static flooding (i.e., storing of stagnant water). The latter method, if it were practiced strictly, would require farmers to regularly open and shut all of the openings between terraces in order to keep filling up the terraces when they had gone nearly dry. This would be especially cumbersome where the percolation and seepage rates are as high as they are in these systems. Although there seems to be some logic in the proposition that farmers should store water against a risk of future stress, farmers insisted that they could not do this. My questions about what levels of water depth were desired seemed beside the point to these farmers (except around the time of transplanting or pesticide or herbicide application). What they seemed to care more about was that there was a continuous flow. Depth was of secondary importance, except that it should not be too deep or stagnant.

Research results on the effects of continuous flowing versus continuous static flooding irrigation upon padi yield are rather ambiguous. Studies in Japan during the hot summer months have shown that where water temperature is high (i.e., thirty degrees to forty degrees C), continuous flow irrigation lowers water temperature and can produce higher yields between padi in flowing versus static irrigated fields (De Datta, 1981, p. 323). The mean monthly air temperature (as an approximate surrogate measure for water temperature in the Dumoga Valley) ranges from 25.7 degrees C in January to 26.8 degrees C in August. Since the temperature level is moderate and the variability is light, it is not reasonable to infer, on the basis of research to date, that continuous flow irrigation in the Dumoga Valley is necessary to prevent water temperatures high enough to impair yields. Nevertheless the farmers all stressed the importance of continuous flow and preventing the water from being too hot. Interestingly, recent research

in Thailand and Nepal reports similar attitudes of farmers in those countries.'

5 Summary

In this chapter we have outlined the basic physical characteristics of the two systems, noting the spatial configuration of slope, soil permeability, channel architecture, and water sources. Also some aspects of terrace making, land preparation, and padi cultivation have been described because of their relevance to water allocation. The following two chapters analyze how such physio-technical aspects of the systems actually are related to the nature of water allocation.

•personal communications from Yoder, 1985, who conducted Ph.D. thesis research in Nepal and Dennis, 1985, who conducted Ph.D. research in Thailand.

CHAPTER FIVE Dividing the Water: Second Approximations

1 Introduction

This chapter is about the criteria and interactive processes farmers in these systems use for altering the standard division of water in order to cope with the relevant physical inequalities in the systems. Through mutual adjustment, interpersonal negotiation, and assertion of rights, this second approximation is created. It constitutes an order or pattern of interaction and results. While the order itself may seem rational and purposive, it is forged or derived without centrally authoritative/ analytical methods of organization. Rather, it proceeds, to use Lindblom's words, by way of the local, incremental adjustments of temporary borrowing, or giving and taking, of water.

When these two systems were designed, channel offtake and farm intake sizes were set in proportion to the amount of land to be irrigated in each sub-division of the system. This rule however, should be understood as a first and rough approximation of the water allocation needs of the system. Farmers perceive such needs subjectively and individually (though not exclusively so). They respond to them socially, through negotiating and testing.

As we have seen in the preceding chapter, these two irrigation systems contain considerable physical diversity. Farmers respond to this diversity by classifying it in ways which are

adaptively relevant to irrigating. This core set of physical criteria which are adaptively relevant to irrigation are utilized in making what could be considered as second, and somewhat less rough, approximations of the water allocation needs of the system. This second approximation is an attempt to cope with the physical inequalities in the system. Such inequalities make the first approximation (i.e., the design and land size proportionality rule) a method of resource allocation which does not fulfill the minimum levels of adaptive acceptability of many of the water users. Hence by itself, this first approximation is an inadequate mechanism of allocation. It cannot "satisfice" because it does not fulfill, in Simon's terms, the criterion of minimal acceptability of the adaptive goal of farmers for obtaining adequate water supplies for their fields.

It is assumed in this study that differing patterns of behavior among farmers in temporarily altering the division of water are based upon more fundamental reasons than the casualness or happenstance which may be associated with a single act of altering the flow of water. By such differing patterns of behavior we mean differences in the frequency among irrigators of altering the standard division of water. We also mean differences in methods used to alter the division of water. In consequence of this behavior there is a spatial variation in the relative frequency of alterations which occur in different locations of the

! system. The reasons for such patterns will be the focus of this chapter.

It could be hypothesized that the informal altering of the standard water division in irrigation systems is primarily due to individual opportunism, social stratification, factions, or otherwise due to the abuse of privileges, especially where strong, standardized, legal sanctions are not in force. It might be assumed that such informal practices are the primary causes of inequity in irrigation systems. This often may be the case, especially where social inequalities are extreme and in large but highly interdependent systems (perhaps especially where groundwater recharge is not available to lower-enders).

However an alternative possibility may be that such patterns of behavior are based more on counteracting than exacerbating the natural inequalities imposed by the physical characteristics of the system. Outsiders are usually unaware of the magnitude of micro-level variation that exists in irrigation systems--in soils, alternative water sources, and topography. They are prone to view the standard division imposed by the physical structures and government regulations as being a better approximation of equity than what farmers would cause by a regular, informal altering of the division of water. Differences in borrowing patterns in some contexts might be based less on individual abuses or class or factional cleavages than on locally-derived justifying criteria for permitting access to extra water

supplements. Such criteria would be what farmers consider to be valid excuses for needing to borrow water more or less often than one's neighbors. Such may be the case in smaller, farmer-built systems, especially where class or ethnic cleavages are not significant. In such systems considerable temporary adjusting and borrowing might be needed, and in fact used more for an equalizing than an unequalizing purpose.

2 The Balinese Style of Social Interaction

Implicit in interpersonal interactions among the Balinese is the notion of rukun. This is both a norm of solidarity and a civic process of "mutual adjustment," which has as its purpose "the creation and maintenance of order" (Geertz, 1980, p. 48, 84). Farmers in both systems occasionally used the terms kesa-daian (common understanding) and kebulatan (unity), which are close in meaning to rukun, to refer to desired, if not actual, relations among subak members.

Two strong cultural virtues underlie the process of rukun in these subak. One is that of sabar[1], which means patience or tolerance with others. Among these water users, to be sabar is to recognize the rights of others to at least partially counteract the physical inequalities of soils, water sources, and channel

[1]These are all Indonesian terms and were commonly used by the farmers.

position through informal water borrowing. It is also a recognition of the need for granting flexibility in a climate of uncertainty and tentativeness in the new systems. Farmers used the term sabar to describe how one should react to the actions of others, even those whose actions were clearly not justifiable. The other virtue is malu, to which we have already referred, and which means roughly, restraint due to embarrassment, shame, or modesty. In the process of testing expectations about rights of access to water, one's actions should be constrained by a social sense of malu. Farmers used the term malu to refer to how they would feel before others if they were seen to be taking-brazen or selfish actions which would impinge upon the rights of others. They referred to it in the following kinds of contexts. In Werdi Agung, Pak Kertia, a young son-in-law of the owner of E7, who was sharecropping on the field, said he was reluctant to borrow water frequently without returning the division to normal because if the upper-enders came and saw that he was borrowing water, they might think he was always doing it. He would feel malu. Farmers say they are especially inclined to feel malu if they borrow water when the padi of field neighbors is in a critical water demand stage (such as at, or immediately after, transplanting or at the reproductive stage). Pak Patera (L2), the former klian subak, was malu to make sawah in a neighboring tertiary block since there wasn't enough water to go around (even though his field was at the top of the block) and since he already

had two hectares of sawah in other locations. Subak leaders say they are malu to report and fine for water theft without first receiving complaints from the effected farmers.

In both of these subak rukun is created, approximated, maintained, tested, and sometimes obfuscated by the two mechanisms of musyawarah, direct deliberation, and baku tarik, the giving and taking of water from one another according to the differential conditions of need and excuses among irrigators. In Balinese society this process of negotiating with channel neighbors and giving and taking of the water supply should be imbued with the virtues of sabar and malu.

These virtues, which are strongly emphasized in the culture and rhetoric of the Balinese, are associated with the generally self-effacing style of discourse, the characteristic understatement, the rhetorical images of flexibility, the reluctance to assert authority, and the usual aversion to directing confrontational demands or abuse at others.[1]

When I was with farmers and we observed an alteration in the standard division of water, they were loathe to call it stealing and usually called it pinjam, or borrowing, even when they subtly indicated that it was done improperly. This was both out of characteristic understatement and because of an expressed need for sabar, with the explanation that such things were done

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[2]See Covarrubias (Ibid) and Geertz (1973:Chapter 14) for discussions of these Balinese social virtues and styles.

back and forth with a sense of give and take and tolerance. Farmers nearly always referred to their channel or field neighbors not with the term tetangga, meaning neighbor, or anggota, meaning member, but with the term teman, meaning friend. With the frequent use of the terms teman, baku tarik, or musyawarah farmers emphasized the idea of interpersonal reciprocity, not conformity to rules or formal arrangements. Often it seemed more problematic for farmers to pass judgement on whether a given act of altering the water supply was wrong or unacceptable than to determine who had done it.

Through the individual forbearance brought on by malu and the flexibility and tolerance of sabar, Balinese feel that a sense of rukun can be attained. It is apparent that such cultural virtues and sentiments shape the style of social interaction. We will see in this chapter whether or not such virtues seem to have a social force in, or are compatible with, the results of allocating water in the subak.

3 Adjusting the Standard Division of Water

3.1 The Standard and the Actual Division

The term "standard division of water" was defined in Chapter Three to mean the proportions of water designated for plot intakes or channel offtakes by the subak. At the level of the plot intake, the meaning of the standard division of water is the

same as the meaning of the commonly used term, "water share" (see Levine and Coward, 1985). We use the term "actual division of water" to refer to the actual physical distribution of water in a system at any point in time (i.e., the actual distributional results of irrigating). The designation of a given water share may or may not itself guarantee a result or implement a practice. The actual process and results of irrigating may vary substantially from what formal rules, rights, or other official institutions may imply. Hence the distinction between the standard and actual division of water is used in order to emphasize the difference between the rules and processes of irrigating.

Except for the few exceptions referred to in Chapter Three, the standard division for almost all plots is simply based on size of land irrigated. And yet in these systems the process of altering the standard division of water is very frequent, is widespread among users, and is therefore quite important in the process of allocating water. In this study the phrase "adjustments in the standard division of water" refers to any temporary departure from the officially-sanctioned proportional shares rule which is set by the permanent physical structures of a system. Such temporary adjustments are made either in order to obtain extra water or occasionally to cut off the flow into one's own field for temporary drying.

In these two systems the actual division of water is the result of both the constraints of the standard division and the processes of informal interaction and mutual adjustment. I assume that this is the case in nearly all irrigation systems. The relative adequacy of the standard division in approximating the actual division may be related to the nature of physical and social complexities in the system, the predictability of weather patterns and water supplies, the timing of farming practices, and the local relative importance of subak rules and processes of interaction.

To the extent to which studies of irrigation systems emphasize descriptions of formal rules and institutions to the neglect of analyzing actual processes and results, an inflated sense of the importance of formal, authoritative modes of organization may be conveyed. At the same time the nature, effects, and capacity of informal interaction and interpersonal adjustments may go unperceived. It is the purpose of this and the next chapter to examine the nature of interaction and mutual adjustment and accommodation among water users and to relate it to the results of efficiency and equity in the actual division of water.

Membership in the subak or renting water and maintaining channels establishes a right to a standard division for a plot's given size category. This proportion of water is formally established by the subak and is not changed permanently unless there is a significant change in the amount of sawah irrigated or unless some more permanent exception to the land size basis for a division emerges, due to some other physical condition. Subak

authorities reported only three such cases in the two systems. The one reported case in Mopugad was where a small plot near the ravine <C3> did not receive any drainage from neighbors. The cases in Werdi Agung were plots next to gullies which had exceptionally high infiltration rates.

We might ask why so few official and permanent exceptions to the standard division had been made in settings where altering the division of water was so frequent. Over the course of my observations three reasons became apparent. First, I was observing water allocation during two unusually dry planting seasons. Water borrowing, though still said to be common under normal conditions, is probably less frequent under water abundant conditions. Second, the climate of uncertainty, due to the newness of both systems and the magnitude of micro-physical variations within them, seemed to make farmers reluctant to petition for, or grant, official, permanently enlarged exceptions to the standard division (based purely on land size) in more than a few extreme cases. Third, the subak secretary in Werdi Agung said that if official enlargements were granted more widely then many of those farmers wouldn't bother to plow and harrow their terraces as carefully since they had more water anyway. As a result, the overall efficiency of water use would decline, he said.

For those plots which have exceptionally high water loss rates due to soils and not to some highly visible topographical condition, such as having a gully adjacent to one's plot, the burden is placed on the petitioning farmer to demonstrate that he has made a proper and thorough effort of terracing and land preparation. One petitioning farmer in Werdi Agung (E3) was denied a permanent enlargement because the subak secretary decided that his terracing and land preparation had not been done properly. Subak authorities in both systems identified a few farmers whose plowing techniques were thought not to be thorough enough and to cause higher infiltration than otherwise would be the case. We have seen in Chapter Four that this is demanding and involved work which continues for several years until the degree of compaction stabilizes. But in a more limited sense, the process of compaction and terrace plastering continues as long as new and deeper topsoil is being created. So for the first several years of a new irrigation system, most plots have not yet reached a point of stabilized compaction. Relative rates of infiltration could change after the first several years of terracing.

Some farmers may be too busy acquiring and cultivating other fields to do a very thorough job of terracing and land preparation in the early stage of resettlement. Several farmers were apologetic to me about their terracing and expressed the desire to modify the shape of terraces in their field in the future, to make them longer and more uniform. Such fanners have less incentive to do so thorough a job of land preparation if

they expect significantly to alter the terraces in the near future, part of the purpose of land preparation is to invest in the long-term water holding capacity of the terraces.

In such a context it may be unclear who already has done, or who will do, a proper and thorough job of terracing and land preparation. Micro-variations in topsoil depth add to the uncertainty. It is not surprising under such conditions, therefore, that so few plots in both systems have received official, permanently enlarged intakes. It should be pointed out that in neither system were any upper-enders given enlarged intakes, despite the existence of several such plots which met the criteria of high water loss and no access to drainage. Being an upper-ender is, by itself, recognized as a sufficient disqualifying criterion for getting a disproportionately enlarged intake.

Since irrigated land size is still nearly the sole basis for the standard division of water in these new systems, any allocational patterns which depart from it (except in the case of taking equal rotation turns) are departures from, or are augmentations of, the land size criterion for water allocation, our task is to identify these bases or criteria for differential patterns among irrigators of altering the standard division of water. In contrast to the land size criterion for establishing the standard division of water, it is more difficult to identify precisely the perceived purposes, specific rights, and bases behind patterns of temporarily altering the division of water.

In the attempt, we must rely on a record of the rhetoric employed and the behavior exhibited.

3.2 Methods for Adjusting the Division of Water There were eight methods of altering the standard division of water which were used by farmers in both systems. These were to: 1) enlarge one's own normal intake; 2) make an additional intake; 3) make a hole beneath the temuku (proportioning log) in the channel at an upstream neighbor's intake; 4) close the intake of an upstream neighbor; 5) block the channel just below one's own intake; 6) block another channel to add water to one's own channel; 7) increase the water supply entering the system at the main offtake; 8) use an aquaduct across a channel to prevent a neighbor's drainage from entering the channel and to redirect it into one's own plot; and 9) to use various combinations of the above methods. Methods seven and eight were rarely used.

There are various physical and social reasons why farmers choose or avoid certain of these methods. For example, enlarging one's own intake generally may be adequate for top-enders, where the flow is larger. But the same method often may not bring in enough extra water to a lower-end borrower. Additional intakes may be opened up because of topographic irregularities in a plot which inhibit flow from the normal intake to certain parts of the field. If more water is wanted than what can be obtained by

either of these two methods, a farmer may block the channel just below the plot intake. This brings in a much higher volume of water but it tends to be more noticeable and less tolerable to downstream neighbors than just enlarging one's intake. These three methods have two similarities. Each occurs at the plot of the borrower and tends to be more common among the top-enders, where the flow at one's intake more often is adequate for most borrowing purposes, than is the case at the intake of lower-enders.

Method three (making a hole beneath the intake temuku in the channel of an upper neighbor's intake) and method four (closing an upper neighbor's intake) are used at the intakes of upper-enders. These methods are more frequently used by those along the lower and middle sections of the channels, to divert water from the upper plots to the lower ones. Closing the intake of an upstream neighbor is a more socially intense form of borrowing in that it focuses the loss on the given plot. A farmer will not do this without permission if the respective upstream neighbor is in his field. However, if the neighbor is not present and there are several downstream users, this method has the advantage of anonymity. Even more anonymous is the person who makes holes under the channel side of the temuku of a neighbor up channel. Such holes, if small, may go unnoticed.

Unless this method is used to counteract the blocking of a channel upstream, it is considered to be an affront to the physical integrity of the system, as well as a breach of the reasonable range of giving and taking of water. Its surreptitious nature tends to circumvent the one element of reciprocity which exists in all other forms of water-taking, namely visibility. If a farmer arrived at his plot and his intake had been shut overnight, he would immediately see it and be able to open it. However, if small holes are made underneath temuku, they will allow more water go under the log and go down channel, past the intake. Such alterations could go unnoticed for some time, leaving the farmer unaware that the standard division of water had been altered against his favor.

The saying, "Yg sering ke sawah dapat air" ("The one who often goes to the sawah gets water") was often said in an ironic tone. It was also said in reference to those who did not tend their fields often enough. If a farmer often went to his plot, at least to inspect the water, he would be able to see if someone were borrowing water from him and he would be able to redirect it back into his plot. At the same time, he would be more likely to meet other users and be available to negotiate temporary arrangements.

Fanners in both systems felt that if a farmer was not conscientious enough to go regularly to his sawah fields and help inspect the water, he shouldn't expect the subak leaders to keep things in balance. However, farmers in both systems felt that others should not regularly take water from them if it made

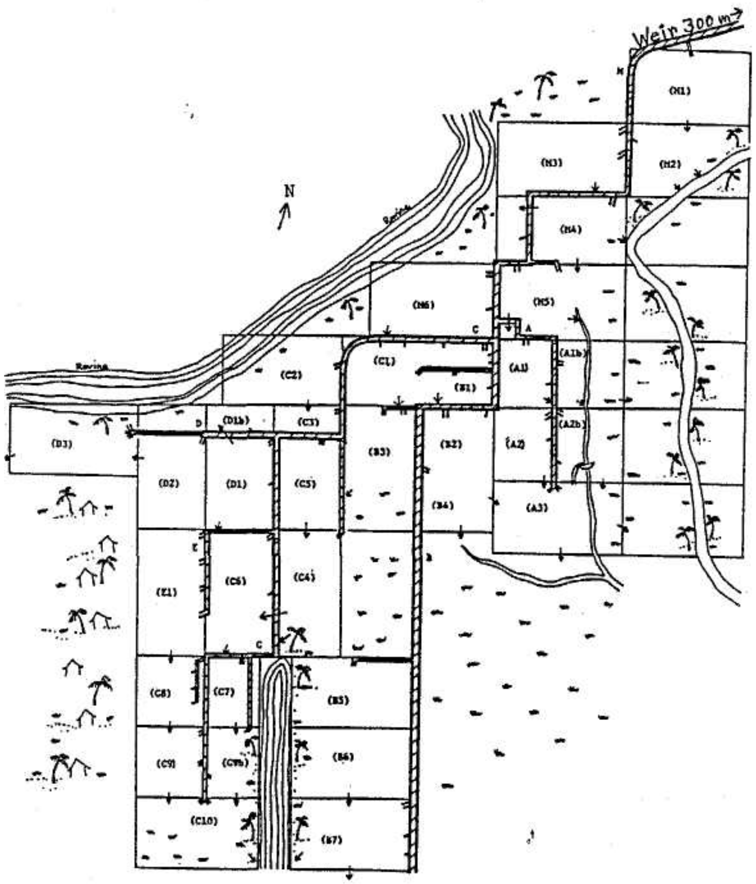
their plot go dry. A farmer should feel malu, or ashamed, to close the intakes of others when their field was already dry, unless they had explicitly arranged to rotate water. In neither system would the subak authorities act unless the respective farmer made a formal complaint based on direct observation. Even such complaints would be ineffective without the frequent presence of the fanner at his plot personally to see that water allocation did not get too far out of balance.

The method of blocking another channel to add water to one's own has the advantage of avoiding tensions with one's immediate channel neighbors and generalizing the exchange to a more distant and anonymous level. It also has the potential of bringing more water into one's field than do the other methods.

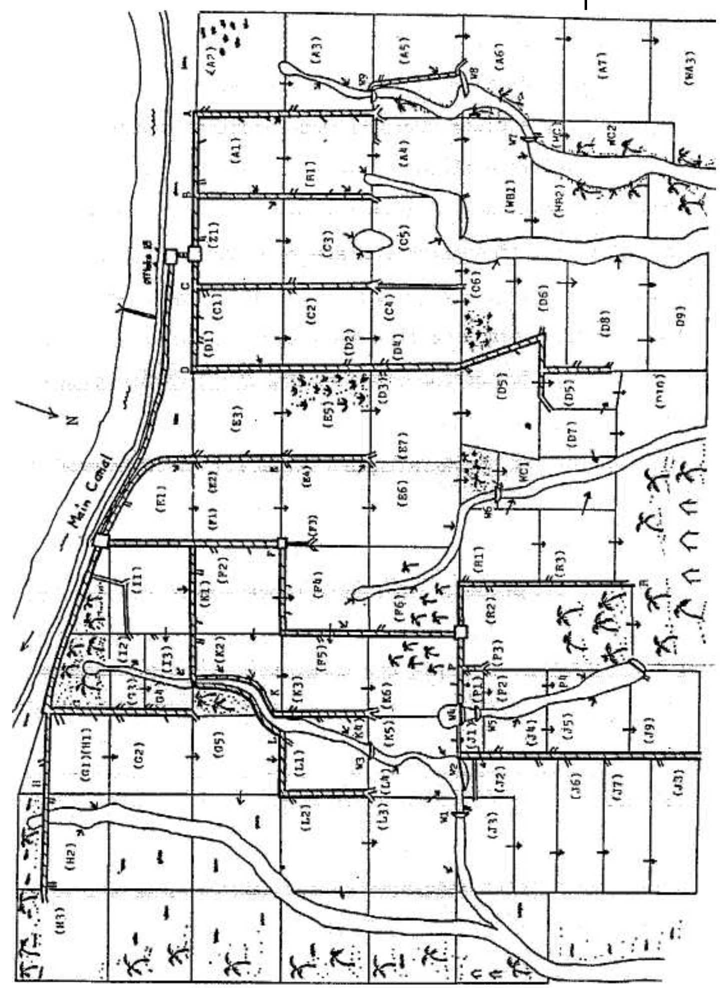
4 Interactive Environments

The narrower and elongated nature of the system in Mopugad (see Figure 5-1) means that a greater proportion of the acts of altering flows have more cumulative effects down through the system, than is the case in Werdi Agung (see Figure 5-2), with its more spread out and segmented channel layout. In Mopugad water borrowing tends to affect more plots on the average, than is the case in Werdi Agung with its generally shorter channels.

Hence, there is a greater potential in Mopugad for patterns of borrowing to develop which are more often anonymous because



Figure



of the existence of more fanners per channel and because of the frequent interactions between bottom-enders of channels B, C, or D and top-enders of channel M. The split of the main channel in the upper-middle part of the system into channels B and C invokes a tension between lower-enders of channel B and lower-enders of channel C.

The more segmented nature of the system in Werdi Agung tends to focus the effects of borrowing within smaller sets of plots, except of course when borrowing happens to occur at channel division points. However, as we will see in the next chapter, a greater proportion of the borrowing in Werdi Agung occurs at intakes (compared with channel division points) than is the case in Mopugad.

The set of neighbors one commonly associates with in the interaction or give-and-take of water allocation can be considered as one's water allocation interaction group. If one's most common location of altering flows is at one's plot, then by our definition that person's allocation interaction group would be all those affected by this as well as all those who commonly affect his flow of water. The size of such groups varies according to channel configurations, the number of plots along channels, and methods used for altering flows.

Such groups tend to be smaller in Werdi Agung than in Mopugad because of the shorter channels in Werdi Agung and the greater tendency to alter the division higher up in the system in Mopugad.

While channel A in Mopugad is an exception to this tendency because it is short, channel D is not, because of the frequency of which the fanners of plots Dl and D3 alter channel division points at the C/D and B/C points and close the intakes of top-enders. (This will be shown in the following chapter.) This creates a large interaction group for these users, by our definition. In Werdi Agung the shorter channels break up the lines of water-related interaction into small groups. Also, the need for going up channel more often is mitigated in Werdi Agung by the presence of alternative water sources lower in the system, something which doesn't exist in Mopugad.

To better understand the kinds of criteria the farmers use to assert rights to alter the standard division of water, we will now describe the nature of interactions among farmers in two selected locations in each system. Such locations were selected to illustrate the range of "interactive environments" in each system, from environments where the water users are relatively mutually accommodating to those which are more conflictual.[3] The four locations below are presented in order of going from more accommodative to more conflictual environments.

[3]A detailed description of the nature of interpersonal water allocation relations in the other parts of each system, other than the locations described here, is found in Appendix Two.

4.1 Location One: Channels A and B in Werdi Agung Channels A and B serve eight plots directly (beginning with Zl) and five lower plots indirectly. Any altering of the water division by these farmers nearly always is done only locally, within this group. As was seen in the preceding chapter, there is a general physical, equalizing tendency for plots lower in the system to have lower infiltration rates and relatively less dependence upon the channels for their water sources. Generally, the reverse is true for upper-enders. This pattern is especially marked along channels A and B and seems conducive to the largely accommodative relations among the irrigators.

An accommodating relationship over time developed among farmers of plots Al, Bl, A3, A4, and A5. Originally channel B cut through the middle of plots Al and Bl, running along a ridge. After the ridge gradually disappeared over several seasons of land preparation, A4 requested that channel B be moved over to the left boundary of plots Al and Bl so that the water would not run through the middle of the plots and be more likely to be tampered with by those users. It was easy for fanners to say that they had a right to extra water because the channel cut through their field, using up part of their land. So the channel was moved to the boundary. But afterwards a marshy spot or spring developed which blocked the flow of channel B water to A4. This proved beneficial to CS, however, who had the right part of his plot unable to get water from channel C because of

a small gully being in the way. So he was able to get some water from channel B as a result of the change. Thereafter A4 began using an intake from channel A. Since A5 received considerable amounts of groundwater, A4, who did not receive such groundwater, developed a pattern of borrowing from AS more than A5 borrowed from him. A5 understood this, and since he was comparatively better off (because of the groundwater return flow), he usually tolerated the borrowing practices of A4 as well as those of A3, who often enlarged his own intake above. A3 had sandy soil and the water he took drained or seeped to A5, A6, and A7 anyway, he said. So, as he put it, it didn't matter that he took more than the official amount.

Common knowledge about each other's differing configurations of water sources, channel locations, uses of drainage, and soil permeability helped make viable patterns of accommodation in this small group. The nature of such overlapping configurations tended to minimize rather than exacerbate the need for competition over channel water. Differences in infiltration rates and configurations of water sources available to the plots were understood and considered to be valid criteria for justifying the differential borrowing practices.

4.2 Location Two: Channel A in Mopugad This small channel, which branches off to the right of the main channel just above its division into channels C and B, serves just under four hectares of sawah. Since the channel passes through the middle of all but the bottom plot, there are intakes on both sides of the channel. A2 has given the right side of his plot to his son to cultivate. Al cultivates his land on both sides of the channel. Since A3 gets water by tapping the drainage stream above the right side of his plot, he generally is less dependent on the channel than the others. Also under normal water conditions, he receives drainage from B2 and A2. However the infiltration rate of plots A2, A2B, and A3 are much higher than that of Al.

Although A3 is at the bottom and suffered water stress clearly more severely than the others along the channel, he was not a frequent borrower. The three upper neighbors were all very frequent borrowers (usually doing so more than once a week) and they relied more singly on the channel for their supplies, except for small amounts of drainage from upper neighbors. Their common methods of borrowing water were at their own intakes, frequently blocking the channel to A3. The surface drainage from these plots either drained directly to A3 or into the depression on the right, which they knew be was able to tap. At the same time, he was accustomed to receiving steady drainage from B2, another source to which neither Air A2, nor A2B had access. A3 is a quiet, timid man and slow of speech. He expressed a culturally characteristic, meager expectation of water rights once, by saying, "Asalnya basah, cukup" ("As long as it's wet, it's

enough"). During the first season observed, A3's fields began cracking severely and the channel checking upstream from A3 became too frequent for him to tolerate. Reluctant to confront A2 and A2B about this directly, A3 complained to Pak Sulawa, the klian subak, who then gave A2 a first warning, with the threat of a Rp. 5,000 fine upon a second complaint.

At the outset of the second season, which appeared as though it would be just as dry as the first, A2 attempted to relieve some of the tension by building a small ditch to drain water from M5, which would have gone into the drainage stream or out to the river to the right. This directed the water back over to where it could enter channel A. During the second season some tension between A3 and A2/A2B continued, however, with A2 and A2B borrowing water frequently and A3 trying to at least get his field soaked periodically by resorting to arranging through Pak Sulawa to get occasional rotation turns.

During this time the water supply was so short that A3 usually did not receive any drainage from A2 or A2B and the supplement from the drainage stream was wholly inadequate. While the relative borrowing patterns between A2, A2B, and A3 would seem to suffice under normal water supply conditions (i.e., when A3 was receiving significant drainage from above), A3 began complaining about the borrowing since he was not getting enough water through drainage.

4.3 Location Three: Channels C and D in Werdi Agung In Werdi Agung, the physical setting of Channels C and D differs considerably from that at channels A and B. The quality of social relationships among irrigators differs as well. As was seen in Figures 4-4 and 4-7, a pocket of sandy, highly porous soils extends down through the middle part of the system to the lower plots. The plots in this area also tend to have a high dependence upon the channel, since substantial alternative water sources are not available. These characteristics combine to invoke a pattern of frequent and often competitive altering of the division of water, in contrast to the more stable and accommodating relations along channels A and B.

During the two dry seasons observed, most of the farmers along channels C and D regularly took extra water (i.e., more often than, and independent of, the seasonal periods of high water demand, namely, at land preparation, immediately after drying periods, and at the reproductive phase). And yet, there were three farmers who were recognized as being especially frequent borrowers. These were the operators of the plots Cl, C4, and D8 (D8 also owned and operated D5). Cl had very high percolation and seepage rates (measured roughly at ninety millimeters per day) and received no drainage. C4 was located toward the end of channel C and also had an especially high rate of infiltration (measured at roughly sixty millimeters per day). However, ordinarily he received some drainage from C2. Plots D5

and D8 had infiltration rates of about fifty-five millimeters per day, were completely dependent upon the channel, and were the further of the three from the headworks. Both were operated by the same farmer.

Where two or more criteria for access rights were involved and were in competition, it became more difficult to compare the relative needs or excuses of one another, even where presumption of faulty terracing or land preparation was not at issue. Cl complained on occasion that not only were his infiltration rates extremely high, but his intake was very often getting shut by lower-enders. However, C4 would refer to his being at the bottom of the channel and having high infiltration rates. The farmer who owned both D5 and D8 also was a bottom-ender and he asserted his need for extra water for new terracing. Besides the fact of subtle differences in infiltration rates, the relative merits of access rights were difficult to gauge due to the differing criteria involved. It was arguable whether the excuse of being a bottom-ender with soils with rapid infiltration rates (e.g. C4) was more compelling than being a top-ender who had the highest infiltration rates, no supplementary sources such as drainage, and an intake which was regularly being shut by lower-enders. A pattern of frequent and direct borrowing and counter-borrowing, with varying levels of tension, had accordingly developed among these farmers. Usually the farmers engaged in direct negotiation only if two happened to meet while one was altering the division. Otherwise, the frequent temporary altering of the division constituted a non-verbal form of negotiation, or testing for the levels of tolerance or acceptance of such practices. Both Cl, C4, and D5 altered the division very often. Cl often seemed to take advantage of some of the competition between D5/D8 and C4 by sometimes enlarging his intake and shutting channel C and other times enlarging his intake and shutting channel D. However, each one recognized the claims of each other. More than once I witnessed either D5/D8 or C4 walk up to the C/D channel division point to see what the division was, see that it was altered against their favor, and then leave it as found for awhile longer. Being sabar or tolerant towards a channel neighbor was not only an important social virtue but also was a means of avoiding disputation and of invoking tolerance in return.

4.4 Location Four: Upper Section of Main Canal in Mopugad In the upper portion of the main channel, differences in water loss rates are relatively minor. All of the plots except M2 are directly dependent upon the channel. During the first season of observation M2 had a direct intake from the channel. M1 had just made sawah and had begun irrigating the season before. M2 began receiving a considerable amount of drainage from M1. With the new experience of the major drought in 1982 and with complaints from lower-enders about excess use of water at the

top, M2 closed his old intake, obtained his division at the same place as Ml's intake, and began receiving all of his supply in the form of drainage from Ml. The prior arrangement of the direct intake on the side made it difficult to get water to the far side of his field. Although the water for M2 went through the plot at Ml first, M2 said that he preferred this change because now the water better penetrated to all sides of his field.

During both seasons observed, the intake at Ml was frequently opened very wide, with a small stone and brush drop structure frequently bringing in a much higher amount of water than was standard elsewhere, proportional to land size. One day I walked up and saw him piling up more logs in the channel below his intake, which he had widened to about thirty centimeters. He said that he had very new terraces which were not yet compacted and that he was in the process of making two or three more. Besides, he said, lower-enders were always tearing down his drop structure and closing his intake. If he weren't there for two days, there wouldn't be any water in the field.

Needing more water for terrace construction, making up for the decreased water supply due to having his intake frequently shut by lower-enders, and taking enough water to drain to his neighbor were all reasons which Ml used to justify his case for frequently altering the division of water in his favor, even though he was at the top of the system. He said that, "If a lower-ender (often D3, C8, or C9) came up and wanted to shut his intake for the night, if his sawah terraces didn't have water in them, how could he let them?" Such considerations were all part of the locally-recognized repertoire of "justifying criteria" for altering (or refusing to permit the altering) of the standard division of water.

On this occasion Ml had just opened his intake one-half hour before and had widened it to at least thirty centimeters and was getting a very large inflow. "Already I don't have any water in the terraces," he said. Therefore, he set the intake very wide, as was often the case, knowing that someone else soon would shut it again, probably that night. This occurred during an official rotation turn for lower-enders, of which he seemed to be unaware. As I left him, I looked at the terraces in the middle and lower portions of his field and saw a depth of water of one to two centimeters. Since this level was lower than the usual coverage, it was clear that his expectation of rights to enough water exceeded that of the lower-enders, who usually talked about their right (under the very water scarce conditions observed through most of the two seasons of the study) to at least be able to siram (soak) their land as often as others. This is consistent with Simon's argument that minimum levels of acceptability of goal attainments tend to be inversely related to the

More than once however, I heard lower-enders say that not only were these two upper-enders (Ml and M2) taking too much water, but they were draining much of it out of the system where it was not reused by the subak. Draining water out of the system from lower plots (such as from B3, D2; El) was considered to be justifiable. Doing so at the top was not, unless it was absolutely unavoidable. The only complaints I heard about non-communal drainage practices (i.e., draining water out of the system) were those aimed at the upper-enders. However, partly because of the dry conditions and perhaps partly aided by these complaints about drainage, M4 petitioned M2 to start draining a portion of his water to M4 via a short channel. This would supply three terraces in M4's field which were hard to be reached (due to topography) from the normal intake. M2 obliged him. This helped lend some visible credibility to M2's actions, whose change in intake location actually directed more water over to the right side of his plot, to be drained out of the system.

With the onset of the dry weather in 1982, M3 also began having troubles with lower-enders dismantling his intake drop structures. He had two intakes which were altogether at least double the standard division. He was using half of his irrigated land for sawah and half for fish ponds. Because of the fish, he never permitted his inflow to be cut off, even during rotations. During the second season observed, which was very dry, lower-enders began dismantling th<e drop structures below his intakes

and cutting off his inflow. Since he had a small house at the side of his field, he was nearly always present and therefore could quickly reopen his intakes. But toward the ripening phase of the rice season, in order to assert his notion of water rights, he positioned a wooden post at each of his two intakes, with a fish-shaped piece of zinc sheeting attached as a reminder that he had a fish pond which could not tolerate a disruption of its water supply. In this case the sign was not a symbol of formal subak authority, but a symbol of his own denial of personal permission to others to shut his intake.

Toward the end of the season, Pak Tangkas (owner of M3) had an unusually heated argument with the secretary of the subak, Pak Maning. Shortly afterwards each of them independently offered a summary of the confrontation. Maning told Tangkas that it was not appropriate, especially under these dry conditions, to be taking so much water. Everyone was supposed to follow the rotations, when established. He said that in the subak deliberations, the accepted principle of equal divisions of water had meant to apply to sawah, with no expectation of special water requirements for fish. Therefore the subak water was not intended to be used in this way. Tangkas said that Maning drained his water out of the system, not to be used by subak members again.*

'This was only partly true. Some of his drainage went directly out of the system, some was drained directly to Al, and some went into a natural depression which was then blocked and used below by A3.

Tangkas said that he himself drained all of his water directly back into the main channel (as opposed to draining directly to another's fields, as Maning and most others were doing). He said that this practice was in accordance with adat subak (traditional subak regulations) in Bali.[5]

Tangkas then referred to the fact that Maning had come from the mountainous, rainfed farming lands near Gunung Agung (the high volcano in eastern Bali) and did not have prior experience with adat subak before coming to North Sulawesi. He said that he himself came from the lowlands and knew subak customary law and sawah cultivation by long experience, and that in Bali they often had fish ponds with water rights as long as one's drainage re-entered the channel. He said that it should be all right to permit him to direct the whole main channel to flow in and out of his ponds. Besides, he got some groundwater from the hills above his field. This water entered his field and drained into the main channel. Therefore, he said, his drainage probably added some water to the system.

In this exchange which ended without a resolution, each party referred to the mutually accepted and legitimate rhetoric of fairness, individual and group rights, and even the "Balinese-ness" of customary subak law. In this case Tangkas (M3) emphasized traditional Balinese rules and Maning emphasized the

[5]This practice was also mentioned by Liefrinck as part of adat subak in the south central plain of Bali, which is where Pak Tangkas came from.

deliberative process to reach kesadaran or common consensus. To Maning the farmers were in a new environment which required either new rules or new interpretations. The basis for group adaptation was musyawarah, or deliberation. The rhetoric used in this interchange was mutually recognized as part of the relevant repertoire of considerations or criteria pertaining to water rights. On this occasion, however, they used the rhetoric not to create a new solution in a new setting, but to contest each other's understandings about what the valid criteria should be for having so large and stable a flow as was being insisted upon by Tangkas. The subak secretary was unwilling to accept the excuses offered by Tangkas.

Soon thereafter, the owner of C4 told me that he and others in the system did not like M3 taking so much water, even though most of it was drained back into the channel. He said that it was certain that not all of it returned to the channel and even that which did return would be late in arriving below. Moreover, it was bothersome to see such a large flow enter M3's field when the fields below were dry. Lastly, he emphasized (as though making his most basic point) the question of mutuality: "If everyone did it, then what?"

He was saying that it couldn't be right because there was not enough water to permit everyone who might want a fish pond to have one. They felt that no one should have them if some didn't have even enough water to keep their sawah from cracking.

If the action precluded others in the group from acting in a reciprocal manner it couldn't be right. The ethic of kebulatan, or mutuality, was more immediate in the discussion than was a concern with approximate equity of result. Underlying these complaints was the notion that the subak's fundamental purpose was to permit sawah cultivation by all members. Any other enterprise which used Water in a way detrimental to the guarantee of sawah cultivation by others was improper. Implicit in this exchange was the notion that exceptions to the rules could be permitted only as long as the actions could somehow be reciprocated by others doing the same thing as needed, or else by just not interfering with the sawah-based, give-and-take in the system.

4.5 Conflict, Accommodation, and Spatial Configurations of Justifying Criteria

In these four cases described above, the locations experiencing greater levels of conflict were settings where water shortage was experienced by each of the contending water users. Also differences occurred between farmers according to two or more criteria. But the criteria invoked frequent borrowing incentives in each of the contending farmers (rather than nullifying such needs for some, as in the first location described) . Where two or more criteria were in competition, the rhetoric and comparisons of rights between farmers seem to become more controvertible.

In the first location relations among water users were relatively accommodative because those farmers having fields with high infiltration rates could readily borrow water from those whose fields had low infiltration rates and substantial ground-water return flow. Not all users experienced chronic water shortage, and the differences between them regarding the criteria of soil porosity and water sources were complementary, not competitive. In the fourth location, not only were there multiple criteria which were in competition (e.g., channel position, soils, water sources, water demand for fish ponds), but one of the criteria (e.g., water demand for fish ponds) was challenged as to whether or not it should be recognized as a justifying criterion at all, for adjusting the division of water.

5 Relative Patterns of Frequency of Adjusting the Standard Division of Water

We will now examine the question of who in the two systems altered the standard division of water often or not often, relative to fellow water users. Sections 5.1 and 5.2 provide answers to the following questions: "Are different patterns of altering the standard division of water based more on personality differences, nepotism, abuse of being in strategic positions, or factions? Or are they based more on water-related physical inequalities around the systems?" In the preceding section we saw some indications of opportunism among water users. Nevertheless physical inequalities, such as relative soil infiltration rates, channel position, the availability of alternative water

sources, or forms of land use with high water demand (such as new terracing or tending fish ponds) were clearly at the hub of the rhetoric of water allocation. We will now see if they are also central to the practice of altering the division of water.

5.1 A Model of Adjusting the Division of Water

We will first identify the irrigated plots in each system whose farmers take extra water more frequently than their fellow water users. It was not possible either by regular observation, informant accounts, or farmer interviews to obtain reliable estimates of absolute frequencies of how often each farmer took extra water during a given season or other time period. Even if such information could be obtained for periods of less than a whole season, it would be impossible to extrapolate from this to make estimates for the whole season, because of the varying effects on farmer water demand of changes in growth stages, rainfall, and irrigation discharge.

However, informants could readily make a two-way, rank-order comparison between farmers who often or did. not *often* take extra water. Informants who generally were the more articulate farmers in different parts of the systems, grouped farmers into either category, relative to other farmers they were comparing. My discussions with other fanners and my own data on locations and frequencies of altering the division of water also were used as a check to help assign farm plots to these categories. The rank order was considered to be consistent from season to season, although the actual levels of borrowing might have varied considerably over time. Farmers seemed ill-disposed to make any more precise categorizing of relative frequency of taking extra water. Informants associated borrowing water often with generally borrowing water more frequently than the peak water demand periods of land preparation and the restoring of water to fields after drying for weeding or for the application of chemicals. To not often borrow water meant typically to borrow water only at these intermittent, high demand periods, or even less often. Nevertheless, because of the variations in levels of borrowing the ranking is used herein only in a relative and ordinal sense. In Mopugad, because of the smaller number of plots (thirty-four), the frequent forms of borrowing near the top of the system in ways that affected most or all of the plots, and the fact that comparisons could naturally be made by informants at this level, comparisons were made across the whole system as a single comparison group. However, in Werdi Agung, because of the larger number of plots (seventy-eight) and the more segmented or self-contained patterns of borrowing, comparisons could be made confidently only within the different channels where most of the borrowing took place. These eight allocation interaction groups were channels A/B, C/D, E, F/P/R, K, L, G/H, and J.

In Figures 5-3 and 5-4, we can see the distribution of plots whose farmers adjusted the division of water often or not often,

relative to other farmers in these interaction groups. As can be seen, the darkly-shaded plots, which are those labelled often, do not group together in either the upper or lower sections of the channels in either system. Factors other than mere channel position are involved in the predisposition to take extra water more or less often than one's neighbors.

A particular act of borrowing water may involve conscious considerations about the incentives or disincentives of taking extra water. Over time such considerations become latent, or tacit, and the borrowing practices evolve into a "preattentive" pattern of routine actions." By "preattentive" actions we mean those which are taken without conscious evaluation of reasons for the actions or alternative courses of action. They are routine or automatic and hence do not really involve discrete decisions, over time, conscious decisions may evolve into tacit dispositions toward routine practices. Such an evolution itself is seen as a kind of adaptation, not only adaptation to a complex environment, but also to the psychological need for a cognitive shorthand to deal with repeating processes:

> Therefore, instead of going through a complicated decision process to do something...every year, farmers develop a plan . . . to do it, in order to save cognitive energy and avoid stress. ... The decision is made so frequently, so routinely, that the decision rules become part of a preattentive plan or 'script,' like the script in a play. . . . (C. Gladwin, 1984:209)

•See H. Gladwin and M. Hurtaugh, 1980 for a discussion of "preattentive" or tacit decision processes.

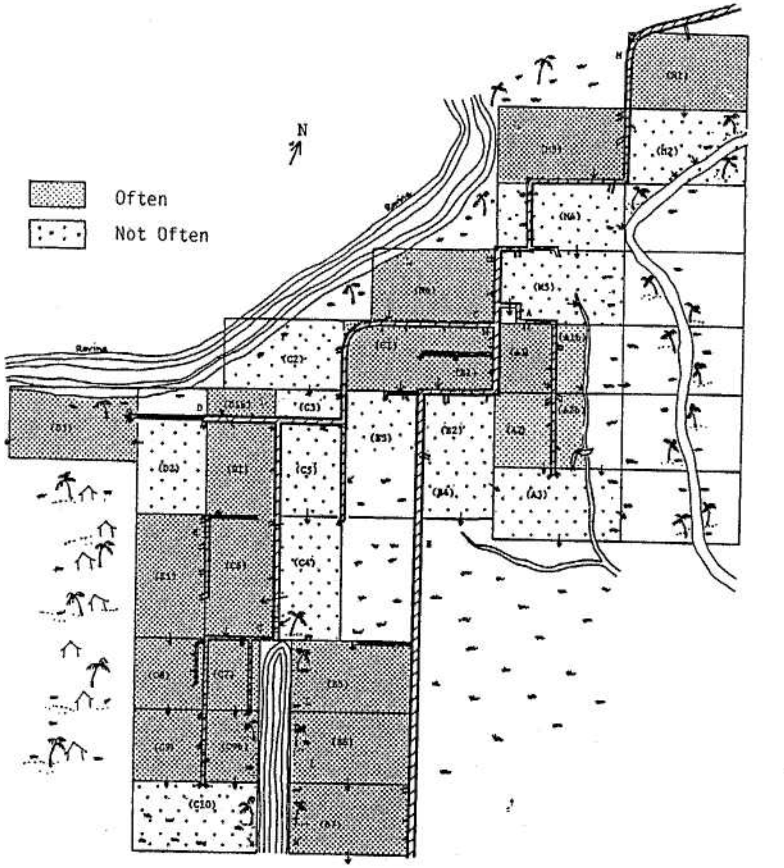


Figure
5-3

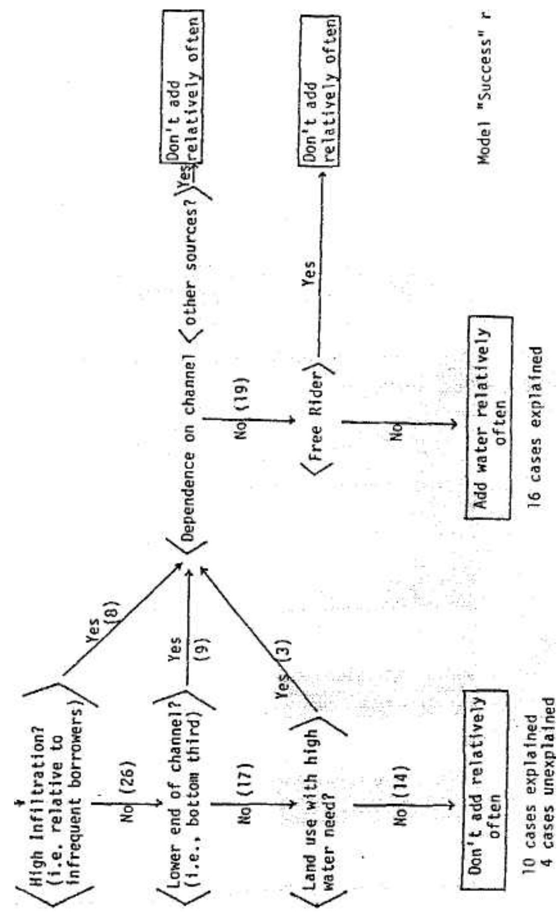
Figure 5-4. Relative Frequency of Adding Water, Werdi Agung

After a few seasons of irrigating, farmers develop either common understandings or chronic tensions with channel neighbors. Eventually habitual patterns of borrowing water develop. The implicit reasons or criteria underlying the pattern of behavior need not be consciously considered at each act of altering the division of water to one's advantage. The criteria become "justifying criteria" when someone refers to them to justify to a neighbor, or to oneself, one's right to such supplements of water.

Based upon fanners' statements and personal observation, I constructed a model of the incentives and disincentives that farmers indicated were relevant to the predisposition to often or not often add water, relative to channel neighbors. The model is meant to explain, as concisely and as accurately as possible, to what we may attribute the differences in relative frequencies among farmers of adjusting the standard division of water.

Although the model is a model of a pattern of behavior, not a discrete decision, it is presented in the form of a decision tree diagram for clarity of presentation.' Figure 5-5 shows the model for the irrigation system in Mopugad. The three factors on the left were those identified by farmers to be the predominant incentives for wanting to borrow water often. The occurrence or not of each of these three incentives were classified in such a

'This format follows C. Gladwin's (ibid.) use of decision trees.



way as to approximate how the fanners themselves usually posed them. The first incentive is whether or not one's plot infiltration rate is higher than the average infiltration rates of others in one's channel (or allocation comparison group, which is identified below) who do not often take extra water. The second incentive is whether or not one's plot is in the lower end of the channel, defined here as the bottom third of the channel (in terms of distance). The third incentive is whether or not the plot, during the present and/or previous season, has had a form of land use with a particularly high water demand (e.g., land levelling, new terracing, or keeping fish ponds).

In Mopugad twenty of the plots had at least one of the incentives and fourteen did not.' Of the fourteen cases not having one of the incentives, ten of them in fact did not take extra water often, as the model predicts. However, the behavior of four of the fourteen cases was unexplained by the model. They did not have any of the incentives in the model and yet were frequent borrowers. These were plots Cl, Bl, M6, and Al.

Sixteen of the twenty cases which had incentives did not have either disincentive and therefore pursued a pattern of relatively often taking extra water. Four of the twenty cases were constrained by disincentives and did not relatively often borrow

'The step-wise, sifting out nature of this model obscures the fact of overlap, that several cases had more than one incentive. Actually ten plots were in a bottom position and six had high water demand land uses. However the presence of only one incentive usually is enough to prompt frequent borrowing.

water. The first disincentive listed is that the given plots's dependence on water from the channel is less than its dependence on other sources (e.g., neighbor's drainage, groundwater recharge, or other surface sources). The second disincentive refers to incidences where a plot automatically obtains the benefits of the frequent borrowing practices of a channel neighbor, because the common methods of borrowing which the neighbor uses generally add water to the flow to both plots. Of the four which were so constrained, one had low channel dependence and three were "free riders" of other borrowers. Altogether the model "explains" the borrowing patterns of thirty of the thirty-four plots, or eighty-eight percent.

The model for the Werdi Agung system is displayed in Figure 5-6. Fifty-seven of the cases had at least one of the incentives and passed to the disincentives in the model. Eighteen cases did not have any of the incentives and fourteen of them did not often borrow water. As can be seen, nineteen cases were constrained by low channel dependence from often borrowing water. This reflects the prevalence of groundwater recharge and alternative water sources in the lower portions of the system, in contrast to Mopugad which generally lacks return flow lower in the system. Six others were free riders and did not often borrow water. There were thirty-two cases which had incentives but no disincentives. Of these, twenty-five were frequent borrowers, as the model predicts, but seven were not. Altogether

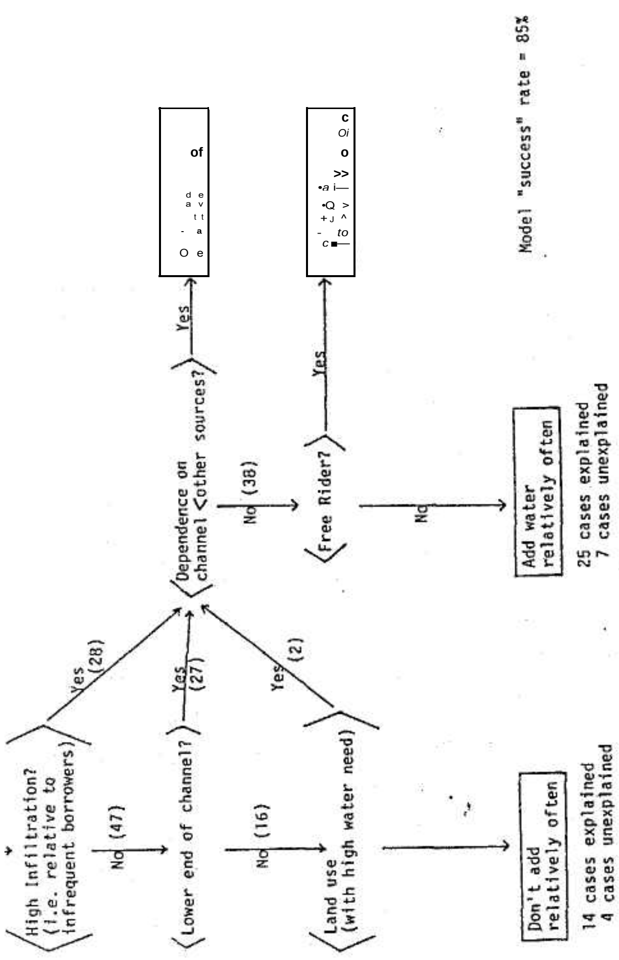


Figure 5-6. Relative Frequency of Adding Water Beyond the Standard Division, Werdi Agung

the model successfully explains the relative borrowing patterns of eightyfive percent of the cases.

Of the eleven unexplained cases in Werdi Agung, seven had incentives and no disincentives but still did not borrow often, regardless. Two of these, Zl and A2, had high infiltration rates but were at the top end of channels, where the flow is relatively high and stable. So most of the unexplained cases were not those who often took extra water without apparent reasons, but those who did not often take extra water, despite having apparent reasons.

In Mopugad four cases (Bl, Cl, M6, and Al), or twelve percent, were frequent borrowers without having apparent physical reasons, or justifying criteria. In Werdi Agung four cases (J2, L2, Kl, F2) or five percent, were frequent borrowers without having a reason which is apparent in the model. We will now discuss the context of these patterns and their exceptions.

5.2 The Context of Patterns of Water Allocation As has been mentioned in the preceding chapters, the patterns of water allocation occur in a relatively simplified and homogeneous social setting. The level of landlessness is small by third world standards. Almost all of the fields are operated by the owners. Among the few who are sharecroppers in both systems, they are nearly all spontaneous transmigrants who are closely related to the owners of whose fields they work. In these cases only a portion of the field, not all, is given over to the relative to sharecrop. Typical shares are 50:50 of the harvest. It is the convention in both Mopugad and Werdi Agung for the owner to take responsibility for (tanggung jawab) the allocation of water to the plot.

Besides the lack of exploitative socioeconomic relations among these farmers, there is a lack of extensive or powerful kinship networks. In ray direct observation of behavior and in discussions among farmers in Werdi Agung, it was apparent that differences in religious, caste, or political affiliation mattered very little in allocating water in the subak. As in Bali, both of these subak allocated water within the systems without much reference to village or banjar governmental affairs. Although in Werdi Agung the timing of planting may be constrained by staggered water deliveries along the Kosinggolan Scheme, the allocation of water within the subak was as independent of outside manipulation as it was in Mopugad.

5.2.1 "Unexplained" Cases in Mopugad In Mopugad, of the four irrigated plots which often altered the division but which had no apparent incentives, two were operated by Pak Sulawa, the aggressive and controversial subak head (Bl, C1); one by Pak Ganderi (Al), a soft-spoken, aging, and low-key member; and Pak Puja Gunung (M6), a young farmer in his twenties whose land preparation technique others have said was rather careless and hasty.

Pak Sulawa had acquired twelve hectares of land besides the two which he had been granted as a transmigrant. He was by far the largest landholder in the subak. The next largest was Pak Maning who owned eight hectares. Most of Sulawa's other fields were planted in rainfed seasonals and tree crops, using share-croppers. Some of it was not yet cultivated. He worked on his own sawah field. Pak Ganderi owned only three hectares, one of which was planted with soybean and corn. During the second season I observed, he let Sulawa work a small part of his sawah plot, under a sharecropping agreement, because of his loss of strength due to apparent arthritis and ulcers. Part of the frequent borrowing at his plot was due to Sulawa. Pak Puja Gunung owned four hectares, two of which were planted in soybean and corn.

Therefore, except for Sulawa, these farmers who often altered the division without apparent excuse were farmers with roughly average landholding sizes (3.7 hectares being the sample mean, see Chapter Three). All three were Hindu Bali. None were of high caste or were in important village leadership positions. Those who were in positions to be ill-affected by these alterations were not compliant sharecropping clients or a contending kinship faction. Sulawa had a nephew at the bottom of channel B, who was often ill-effected by such alterations.

Sulawa was not on good terms with the village authorities. The village head failed even to be able to summon him to talk

•See Appendix Two for a description of this dispute.

about getting Sulawa to stop refusing water to Pale Nesa (B2) , during a dispute between the two.' Although the village head had legal authority to intervene in the dispute, he did not have traditional jurisdiction over the subak, according to Balinese customary law. Sulawa resisted his extension of village authority into the subak. By the middle of this season, as a result of general disagreement with Sulawa about this matter and a general dislike for his abrasive and ambitious style, a subak meeting was held and Sulawa was finally ousted from his position as head of the subak by the membership.

So almost all of those who were relatively frequent borrowers of water had known reasons for doing so that were within the common repertoire of justifying criteria. The above-mentioned exceptions are not related to broader potential socioeconomic factors such as differences in landholding or wealth, kinship, religious or caste affiliation, village politics, or patron client relations.

5.2.2 "Unexplained" Cases in Werdi Agung In the subak in Werdi Agung there were also four irrigated plots whose operators often altered the division of water in their favor, though without apparent reason (i.e., apparent in the model). These were at plots Kl, F2, J2, and L2. Two of the plots, Kl and F2, were owned and operated by the same person, Pak Lateri, who was a spontaneous transmigrant who owned only this single, one-hectare

plot. He was not a leader in village politics nor a powerful agrarian patron. He was considered by his neighbors to be very independent-minded. One neighbor said that he didn't want to be ordered to do things by anyone else. Pak Puger was a successful and respected farmer (called by the klian subak a petani betul, or a real farmer). He owned and operated plot J2 and a total of 5.5 hectares altogether, including 2.5 hectares of sawah and three hectares of rainfed crops. Pak Patera, owner and operator of plot L2, owned a total of five hectares, of which two hectares were sawah, two were planted with rainfed crops, and one was still uncultivated.[10] Pak Patera was the original klian subak when it was first formed. Part of the reason he quit after several years as klian, was because he reportedly had little disposition to entertain the stream of petty government officials that repeatedly call upon the heads of kelompok tani.

None of those effected by the altering practices of Pak Lateri, Puger, or Patera were agricultural laborers or sharecroppers who were otherwise dependent on these three as clients. Immediately below Pak Patera's plot was the plot of Pak Kolin, a respected head of another subak and a schoolteacher. Those who were ill-affected by such practices (and only moderately so, as

[10]He said he hadn't yet made sawah there because, although it was at the top of the block, near the gate, there was a chronic shortage of water. According to his field neighbor, since he already had sawah elsewhere, he was "malu" to make more sawah at that location when there were some who only had a little bit of sawah and not enough water.

will be seen in the next chapter) were independent owner operators, with no common factional, ethnic, kinship, political, or economic cleavage from these frequent water borrowers.

Also "unexplained" by our model is the behavior of seven farmers who had apparent reasons to add water relatively often but did not do so. These were at plots Al, A2, L3, C2, El, Rl, and R3. These were also owner operators and collectively had average landholdings of 3.1 hectares (the average for the subak being 3.0 hectares). So these were certainly not exploited or powerless peasants. Reasons for their lack of frequent borrowing may be related to physical or personality subtleties not apparent in our parsimonious model. And yet, plots Al, A2, C2, and El have porous soils and are solely dependent on the channel for their water supplies. However, they are all at the top of their channels where the flow in the channels is more substantial than below. Plots Rl and R3 are in the lower part of the system and are highly dependent on the channel, yet they do receive supplementary water supplies from a nearby marsh (to the right on the map) which they are tapping.

The repertoire of justifying criteria, as specified in the model above, does appear to be closely related to the actual behavior of water allocation in these two subak. It should be emphasized, however, that these patterns have emerged within a social context of relative homogeneity, a functionally specific

and independent organizational culture, and with only a small and "non-alienated" group of landless transmigrants."

6 Summary

In allocating water in these two irrigation systems the recognized rules, considerations, or justifying criteria for having rights to given permanent shares or frequent supplements are few. These constitute a common repertoire of justifying criteria for asserting rights to temporarily adjust the division of water.

This repertoire includes reference to soil water retention characteristics, access to different forms of water sources, channel position, having intakes frequently closed by others, and having fish ponds. When this repertoire of criteria is applied to the physical complexities in the systems the potential for discord and differing conceptions is considerable. Such criteria do not directly determine patterns of water allocation. They are used as a basis for negotiation and for testing the relative merits or levels of tolerance of two or more farmers. In negotiating about altering the standard division, farmers select from the common set of justifying criteria, referring to different criteria to fit their own circumstance.

"They are "non-alienated" in the sense of being close relatives of the owners and generally see themselves in a transitional condition of expecting to acquire land themselves.

I observed or heard of incidences where farmers in interpersonal negotiations counterposed such criteria as: drainage rights based on relative plot location versus drainage rights based on relative intake location (as described in Appendix Two, about lower-end channel C water users), being a bottom-ender versus having high infiltration rates, making new terraces versus not having access to a neighbor's drainage, or more abstractly, the need for a simple basis for the division versus consideration of personal situations, and the need for sabar versus personal accountability for excesses.

This set of justifying criteria is part of a broader array of social and physical components which are relevant to the adaptive process of allocating water in these irrigation systems. Such components may be considered as the "adaptive components" of water allocation. The Balinese cultural values which relate to the style of interaction, the functionally specific and independent character of Balinese social organization, the relatively homogeneous social setting, the value of the padi crop both as a subsistence and commercial crop, the formal rules of the subak, the repertoire of justifying criteria about water rights, and those aspects of the landform and system design which are mentioned above, altogether constitute what can be called the adaptive components of water allocation in these two irrigation systems.

The notions of rukun, malu, and sabar shape the Balinese style of discourse—the reluctance to directly challenge others, the self-effacing, understated rhetoric, and the aversion to assertions of formal authority. Hobart (ibid.) argues that these cultural notions do influence the results of debate in Balinese village councils, engendering high levels of consensus. The findings in this model of patterns of altering the division seem to be generally consistent with the interpretation that there is a widespread feeling of sabar and that it is congruous with the apparent general tolerance towards the borrowing practices of those with recognized needs to do so (as defined by the set of justifying criteria). To the extent to which the sense of malu (as a social force) is as prominent as the rhetorical use of it, it seems to have an affinity with our observations that those without socially recognized justifying criteria for frequently borrowing water are, for the most part, correspondingly restrained, if not merely disinterested, from doing so.

And yet such notions as rukun, malu, and sabar are so general and vague that they are difficult to be linked analytically to specific behavior and results. It is easier to link them to the style of interaction than to the purposes or results of it. Based on what is generally known about the sociology of agrarian societies, it seems more reasonable to attribute the results of this model to the relatively homogeneous social setting within which these interactions occur. This is consistent with the assertion of Dror that interaction, as opposed to authoritative/analytical organization, cannot be generally acceptable or persistent as a mode of social organization if it occurs in settings where pronounced hierarchical factionalism or social stratification create unequal biases in resource allocation.

The relatively minor difference in the age of the two systems does not appear to have caused a difference in the nature or elaborateness of this repertoire. It is essentially the same in both systems, evolving quite quickly in the first few seasons of irrigating in a new environment. In Mopugad, the basic topographical differences between the two systems have the effect of permitting little return flow and causing more pronounced inequalities in water supplies between upper and lower-enders, compared with the subak in Werdi Agung. Despite the basic differences in the configurations of physical inequalities between the two systems, the general direction of the patterns of adjusting the standard division of water, in both systems, is aimed towards counteracting these physical inequalities.

The result of these incremental and interpersonal interactions among water users is a second approximation for allocating water, following the first approximation of the standard division of water (which is based on the proportional shares rule based on land size). The inequalities to which these justifying criteria refer, are not integrated into the simple land size criterion for proportional water allocation. This repertoire of jus-

tifying criteria and the interactions among these farmers, in settings not riddled by pronounced factional or hierarchical adversary relationships, may create a more equitable and generally acceptable pattern of water allocation than would a simple reliance on the criterion of land size, which is inherent in the standard division of water in each system.

In the next chapter we will examine the observed operation of both systems through two planting systems, giving special attention to farmer allocational responses to temporal variations in water supply and to the spatial effects on equity of observed alterations in the standard division of water. Hence we will focus on the observed <u>results</u> of the practices and patterns of interaction which have been discussed up to this point.

CHAPTER SIX Operation of the

Systems Over Two planting Seasons

1 Introduction

1.1 Issues Addressed

In this chapter we will examine the operation of the two systems through two seasons and assess the efficiency and equity of water allocation. We will relate variations in water supply to the intensity of allocation activity and to the differential allocation of water in both systems. We will examine the frequencies, locations, and implications for equity of the observed allocation arrangements through two planting seasons. Irrigation cannot be understood as an integrated physical and social process if these dimensions are analyzed in isolation from one another.

Such observations enable us to make an independent check of the patterns of relative borrowing frequency described in the previous chapter. They provide further indications of who are the relative gainers and losers in the process of allocating water. We will obtain a better indication of whether the considerable amount of informal and interpersonal water allocating behavior, typical of both of these systems, makes the distribution of water more or less equal than otherwise would be the case, with a simple reliance on the standard division of water. By this analysis we will be in a better position to attribute the

results of differential water adequacy either to physical or social factors or some combination of them.

An additional purpose of this chapter is to explore the relationships between the intensity of water allocation activity, variations in the ratio between water supply and demand, and plant growth stages. We address the question of whether the intensity of allocation activity is more sensitive to changes in water supply or to changes in plant growth stages, or whether it is a more regular pattern which occurs at least partly independently of these two conditions. Data collection was based on addressing these issues.

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In Werdi Agung nearly all farmers planted rice varieties IR36 and IR38, which matured in approximately ninety-five days. In Mopugad farmers planted a local rice variety, called MR, during the first season and then switched to the IR varieties in the second season. In both systems the first season observed occurred from June to September 1982. The second season observed occurred from December to March 1983.

1.2 Relative Water Supply

1.2.1 Definition The ratio of water supply to demand in an irrigation system has been called the relative water supply (RWS). It is used as a key variable in this analysis, especially the variant of RWS which Levine (1982) has called the theoretical relative water supply. Levine defines the theoretical relative water supply as:

> . . . the ratio of water supply at the location of interest to the water demand associated with maximum production of the optimal crop or cropping pattern grown with appropriate cultural practices on the total irrigable area designed or intended to be served from that location, (ibid, p. 5)

Levine contrasts theoretical relative water supply (TRWS) with actual relative water supply (ARMS) and uses the following definition for the latter variant:

> . . . the ratio of water supply to the water demand associated with the crops actually grown, with the cultural practices actually used, and for the actual irrigated area. (ibid, p. 11)

In this study I consider the "optimal" crop and the "appropriate cultural practices" to be those actually used by the farmers in the two systems, namely intensive cultivation of irrigated rice. Also I further qualify Levine's definition of TRWS by defining the "total irrigable area" to be the area "intended to be served" by water <u>for the given season observed</u>.

In other words, the area actually planted in rice is taken as the area intended to be served by irrigation for that season. Once the area planted in rice is established for a season, that is the area of demand throughout the season. Farmers having fields within or beside the area irrigated which are not planted with irrigated rice may prefer not to plant rice, for various reasons. The total area "intended to be served" is subjective and not necessarily readily definable by outsiders. Taking the

total area actually planted as that area "intended to be served" <u>for that season</u> avoids this ambiguity and yet is still consistent with an analysis of season-specific farmer responses to variations in water supply.

Under Levine's definition of TRWS, intentional temporary drying (such as "for soil oxidation purposes or for a recommended rotation," ibid, p. 8), would reduce the potential water demand. However, in this study TRWS was not adjusted for intentional drying for two reasons. First, farmers generally intended to dry their fields only for very limited periods. For most farmers such temporary drying was done only twice a season, when applying fertilizer and pesticides, generally at two to four weeks after transplanting and again immediately prior to, or at the outset of, the reproductive phase. It was felt that such limited periods would not introduce large errors in the estimate of TRWS, especially since such drying was not done in a strictly simultaneous manner in either system. Second, it was impossible to determine exactly when each of the plots was dry intentionally or not.

In this study management responses to water scarcity during a growing season (i.e., after the intended area to be irrigated is set for the season) is distinguished from the management decisions prior to planting which establish the size of the area to be irrigated for a given season. If one wants to understand the relationship between water supply and allocation practices it is important not to mix the two variables of management and relative water supply, by basing the definition of one (e.g., IWS) upon a characteristic of the other (e.g., intentional drying or rotation). As Levine himself says:

> Since one of the major potential uses of the RWS variable is as an aid to the identification of management implications, confounding of water management factors within the variable is undesireable. (ibid., p. 9)

Therefore, 'in order to keep management factors separate from the RWS variable, within a given season—after the area planted with the irrigated crop has been established, the water demand component of TKWS is considered to be the area actually planted in the intended irrigated crop. In this case it is rice. Of course prior to a season the area to be planted by the irrigated crop is a management decision. But after transplanting it is a fixed parameter for the season.

While this definition of KWS tends to make it a bit closer to the definition of ARWS, because it is based on the actual crops grown, it still differs from ARWS in that the water demand in ARWS is based on the area actually covered by water for a given period while TRWS is based on the potential demand for the entire area planted, regardless of how much of that area had water on it for a given period. However TRWS by our definition, is simply a function of the amount of water available compared to the demand implied by the area planted in the respective crop to be irrigated for a given season (unadjusted for intentional drying). When

TRWS goes below 1.0 it means that there is less water available than is required for the seasonal area planted in padi for irrigation.

1.2.2 RWS and Data Collection Daily measurements of water discharge rates, taken just below the main system offtake, were recorded from transplanting to harvesting. Cipoletti weirs with seventy-five centimeter crests were used in each system. Since the irrigation discharge rate was more variable in Werdi Agung than in Mopugad, measurements were made in Werdi Agung twice daily, morning and late afternnons. In Werdi Agung, water from the main offtake of the Kosinggolan Scheme at Gate Eighteen immediately enters a division box and divides in half, sending water to the left and right sides of the tertiary block. Water in the right-side feeder channel flowed rapidly due to the slope, so fanners did not object to having a cipoletti weir permanently implanted in the channel. However, since the left-side channel had less slope, farmers felt that the cipoletti weir would obstruct the flow. Consequently, I was only able to measure discharge rates in the left-side channel with the cipoletti weir long enough to establish that the relative flows in either direction were approximately equal.

Over nine measurements during a testing period, the leftside discharge was slightly more than the right-side discharge five times and slightly less four times. Discharges during this trial period of comparison varied from 2.6 liters per second to

Table 6-1 Correlations OR)

Between Depth of Water, TOWS, and PSPW	Mopugad TRHS		Werdi Agung	
	ES2S	.47	TRWS	PSPW
	.59	.21	.12	.35
	.79	.75	.67	.35
Overall Mean Depth Upper	.80		.14	.70
Plots Mean Depth Lower				
Plots Mean Depth				

These comparisons show that at lower levels of TOWS (e.g., below 1.0) fluctuations in TEWS constitute a significant influence in the depth of water coverage, especially in Mopugad. As TEWS increases above 1.0, fluctuations in TRWS quickly become less associated with depth of water in the fields.

In Werdi Agung the relative insensitivity of water depth in lower plots to variations in TRWS apparently is related both to the prevalence of return flow, lower infiltration rates in lower plots, and the somewhat higher average TRWS. In Mopugad, water depth in lower plots was highly sensitive to fluctuations in TEWS, reflecting the more severe water shortage and the singular dependence of these plots on water from the channels.[7] When we measure the difference between the mean water depth of upper and lower .

'Scatterplots of the relationship between overall mean water depth and TRWS are in Appendix Three, Figure A6-5. Figures A6-6 and A6-7 in this Appendix display the weekly mean water depth for upper and lower-end sample plots. The area between the two lines is not correlated with TBWS in either system. ,

plots however, we find only low correlations between this upper/lower depth difference and TRWS. This upper/lower depth inequality has a correlation with TRWS with a coefficient of only .11 in Mopugad and .30 in Werdi Agung.

Therefore, it seems that both within the somewhat high range of TRWS in Werdi Agung and within the lower range of TRWS in Mopugad, that variations in TEWS do not strongly effect changes in the inequality of water depth in either system. In Mopugad degrees of water stress are based primarily upon distance from the top of the system (as will be seen in section five below) . Hence the fact that increases in TRWS are strongly associated with increased water depth in lower plots, but not in upper plots, indicates that this is an equalizing process. This is so because the lower-enders appear to be benefiting proportionately more from <u>increases</u> in TRWS than the upper-enders. This was in a context where the average water depth of the upper plots was a slim .74 cms higher than that of the lower plots.

Referring again to Table 6-1, we see that in Mopugad the water depth in upper, lower, and all sample plots was strongly correlated with the proportion of the system covered with water (as estimated by the PSPW). This means that as the PSPW expands, water coverage tends to deepen, either among upper or lower plots or over all the plots. In Mopugad when PSPW contracts, the mean water depth decreases, either among upper or lower plots, or over all of the plots. In Werdi Agung the expanding or contracting

In Mopugad, the area covered with water expands and contracts more readily with changes in TSWS than in Werdi Agung. As we have seen, the farmers in Mopugad are more sensitive to changes in TRWS because of the relatively lower levels of TRWS and the higher relative dependence of plots on the channels. This greater sensitivity in Mopugad is indicated by the stronger associations between both 1) allocation intensity and TRWS and 2) PSPW and TRWS.

4,2 raws and Spatial variations in Depth of Water Coverage We now address the question of how closely water coverage depth in the two systems is related to TRWS. This step will help us to be able to evaluate the relative effects of TRWS, the configuration of water sources, soil permeability, and the spatial biases in water borrowing on the equity of water allocation. Water depth measures were recorded in top and bottom observation plots on different channels in each system. Not surprisingly the average depth in the upper observation plots was higher than in the lower plots, both in Mopugad and Werdi Agung. However, the difference is smaller on the average in Werdi Agung. The absolute levels of both upper and lower plots (measured in centimeters) are higher in Werdi Agung. The mean water depths in Mopugad for the first season were 2.94 cms in the upper plots and 1.96 cms in the lower plots. In the second season they were 2.54 cms in the upper plots and 2.03 cms in the lower plots. In Werdi Agung

the mean depths for the first season were 3.44 cms in the upper plots and 2.81 cms in the lower plots. In the second season they were 3.07 cms in the upper plots and 2.46 cms in the lower plots. This gives an overall mean difference between upper and lower plots in water depth for both seasons of .74 cms in Mopugad and .62 cms in Werdi Agung.

Table 6-1 lists the simple correlation coefficients (r) for the correlations between the mean depth of water coverage in the observation plots (overall, upper, and lower), PSFW, and TRWS. The relationship between the overall mean water depth (across all of the observation plots) and TRWS was much stronger in Mopugad than in Werdi Agung (e.g., .47 versus .12). In Mopugad the mean depth of water in the lower plots was significantly more sensitive to variations in TRWS than in werdi Agung (e.g., .75 versus .14). However concerning the upper-end plots, in Werdi Agung their mean water depth is strongly correlated with TRWS (r=.67). In Mopugad the correlation is only .21. This means that whereas the depth of water in upper-end plots varied with TRWS in Werdi Agung, it remained more stable with variations in TRWS in Mopugad. This reflects the high permeability of the sandy soils in upper-end plots in Werdi Agung.

and sixteen of the second season, TEWS increased at the same time many fields were drying before harvest. This widespread drying caused the divergence in the directions of PSPW and TBWS at this time.

Figure 6-6' shows the TBWS and PSIW for both seasons in Werdi Agung, The relationships are roughly parallel through both seasons. We can see that when TBWS gets close to or below 1.0 the distance between TRWS and PSPW decreases quickly. This is especially apparent when comparing Hopugad with Werdi Rgung. When TEWS is especially low in Mopugad the PSPW more closely approaches and even reaches (according to our rough estimates) the theoretically potential proportion of the system which can be covered with water, given the TBWS. At slightly higher levels of TEWS and PSPW in Werdi Agung the difference between actual PSPW and the potential proportion of the system which can be covered (as implied by the TBWS) becomes greater. This relationship indicates that water use is more efficient at lower levels of TRWS (i.e., the PSPW/TBWS ratio improves at lower levels of TEWS). The ratio of PSPW to TRWS was calculated and averages were obtained for weekly data over two seasons. These average ratios were .60 in Mopugad and .62 in Werdi Agung. These mean that if the total water supply was equal to the total demand, in each system, the proportion of the system which would be covered by water (given the observed levels of efficiency) would be .60 in Mopugad and .62 in Werdi Agung.

WERDI AGUNG

CHOPPING SEASON (: FIRST, 2 SECOND-1

PSPW

1 2 4 5 6 7 8

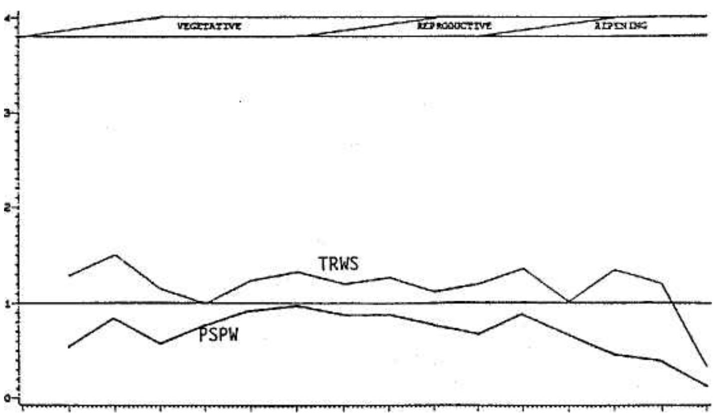
NO OF KEEK IN CHOPPING SEASON

CROPPING SEASON (1 FIRST, 2 SECOND

NO OF WEEK IN CHOPPING SEASON

Figure 6-6. TRWS and the Proportion of Sample Plots with Water (PSPW), Werdi Agung

9 10 11 12



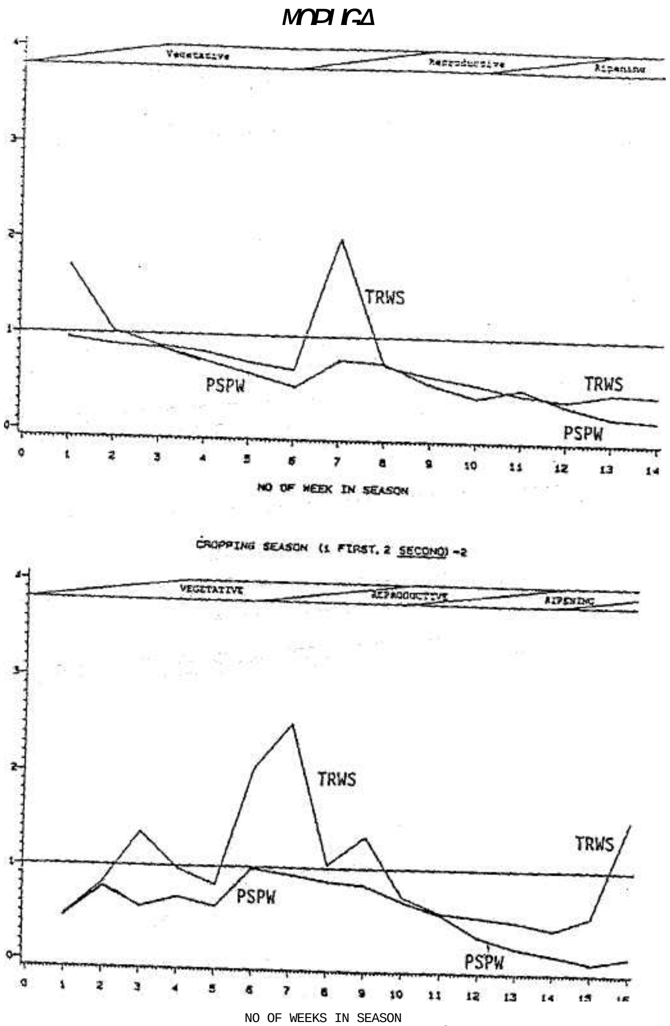


Figure 6-5. rows and the Proportion of Sample Plots with Water *(PSPW)* , Mopugad

extending well above 1.0. Intentional drying, which effects PSPW, occurs independently of variations in TRWS. The existence of several centimeters of water in terraces may act as a buffer between short-term fluctuations in TRWS and PSPW.

The figure also shows that when TRWS is below 1.0 the PSPW generally does not meet and equal the level which TEWS is at, but is a bit below what TRWS indicates is theoretically possible. This difference may be caused either by canal conveyance losses, intentional drying, or the misallocation of water. Section five below provides some evidence that the latter possible cause was not very important, although there were a few plots in the upper part of the system in Mopugad where water was drained out of the system. Also there was some difference in depth of water between upper and lower plots, as is shown in section 4.3.

The two significant occurrences of TRWS and PSPW moving in opposite directions happened near the beginning and at the end of the second season. At week three, farmers in the lower part of the system were still plowing, harrowing, and transplanting and the water was rotated to them both day and night. However, between weeks two and six in the first season, TRWS steadily declined, after a period of more adequate water supply during the land preparation stage. Despite the use of staggering during the first season, water was generally allocated to the entire system each night. This practice helped to keep the PSFW from dropping more rapidly than otherwise would be the case. At weeks fifteen farmers established a scheduled rotation of water. By week fourteen some had begun pre-harvest drying of fields.

4 Systemic implications of variations in TEWS

4.1 The Proportion of the System Covered with Water By the term "the proportion of the system covered with water," we mean the proportion of the system which was planted with padi which had standing water on it. This was estimated for each field inspection by recording the presence and depth of water, if any, in a sample of ten observation plots in Mopugad and fifteen in Werdi Agung. These plots were scattered around each system, in the upper and lower sections of system channels, in order to obtain an estimate of the availability of water around each system.' From these measurements the proportion of sample plots with standing water (PSPW) was calculated and weekly averages were obtained.

Because of the nature of the dispersion of observation plots, it is assumed that the proportion of observation plots having standing water is an adequate approximation of the proportion of the system having standing water. It is also assumed that these sample values are more accurate indicators of the directions and degree of change in the proportion of the system with standing locations of these

water than they are of its absolute value. We seek to understand in this analysis the relationships between changes in TRWS and 1) the proportion of the system with water, 2) the depth of water in different parts of the systems, and 3) the intensity of water allocation activity. The first relationship relates to efficiency. The second relates to equity.[5] The third relates to adaptive process.

Given the more favorable TRWS for both seasons in Werdi Agung and the more common existence of return flow in the system (as was noted in Chapter Four), it is not surprising that the PSPW was higher, on the average, in Werdi Agung than in Mopugad. The seasonal mean PSPW in Mopugad was .59 in the first season and .52 in the second season. In Werdi Agung the seasonal mean PSPW was .76 in the first season and .68 in the second season. Figure 6-5 displays the relationship between TRWS and PSPW through both seasons in Mopugad.' Generally, the PSPW rises and falls parallel with the TRWS. The relationship is not uniform of course. PSPW is a proportion while TRWS is a ratio, with values

[5]Our operational definition of efficiency in this case is the ratio of the amount of the system with water to the water supply, or more specifically, the TRWS. We relate equity to the local rhetoric of justifying criteria for adjusting the standard division to counteract the related physical inequalities in the system. Since such inequalities affect the water demand and supply of plots, we define equity as the approximation of matching plot-level water supply with demand.

'In Figures 6-5 and 6-6 PSPW follows the same scale on the left side of the graph as TRWS, occurring within a range between zero and 1.0.

planting was likewise staggered. By the last week in December, or week three, almost all the farmers had transplanted.

To say that continuous flow was used is to say so in a relative sense—in contrast to a formally scheduled, group-level rotation. Interpersonal borrowing continued as an apparently permanent feature of the system. As with the first season, G5 was the last to transplant. In his case this occurred because of water shortage. He waited until the others along channels G and H had done most of their transplanting so as to limit, as he said, the keributan (commotion or disturbance) of too much borrowing water back and forth at the critical time of final land preparation and transplanting.

Fanners in the system held the view that as long as one had talked to his neighbors at the outset of the season about the general timing of planting and the acceptability of borrowing water, one need not seek permission each time before borrowing water. This was parmissable as long as it wasn't done too often and when it would make his neighbor's fields go dry during a growth phase with critical water need (e.g., land and seedbed preparation, transplanting, flowering, fruiting stages). When farmers in either system talked about their water needs in comparison with others, the stage in the cultivation season was as frequently mentioned as were comparisons about differential water supplies.

So when greater staggering of planting occurs, especially within quarternary groups, it is more likely that would-be borrowers, whose fields are in a stage when water adequacy is urgent, will have neighbors whose fields are not in such a stage. Therefore a farmer tends to feel less inhibited from borrowing from neighbors whose fields are not at a stage of critical water need, such as the vegetative growth or ripening phases. When all of the plots pass through the critical water need phases simultaneously, farmers are relatively more reluctant to borrow from neighbors than would be the case if the neighbor's fields were not at a phase of critical water need.

By mid-January, or weeks six and seven, the transplanting stage had passed and so several fanners started making new terraces and frequently borrowed water to do so. These were at plots A2, E5, F3, K4, H2, and R2. At the onset of the reproductive phase, farmers at channel C, where percolation and seepage rates were quite high, began rotating water in twenty-four hour turns among their plots. This continued for several days. Then in early March (weeks twelve and thirteen), at another dip in TRWS, they resumed a "formal" rotation. They requested that channel A and B rotate with them also. But since the water supply for channel A was more adequate than channel C, they refused and preferred to use continuous flow allocation (which was all the while modified by informal borrowing). At this time channel E soak only about one-half of a terrace per plot, farmers decided to rotate the full flow to individual plots for twelve-hour turns. This made it possible for most farmers to plow about one-half of a hectare per turn. They intended that after this first turn they would wait for rain before harrowing and broadcasting seed in nursery seedbeds. If no rain came they would wait for their next rotation turn and plow the second half of their plots. The right side of the system took rotation turns first.

Some members of the subak who owned sawah elsewhere (which was being better irrigated) expressed a preference to plant soy-beans in Block Eighteen rather than wait any longer for rain, in order to make padi seedbeds. Others preferred to have the rota-tion continue until all plots had had two turns and the plots had been plowed entirely at least once. Some of these were fanners who had their seedbeds already sown on plots in other tertiary blocks which had more adequate water. They were going to transport the seedlings to their plots in this block when it was time.

However, apparently the majority wanted to stop the rotation and switch to continuous flow, despite the continuing inadequate water supply. This was because they didn't want to wait any longer to prepare the seedbeds. They argued that since the soil was so dry the seedbeds would need continuous flow, even if the rest of the terraces would not get water. In their experience

heavy rains had always come in late November and December anyway. So by mid-November water allocation was changed to continuous flow by announcement of the subak leaders, without holding a meeting to formally discuss it. It perturbed some members that a meeting wasn't held to decide the issue. But others said that since such a big majority obviously wanted continuous flow, a meeting would be a waste of time.

The continuous flow arrangement gave farmers flexibility in when to plant the nursery seedbed. The inability of the fanners to predict or to rely on statements about when higher water dis-charges would be made available to their system (i.e.. Tertiary Block Eighteen) discouraged the scheduling of broadcasting or transplanting dates, either on a simultaneous or staggered basis. So there was considerable variation throughout the system in broadcasting and eventual transplanting dates. The variation occurred in every part of the system, with no section having entirely early or late planting dates. This happened because the farmers scheduled these activities not only according to water availability or the expectation of the timing of future water availability, but also according to labor constraints and the ownership or not of sawah elsewhere. The variation stretched over four weeks, with early and late planters scattered around the system. In December the irrigation rate did increase. But because of the informal staggering in broadcasting dates, transblocked channel C just below his intake. Another time Dl reported that C5 had partially blocked channel C below his intake. Cl reported that M6 had blocked channel M just below his intake. El and M5 both saw and reported that C6 had blocked channel C just below his intake, C6 reported that El had closed the C6 intake and blocked channel C. Cl then reported that Dl temporarily had opened up an additional intake to his plot. The mutual water "borrowing" had become rampant and so had the tit-for-tat reporting and fining.

3.2 Werdi Agung

3.2.1 First season Because of rainfall in May and early June, water was relatively adequate" during the land preparation period in the first observed season, compared with the second season. However in the first season, the rainfall and irrigation discharge dropped off just before transplanting (which was just before our water balance measurements began). The entire system, with few exceptions, planted the nursery seedbed all within a week and later transplanted seedlings all within a week (the latter being the first week in June). Soon after transplanting however, the raws dropped and remained low for three weeks. Thereafter TEWS remained above 1.0 for the rest of the season, except for a drop during the reproductive phase at week eight (caused by the scheduled delivery of a large flow of water for land preparation to another section of the Kosinggolan Scheme).

During the week of transplanting itself borrowing occurred between channels A and B, C and D, and L and K. Because of lack of water as well as labor constraints, H2, Gl, G5, and D8 were late in transplanting and this contributed significantly, for several weeks, to the frequency of borrowing and to the tensions at the C/D and G/H channel division points. It wasn't until week six that G5 was able to finish plowing and transplanting in his last terrace. By this time the reproductive phase was beginning and the TRWS, which consisted almost entirely of discharge from the main canal (due to lack of rain), was on the decline. This prompted numerous complaints about the water supply and the occurrence of frequent interpersonal borrowing, especially along channels C, D, E, G, and H. After week nine the TRWS rose and remained above 1.0 until pre-harvest drying began. During the last five weeks of the season mice and birds became a serious problem and this kept more people than usual in the fields, to scare them away. Having more people continuously in the fields may have discouraged some water theft during this time. Partial blocking of channels and plot intakes (as compared with full blocking) appeared to be especially common during this period, indicating restraint in borrowing practices at a time when the fields and channels were being observed especially closely.

3.2.2 Second season. In latter October water from the main canal was permitted to flow through Gate Eighteen for land preparation. When continuous flow irrigation proved to be enough to they had finished transplanting. Due to the water shortage and the late broadcasting of the seedbed by plots C7, C8, C9, and C10 (due to their expectation of not having water to finish land preparation and transplanting), the three turns stretched out to just over four weeks.

Some of the lower-enders complained that the upper-enders should have planted less than their whole plots in padi and that the subak should have limited the area to be planted for each plot for the season. However, even lower-enders like D3, who had barely enough water to prepare their land, broadcasted and transplanted enough seed to fill their entire plots. This was done because even under the risk of drought it seemed better to risk the hazard of wasting seed which might eventually die of drought than to risk not using land which might be productive if the rains did come. After the third stage of staggered transplanting, the members agreed officially that water would be divided equally at night and then borrowed during the daytime in accordance with informal agreements made personally between farmers. Numerous exceptions to this also occurred, both day and night.

When the rain came in weeks six and seven, farmers from the neighboring Javanese transmigration village of Mopuya wanted to plant sawah, which would be irrigated by the same river as that used by the subak, about one kilometer upstream. The Javanese made holes under the weir. Members of the subak filled them in again. However, one week after the first incident the subak

agreed to permit a two-to-one ratio of river water to go downstream for a few days to enable those below to finish land preparation. By weeks eight to ten the rains tapered off and the TEWS began a general decline. Some of the padi in plots A3, B3, D3, and C6 through C10 were prematurely turning yellow because of water stress. The official agreement to keep the standard division intact overnight and allow borrowing to be arranged interpersonally in the daytime continued through the rest of the season, despite the high frequency of borrowing and the tensions among farmers around the system. Their attitude was that such direct arrangements between farmers would suffice about as well or better as would formal rotations arranged through the subak authorities.

By the ripening phase eight members had been fined for water theft. This was the first time any fines had been given by the subak for water theft. Normally they were reluctant to fine members but they felt the stealing had become excessive, given the water stress around the system. The fines were set at only Rp. 2,500 each, instead of the officially-established amount of Rp. 5,000, because of the difficult economic condition imposed by the drought. Almost all of those who reported thefts were those illeffected by them, except in a few cases where a subak official reported them due to the extreme water shortage.

B6 reported that C9 had shut channel B. A week later C9 reported that B6 had shut channel C. Dl reported that C5 had intakes as warnings not to tamper with the division. Occasionally some upper-enders (e.g., M2, M6, CD placed logs or posts along the top of their temuku to witness to lower-enders that they were preventing any inflow above the exact amount permitted. Also the mice were becoming a serious problem by this time.

During week six the members of the subak agreed to have a more formal rotation. The system was divided into five groups: 1) Ml through M6, 2) channel A, 3) channel B, 4) C2, C3, and channel D, and 5) the rest of channel C. Each group received the full water flow for twelve hours, whether day or night. After each group had gotten a second turn, any inequities associated with differences between day turns and night turns (such as evapo-transpiration or supervision capabilities) would be evened out.

The turns started with group five, which was lowest in the system, and progressed upwards, with each group getting a turn every two and one-half days. However after the first set of turns it began raining, hard at first and then sporadically for three days. At the outset of the rain nearly all the farmers left the sawah and went to their rainfed fields to plow and plant mainly soybeans and corn. With the system virtually deserted, the rotation ceased automatically.

After the rain stopped, the TEWS continued to decline even below where it had been before. The subak decided that the full water flow would be allocated to single plots for twelve-hour turns, starting in order of need and request. The subak head,

secretary, and treasurer took turns guarding the water at night. This arrangement continued, although again with numerous exceptions, until well into the ripening phase, when pre-harvest drying began.

3.1.2 Second season Compared with the first season, the second season had more pronounced water scarcity during the land preparation phase. Transplanting was staggered three ways. But this time all of channel A was included in the first phase and all of channel D was included in the second phase. Anticipating a severe water shortage, subak members arranged the staggering so that during the third turn water would be delivered only to plots C7 through C10. In comparison with the prior season, this arrangement added more plots to the earlier stages and decreased the number of plots served in the final turn, when water usually would be divided over the whole system during the night. This helped further offset the advantage of having the first or second turn, where nighttime allocation included only the one or two groups who had yet reached their turn. However, during the second season it also was arranged that the first group received the full flow of water one night each week during the second and third phases, so as to ensure that the newly transplanted seedlings were soaked periodically.

Farmers arranged within these groups to take water turns for final plowing and transplanting. Those not finished during their official turns were allowed to continue_ taking- water-antil

3 Description of Two Seasons

3.1 Mopugad

3.1.1 First season The season began with a decision to stagger final land preparation and transplanting three ways. This was done because of water shortage and also because of a desire to allow for the use of exchange labor among farmers who were at different stages of land preparation or transplanting. During the first week plots Ml through M6, channel A, and plots Bl and Cl all got the full supply of water twenty-four hours per day. After the first week the water went to the rest of channel B and to plots C2 through C6. However, at the second week the full flow was designated exclusively to those in this second group only during the twelve daylight hours. At night upper-enders, who had already transplanted, were allowed to open their intakes half-way while those in the second group were officially permitted to keep their intakes open the normal width. This was so that the vulnerable, newly-transplanted seedlings of upper-enders would get at least a minimal amount of soaking; This same arrangement continued, with several exceptions due to labor constraints and informal water borrowing or stealing, during the third step of the staggering. Channel D and the lower end of channel C took the third turn.

At week three, when TEWS had just dropped below 1.0 and all transplanting was completed, farmers of plots C9 and D3 requested

there be a formal rotation. The subak secretary said to wait yet a few more days to see if it rained. If no rain came then he would agree to it if the rest of the subak did as well. Also at this time a group of farmers went up unofficially and repaired some leaks in the weir in an effort to help increase the water supply for the whole system. This did help increase the discharge, but only from 51.0 to 54.4 liters per second. By week four the subak agreed that any of the intakes of the following plots could be shut overnight by lower-enders as needed; Ml through M6, Al, A2, Bl, Cl, and C2. The lower-enders which were given this official right to borrow nightly were plots A3, El, C6, C7, C8, C9, and channel D. During weeks five and six the intensity of borrowing or stealing water escalated considerably. Soils were cracking in plots at the bottom of channels A, C,

and D.

I observed numerous incidences of altering the division of water, both in accordance and not in accordance with the official arrangements. There was frequent sabotaging or counteracting of such alterations, sometimes by such methods as making holes where others had checked a channel (especially at channel A, B, and C division points) or by putting holes in small water bridges which were meant to temporarily "privatize" the drainage of one plot by conveying it across channels to another plot (rather than permitting the usual practice of draining into a "public" channel). Signs were frequently placed at drainage points or

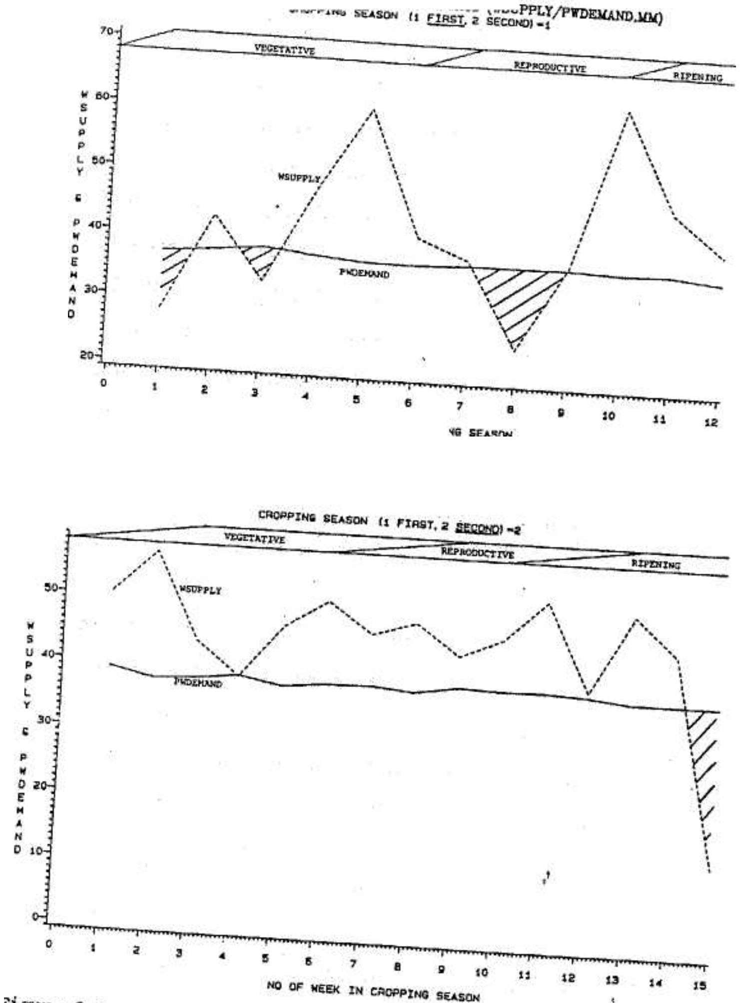


Figure 6-3. Water Supply and Potential Water Demand, Werdi Agung

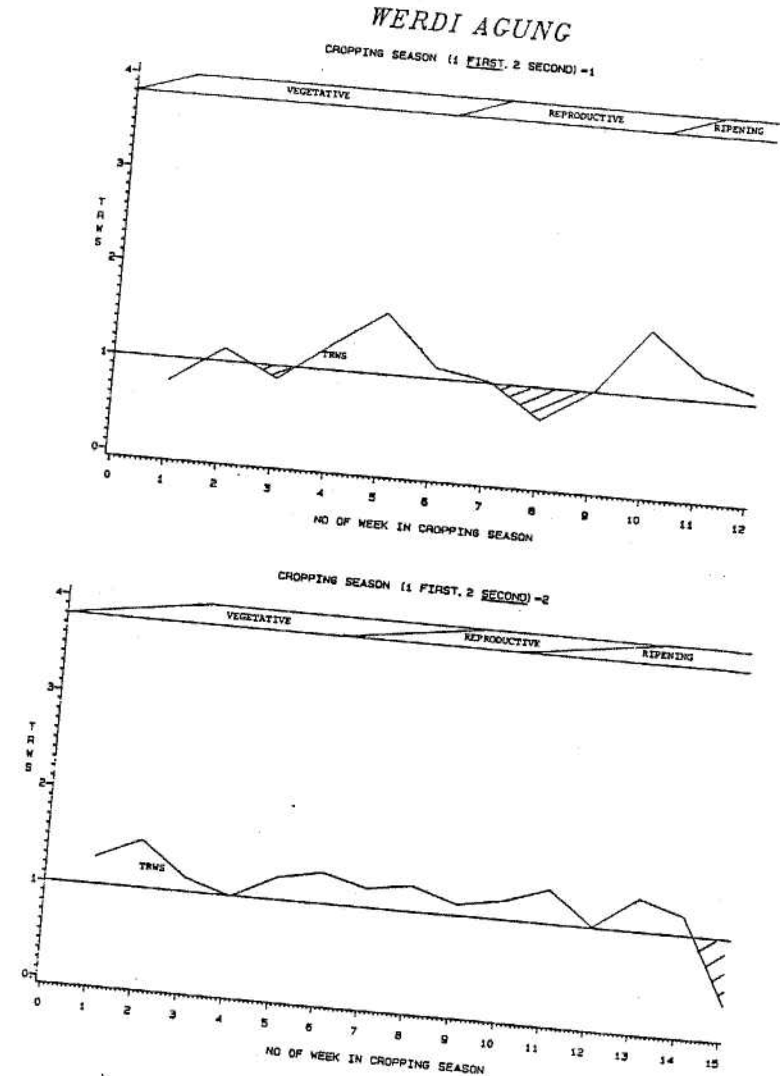


Figure 6-4

Theoretical Relative Water Supply

WER DI AGU

THE RELATIVE WATER SUPPLY COMPONENTS

NO OF WEEKS

Werdi

MOPUGAD

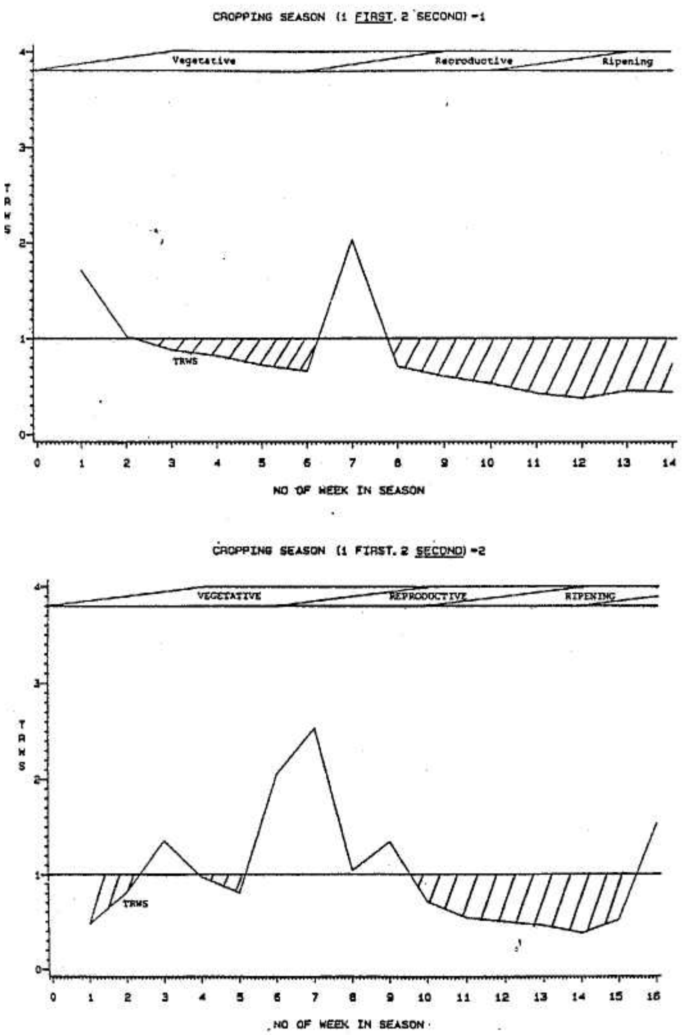


Figure 6-2. Theoretical Relative Water Supply, Mopugad

2.2 Theoretical Relative Water Supply in Werdi Agung In Appendix Three, Figures A6-3 and A6-4 illustrate the components of water supply and potential water demand for both seasons in Werdi Agung. As is shown in Figure A6-3, although the rainfall was relatively low, the irrigation rate generally was higher than in Mopugad. In Mopugad the water supply varied between about ten and forty-eight millimeters (mm) per day for the system. In Werdi Agung it usually varied between about twenty-five and sixty-two mm per day. However, as is shown in Figure A6-4, the estimated mean potential percolation and seepage rate is much higher than in Mopugad, being thirty-three millimeters per day. As in Mopugad, the PET generally varied between four and six mm per day. In Werdi Agung it constituted an even smaller share of the total potential water demand than in Mopugad.

Figures 6-3 and 6-4 show the relation between water supply and potential water demand and the TOWS in Werdi Agung. The ratio generally is more favorable than in Mopugad, especially in the second season when supply never dropped below demand (at least on a weekly average). During the first season supply fell below demand in only three out of twelve weeks—in the beginning and middle parts of the vegetative phase and in the middle of the reproductive phase.

the second half of the TRWS ratio. It is the estimated amount of percolation and seepage and evapotranspiration which would occur if there were water covering all fields in the systems which were intended to be irrigated during the season. As can be seen, potential evapotranspiriation (PET) constituted no more than about one-third of the total potential water demand for any measurement period. The PET varies with climatic conditions. However, the estimate of the potential percolation and seepage rate is assumed to be roughly constant, for our purposes. Since the PET usually only varied between four and six millimeters per twenty-four hours, the overall potential water demand likewise varied only slightly. Therefore the potential water demand was much more stable than the water supply, as can be seen in Figures 6-1 and 6-2, which show the water supply and demand components of the TRWS and the TRWS itself. By far, most of the variation in the TEWS is due to the variation in water supply. In both seasons we see that it was common for water supply to be below the level of potential demand. This was the case in eleven of the fourteen weeks in the first season and in nine of the sixteen weeks in the second season.

in a hydraulic or agronomic sense (i.e., that the demand is based purely on the size of the area to be irrigated), it can be considered as actual demand in a social or more holistic sense, in that it is the actual area which farmers want to be irrigated for that season.

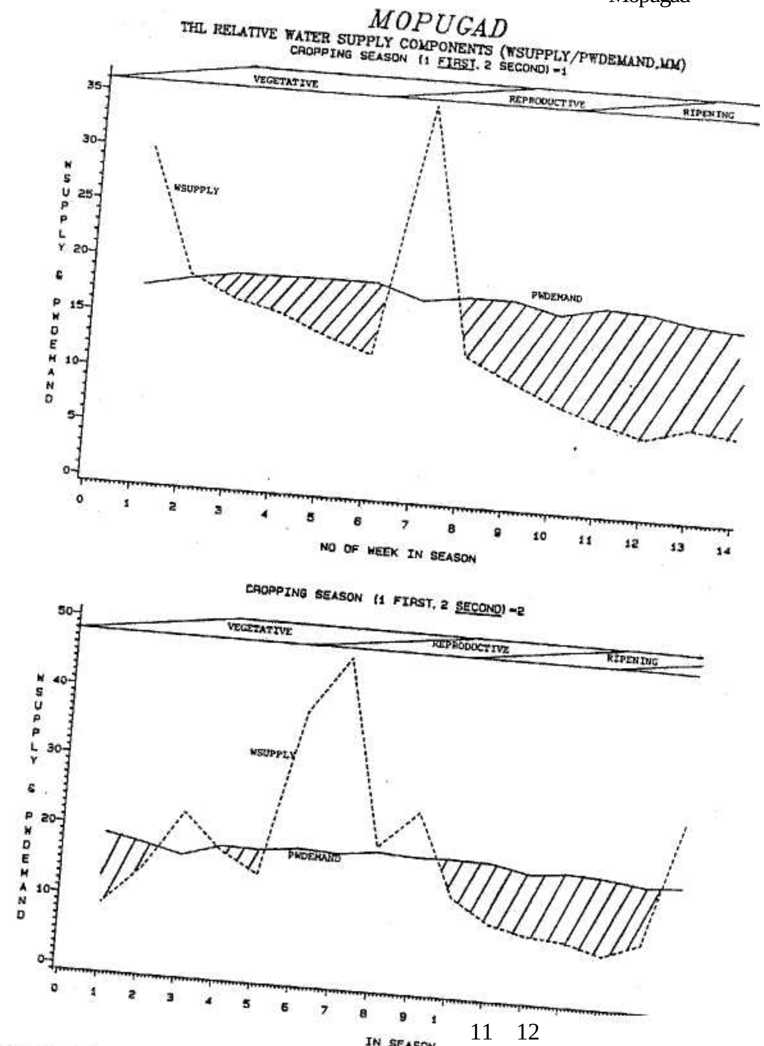


Figure 6-1. Water Supply and Potential

dwarfed in significance by the magnitude of percolation and seepage rates in both systems.' Percolation and seepage was measured with sloping gauges, as mentioned in Chapter Four.

From these seasonal physio-climatic data I estimated the total water demand and supply for each system. Total water demand was a function of seepage and percolation plus evapotranspiration. Total water supply was a function of irrigation discharge rates plus rainfall. All water balance data was calculated in millimeters per twenty-four hours and then was averaged over seven-day periods.

2 Water Balance Analysis

In both systems data about water supply, demand, and allocation was measured from just after transplanting until pre-harvest drying of fields. The number of weeks measured varies by season partly according to the length of staggering of planting dates (which was greater in the second season in both systems) and partly due to a decision to extend the inspections to when nearly all of the system was drying for harvest. Figures for the weekly components of the theoretical relative water supply (TEWS) are listed in Appendix Three, Table A6-1 for Hopugad and Table A6-2

'The evapotranspiration coefficients are as follows; a multiple of 1.15 times the evaporation rate at and shortly after transplanting, 1.10 during vegetative and reproductive phases, and .90 during the ripening phase.

for Werdi Agung. The water supply and demand components of TRWS were calculated in millimeters per twenty-four hours and then were converted into seven-day average rates.

2.1 Theoretical Relative Water Supply in Mopugad Figure A6-1 in Appendix Three displays the data on the components of water supply for both seasons in Hopugad. In both seasons irrigation constituted nearly all of the water supply of the system, this being especially so in the first season. Rainfall constituted a small proportion of the total water supply, due to the exceptionally dry weather during both seasons. Except for limited rainfall at the first and middle of the first season, rainfall was absent or negligible. In the second season rainfall occurred slightly more often, especially during the early part of the vegetative, reproductive, and harvest stages. However, since both rainfall and the irrigation rate were so low at the outset of the second season, transplanting was staggered over four weeks. In the first season transplanting was staggered over only three weeks because of more adequate water supply at transplanting.

In Appendix Three, Figure A6-2 we see the components of the potential water demand for both seasons in Mopugad.' This is

'The distinction between potential and actual water demand is a purely hydraulic or agronomic one, as it is used here. This is the way the terms are used in the literature (see Levine, ibid., and Svendsen, 1983, for example). However, while water demand for an entire area planted may be considered as potential.

the second half of the TRWS ratio. It is the estimated amount of percolation and seepage and evapotranspiration which would occur if there were water covering all fields in the systems which were intended to be irrigated during the season. As can be seen, potential evapotranspiriation (PET) constituted no more than about one-third of the total potential water demand for any measurement period. The PET varies with climatic conditions. However, the estimate of the potential percolation and seepage rate is assumed to be roughly constant, for our purposes.

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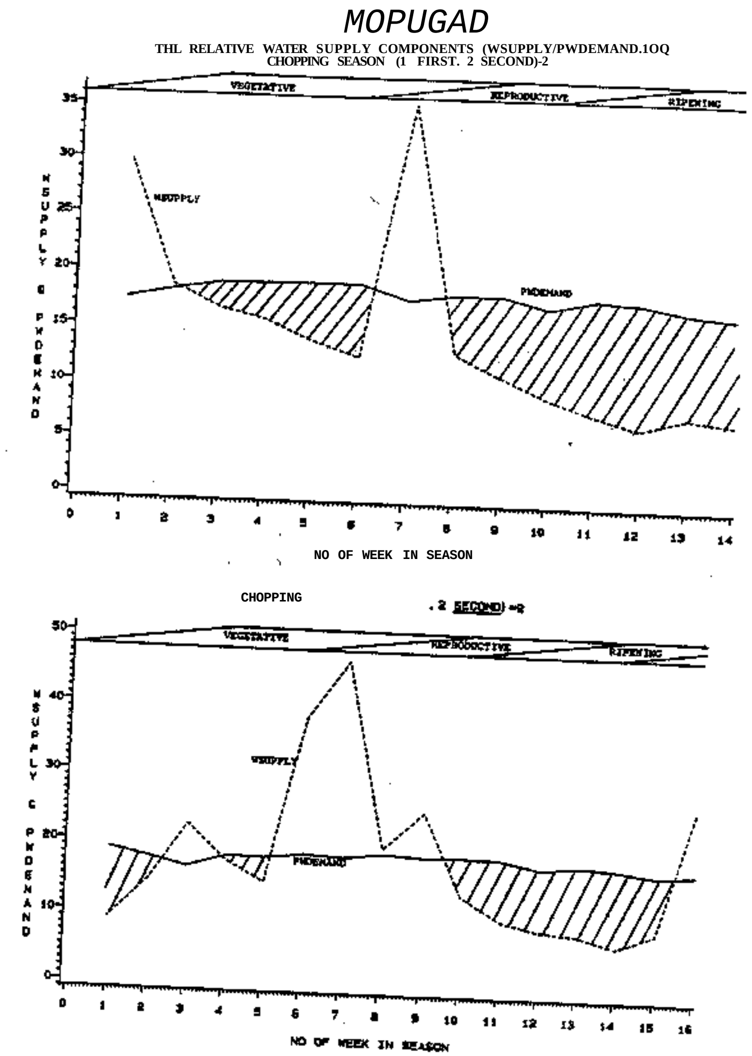
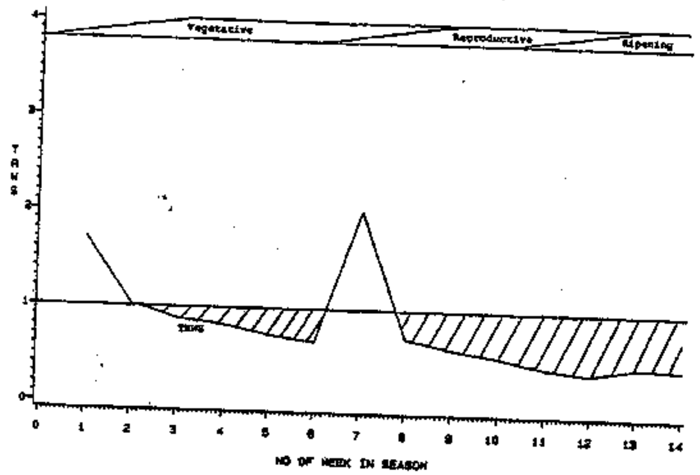


Figure 6-1. Water Supply and Potential Water Demand, Mopugad

MOPUGAD



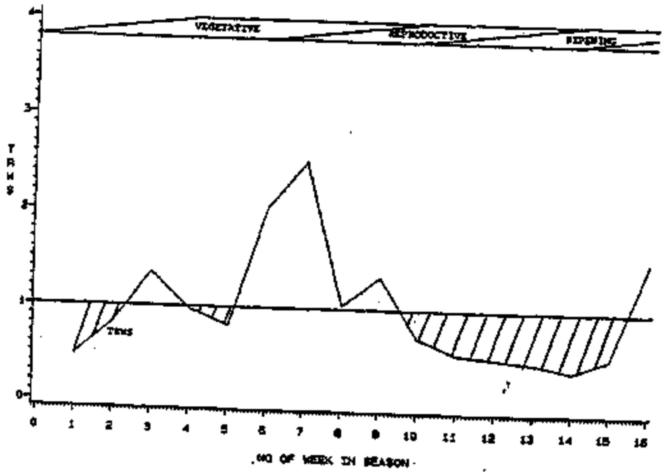


Figure 6-2. Theoretical Relative Water Supply, Mopugad

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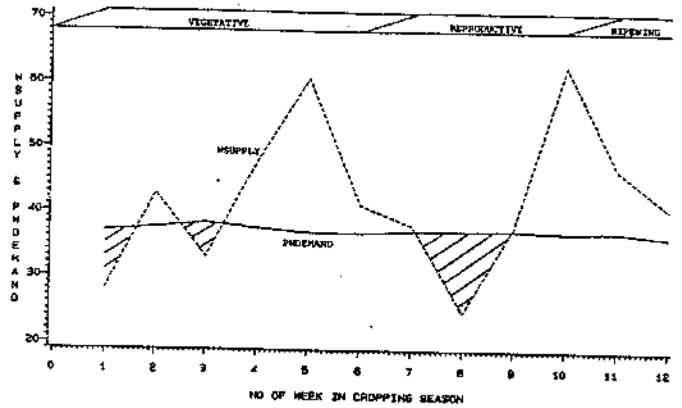
WERDI AGUNG

THL RELATIVE WATER SUPPLY COMPONENTS (WSUPPLY/PWDEMAND.MM)

CHOPPING SEASON (1 ~~FIRST.~~ 2 SECOND)-1



CROPPING SEASON (1 FIRST. 2 5FC0ND) -2

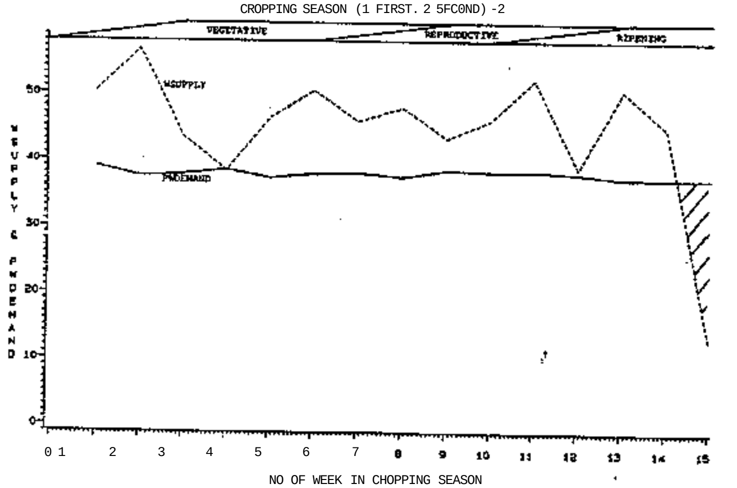
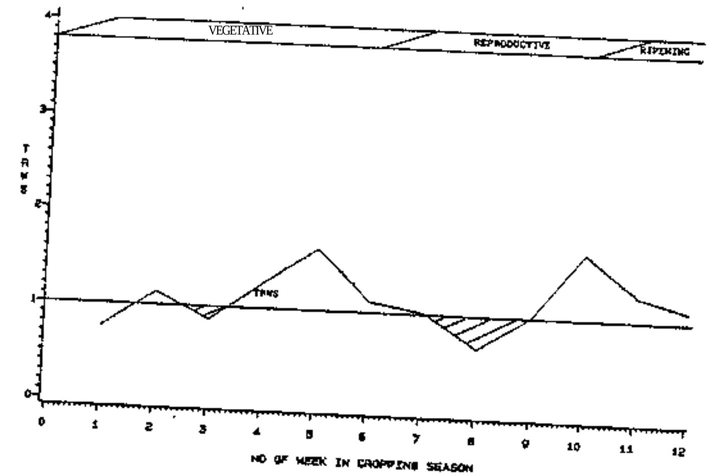


Figure 6-3. Water Supply and Potential Water Demand, Werdi Agung

WERDI AGUNG

CROPPING SEASON (1 FIRST 1 SECOND)-2



CROPPING SEASON (1 FIRST, 2 SECOND) -2

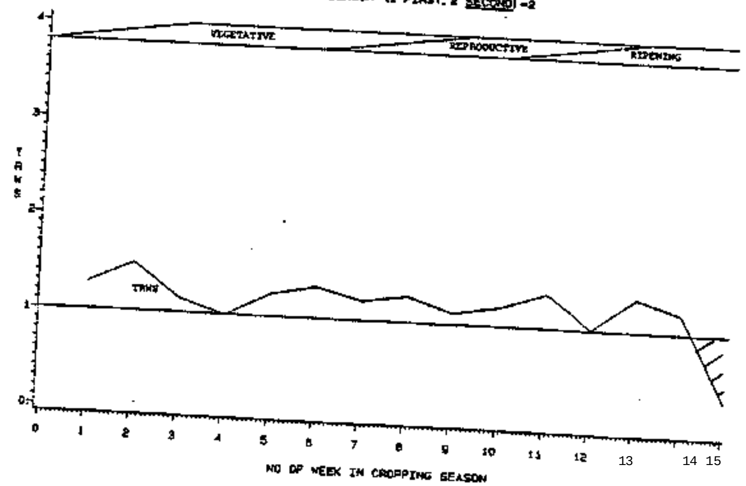


Figure 6-4. Theoretical Relative Water Supply, Werdi Agung

3 Description of Two Reasons

3.1 Mopugad

~~3.1.1 First season~~ The season began with a decision to stagger final land preparation and transplanting three ways. This was done because of water shortage and also because of a desire to allow for the use of exchange labor among farmers who were at different stages of land preparation or transplanting. During the first week plots Ml through M6, channel A, and plots Bl and Cl all got the full supply of water twenty-four hours per day. After the first week the water went to the rest of channel B and to plots C2 through C6. However, at the second week the full flow was designated exclusively to those in this second group only during the twelve daylight hours. At night upper-enders, who had already transplanted, were allowed to open their intakes half-way while those in the second group were officially permitted to keep their intakes open the normal width. This was so that the vulnerable, newly-transplanted seedlings of upper-enders would get at least a minimal amount of soaking; This same arrangement continued, with several exceptions due to labor constraints and informal water borrowing or stealing, during the third step of the staggering. Channel D and the lower end of channel C took the third turn.

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agreed to permit a two-to-one ratio of river water to go downstream for a few days to enable those below to finish land preparation. By weeks eight to ten the rains tapered off and the TEWS began a general decline. Some of the padi in plots A3, B3, D3, and C6 through C10 were prematurely turning yellow because of water stress. The official agreement to keep the standard division intact overnight and allow borrowing to be arranged interpersonally in the daytime continued through the rest of the season, despite the high frequency of borrowing and the tensions among farmers around the system. Their attitude was that such direct arrangements between farmers would suffice about as well or better as would formal rotations arranged through the subak authorities.

By the ripening phase eight members had been fined for water theft. This was the first time any fines had been given by the subak for water theft. Normally they were reluctant to fine members but they felt the stealing had become excessive, given the water stress around the system. The fines were set at only Rp. 2,500 each, instead of the officially-established amount of Rp. 5,000, because of the difficult economic condition imposed by the drought. Almost all of those who reported thefts were those illeffected by them, except in a few cases where a subak official reported them due to the extreme water shortage.

B6 reported that C9 had shut channel B. A week later C9 reported that B6 had shut channel C. Dl reported that C5 had blocked channel C just below his intake. Another time Dl reported that C5 had partially blocked channel C below his intake. Cl reported that M6 had blocked channel M just below his intake. El and M5 both saw and reported that C6 had blocked channel C just below his intake. C6 reported that El had closed the C6 intake and blocked channel C. Cl then reported that Dl temporarily had opened up an additional intake to his plot. The mutual water "borrowing" had become rampant and so had the tit-for-tat reporting and fining.

3.2 Werdi Agung

3.2.1 First season Because of rainfall in May and early June, water was relatively adequate during the land preparation period in the first observed season, compared with the second season. However in the first season, the rainfall and irrigation discharge dropped off just before transplanting (which was just before our water balance measurements began). The entire system, with few exceptions, planted the nursery seedbed all within a week and later transplanted seedlings all within a week (the latter being the first week in June), Soon after transplanting however, the TRWS dropped and remained low for three weeks. Thereafter TRWS remained above 1.0 for the rest of the season, except for a drop during the reproductive phase at week eight (caused by the scheduled delivery of a large flow of water for land preparation to another section of the Kosinggolan Scheme).

During the week of transplanting itself borrowing occurred between channels A and B, C and D, and 6 and K. Because of lack of water as well as labor constraints, H2, Gl, G5, and D8 were late in transplanting and this contributed significantly, for several weeks, to the frequency of borrowing and to the tensions at the C/D and G/H channel division points. It wasn't until week six that G5 was able to finish plowing and transplanting in his last terrace. By this time the reproductive phase was beginning and the TEWS, which consisted almost entirely of discharge from the main canal (due to lack of rain), was on the decline. This prompted numerous complaints about the water supply and the occurrence of frequent interpersonal borrowing, especially along channels C, D, E, G, and H. After week nine the TRWS rose and remained above 1.0 until pre-harvest drying began. During the last five weeks of the season mice and birds became a serious problem and this kept more people than usual in the fields, to scare them away. Having more people continuously in the fields may have discouraged some water theft during this time. Partial blocking of channels and plot intakes (as compared with full blocking) appeared to be especially common during this period, indicating restraint in borrowing practices at a time when the fields and channels were being observed especially closely.

3.9.2 Second season in latter October water from the main canal was permitted to flow through Gate Eighteen for land preparation, when continuous flow irrigation proved to be enough to soak only about one-half of a terrace per plot, farmers decided to rotate the full flow to individual plots for twelve-hour turns. This made it possible for most fanners to plow about one-half of a hectare per turn. They intended that after this first turn they would wait for rain before harrowing and broadcasting seed in nursery seedbeds. If no rain came they would wait for their next rotation turn and plow the second half of their plots. The right side of the system took rotation turns first.

Some members of the subak who owned sawah elsewhere (which was being better irrigated) expressed a preference to plant soybeans in Block Eighteen rather than wait any longer for rain, in order to make padi seedbeds. Others preferred to have the rotation continue until all plots had had two turns and the plots had been plowed entirely at least once. Some of these were farmers who had their seedbeds already sown on plots in other tertiary blocks which had more adequate water. They were going to transport the seedlings to their plots in this block when it was time.

However, apparently the majority wanted to stop the rotation and switch to continuous flow, despite the continuing inadequate water supply. This was because they didn'ij want to wait any longer to prepare the seedbeds. They argued that since the soil was so dry the seedbeds would need continuous flow, even if the rest of the terraces would not get water. In their experience

heavy rains had always come in late November and December anyway. So by mid-November water allocation was changed to continuous flow by announcement of the subak leaders, without holding a meeting to formally discuss, it. It perturbed some members that a meeting wasn't held to decide the issue. But others said that since such a big majority obviously wanted continuous flow, a meeting would be a waste of time.

The continuous flow arrangement gave farmers flexibility in when to plant the nursery seedbed. The inability of the fanners to predict or to rely on statements about when higher water discharges would be made available to their system (i.e., Tertiary Block Eighteen) discouraged the scheduling of broadcasting or transplanting dates, either on a simultaneous or staggered basis. So there was considerable variation throughout the system in broadcasting and eventual transplanting dates. The variation occurred in every part of the system, with no section having entirely early or late planting dates. This happened because the farmers scheduled these activities not only according to water availability or the expectation of the timing of future water availability, but also according to labor constraints and the ownership or not of sawah elsewhere. The variation stretched over four weeks, with early and late planters scattered around the system. In December the irrigation rate did increase. But because of the informal staggering in broadcasting dates, transplanting was likewise staggered. By the last week in December, or week three, almost all the fanners had transplanted.

To say that continuous flow was used is to say so in a relative sense—in contrast to a formally scheduled, group-level rotation. Interpersonal borrowing continued as an apparently permanent feature of the system. As with the first season, G5 was the last to transplant. In his case this occurred because of water shortage. He waited until the others along channels G and H had done most of their transplanting so as to limit, as he said, the keributan (commotion or disturbance) of too much borrowing water back and forth at the critical time of final land preparation and transplanting.

Fanners in the system held the view that as long as one had talked to his neighbors at the outset of the season about the general timing of planting and the acceptability of borrowing water, one need not seek permission each time before borrowing water. This was permissable as long as it wasn't done too often and when it would make his neighbor's fields go dry during a growth phase with critical water need (e.g., land and seedbed preparation, transplanting, flowering, fruiting stages). When farmers in either system talked about their water needs in comparison with others, the stage in the cultivation season was as frequently mentioned as were comparisons about differential water supplies.

So when greater staggering of planting occurs, especially within quarternary groups, it is more likely that would-be borrowers, whose fields are in a stage when water adequacy is urgent, will have neighbors whose fields are not in such a stage. Therefore a farmer tends to feel less inhibited from borrowing from neighbors whose fields are not at a stage of critical water need, such as the vegetative growth or ripening phases. When all of the plots pass through the critical water need phases simultaneously, farmers are relatively more reluctant to borrow from neighbors than would be the case if the neighbor's fields were not at a phase of critical water need.

By mid-January, or weeks six and seven, the transplanting stage had passed and so several farmers started making new terraces and frequently borrowed water to do so. These were at plots A2, E5, F3, K4, H2, and R2. At the onset of the reproductive phase, farmers at channel C, where percolation and seepage rates were quite high, began rotating water in twenty-four hour turns among their plots. This continued for several days. Then in early March (weeks twelve and thirteen), at another dip in TJWS, they resumed a "formal" rotation. They requested that channel A and B rotate with them also. But since the water supply for channel A was more adequate than channel C, they refused and preferred to use continuous flow allocation (which was all the while modified by informal borrowing). At this time channel E farmers established a scheduled rotation of water. By week fourteen some had begun pre-harvest drying of fields.

4 Systemic Implications of Variations in TRWS

4.1 The Proportion of the system Covered with Water

By the term "the proportion of the system covered with water," we mean the proportion of the system which was planted with padi which had standing water on it. This was estimated for each field inspection by recording the presence and depth of water, if any, in a sample of ten observation plots in Hopugad and fifteen in Werdi Agung. These plots were scattered around each system, in the upper and lower sections of system channels, in order to obtain an estimate of the availability of water around each system. From these measurements the proportion of sample plots with standing water (PSPW) was calculated and weekly averages were obtained.

Because of the nature of the dispersion of observation plots, it is assumed that the proportion of observation plots having standing water is an adequate approximation of the proportion of the system having standing water. It is also assumed that these sample values are more accurate indicators of the directions and degree of change in the proportion of the system with standing

•See Figures 6-9 and 6-10 below for the locations of these observation plots.

water than they are of its absolute value. We seek to understand in this analysis the relationships between changes in TEWS and 1) the proportion of the system with water, 2) the depth of water in different parts of the systems, and 3) the intensity of water allocation activity. The first relationship relates to efficiency. The second relates to equity.[5] The third relates to adaptive process.

Given the more favorable TRWS for both seasons in Werdi Agung and the more common existence of return flow in the system (as was noted in Chapter Four), it is not surprising that the PSFW was higher, on the average, in Werdi Agung than in Mopugad. The seasonal mean PSPW in Mopugad was .59 in the first season and .52 in the second season. In Werdi Agung the seasonal mean PSPW was .76 in the first season and .68 in the second season. Figure 6-5 displays the relationship between TRWS and PSPW through both seasons in Mopugad.• Generally, the PSPW rises and falls parallel with the TRWS. The relationship is not uniform of course. PSPW is a proportion while TRWS is a ratio, with values

[5]Our operational definition of efficiency in this case is the ratio of the amount of the system with water to the water supply, or more specifically, the TRWS. We relate equity to the local rhetoric of justifying criteria for adjusting the standard division to counteract the related physical inequalities in the system. Since such inequalities affect the water demand and supply of plots, we define equity as the approximation of matching plot-level water supply with demand.

[6]In Figures 6-5 and 6-6 PSPW follows the same scale on the left side of the graph as TRWS, occurring within a range between zero and 1.0.

MOPUGAD

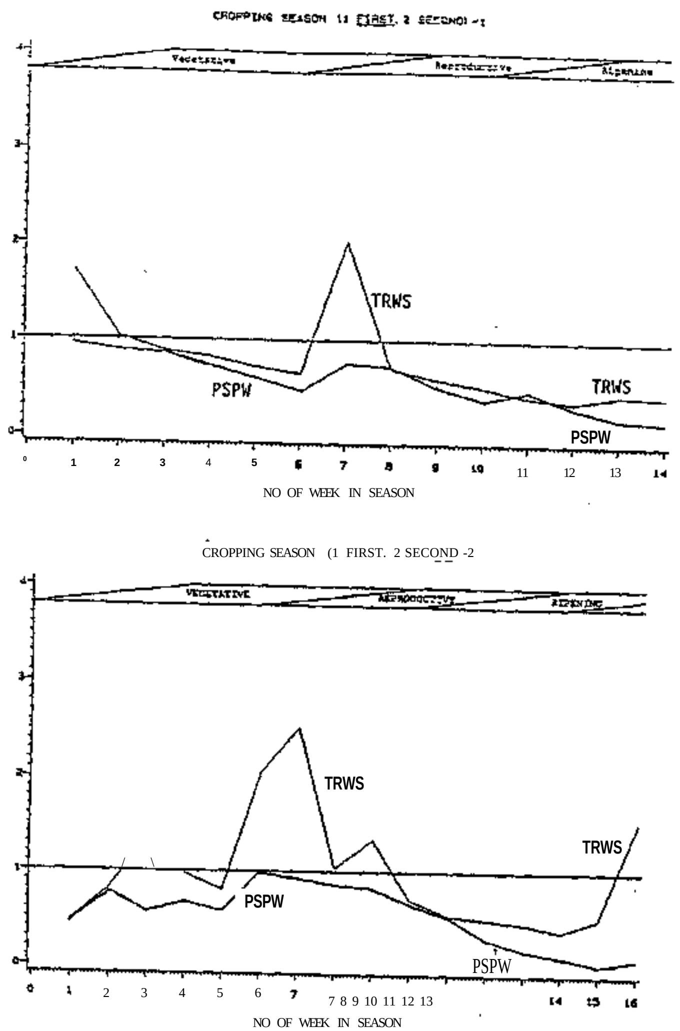


Figure 6-5. TRWS and the Proportion of Sample Plots with Water (PSPW), Mopugad

extending well above 1.0. Intentional drying, which effects PSPW, occurs independently of variations in TRWS. The existence of several centimeters of water in terraces may act as a buffer between short-term fluctuations in TRWS and PSPW.

The figure also shows that when TRWS is below 1.0 the PSPW generally does not meet and equal the level which TRWS is at, but is a bit below what TRWS indicates is theoretically possible. This difference may be caused either by canal conveyance losses, intentional drying, or the misallocation of water. Section five below provides some evidence that the latter possible cause was not very important,although there were a few plots in the upper part of the system in Mopugad where water was drained out of the system. Also there was some difference in depth of water between upper and lower plots, as is shown in section 4.3.

The two significant occurrences of TRWS and PSPW moving in opposite directions happened near the beginning and at the end of the second season. At week three, farmers in the lower part of the system were still plowing, harrowing, and transplanting and the water was rotated to them both day and night. However, between weeks two and six in the first season, TRWS steadily declined, after a period of more adequate water supply during the land preparation stage. Despite the use of staggering during the first season, water was generally allocated to the entire system each night. This practice helped to keep the PSPW from dropping more rapidly than otherwise would be the case. At weeks fifteen and sixteen of the second season, TEWS increased at the same time many fields were drying before harvest. This widespread drying caused the divergence in the directions of PSPW and TRWS at this time.

Figure 6-6 shows the TRWS and PSPW for both seasons in Werdi Agung. The relationships are roughly parallel through both seasons. We can see that when TKWS gets close to or below 1.0 the distance between TEWS and PSPW decreases quickly. This is especially apparent when comparing Mopugad with Werdi Agung. When TRWS is especially low in Mopugad the PSPW more closely approaches and even reaches (according to our rough estimates) the theoretically potential proportion of the system which can be covered with water, given the TRWS. At slightly higher levels of TRWS and PSPW in Werdi Agung the difference between actual PSPW and the potential proportion of the system which can be covered (as implied by the TEWS) becomes greater. This relationship indicates that water use is more efficient at lower levels of TRWS (i.e., the PSPW/TRWS ratio improves at lower levels of TRWS). The ratio of PSPW to TRWS was calculated and averages were obtained for weekly data over two seasons. These average ratios were .60 in Mopugad and .62 in Werdi Agung. These mean that if the total water supply was equal to the total demand, in each system, the proportion of the system which would be covered by water (given the observed levels of efficiency) would be .60 in Mopugad and .62 in Werdi Agung.

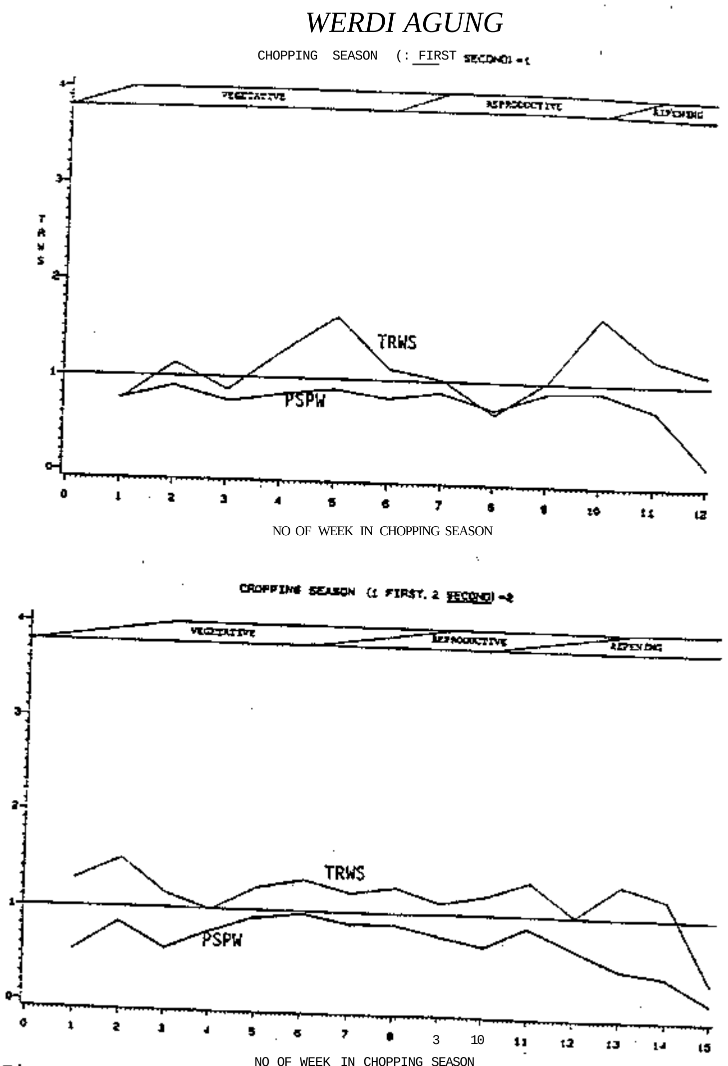


Figure 6-6. TRWS and the Proportion of Sample Plots with Water (PSPW), Werdi Agung

In Mopugad, the area covered with water expands and contracts more readily with changes in TRWS than in Werdi Agung. As we have seen, the farmers in Mopugad are more sensitive to changes in TRWS because of the relatively lower levels of TRWS and the higher relative dependence of plots on the channels. This greater sensitivity in Hbpugad is indicated by the stronger associations between both 1) allocation intensity and TRWS and 2) PSPW and TAWS.

4.2 TRWS and Spatial Variations in Depth of Water Coverage

We now address the question of how closely water coverage depth in the two systems is related to TRWS. This step will help us to be able to evaluate the relative effects of TEWS, the configuration of water sources, soil permeability, and the spatial biases in water borrowing on the equity of water allocation. Water depth measures were recorded in top and bottom observation plots on different channels in each system. Not surprisingly the average depth in the upper observation plots was higher than in the lower plots, both in Mopugad and Werdi Agung. However, the difference is smaller on the average in Werdi Agung. The absolute levels of both upper and lower plots (measured in centimeters) are higher in Werdi Agung. The mean water depth's in Mopugad for the first season were 2.94 cms in the upper plots and 1.96 cms in the lower plots. In the second season they were 2.54 cms in the upper plots and 2.03 cms in the lower plots. In Werdi Agung

the mean depths for the first season were 3.44 cms in the upper plots and 2.81 cms in the lower plots. In the second season they were 3.07 cms in the upper plots and 2.46 cms in the lower plots. This gives an overall mean difference between upper and lower plots in water depth for both seasons of .74 cms in Mopugad and .62 cms in Werdi Agung.

Table 6-1 lists the simple correlation coefficients (r) for the correlations between the mean depth of water coverage in the observation plots (overall, upper, and lower), PSFW, and TRWS. The relationship between the overall mean water depth (across all of the observation plots) and TRWS was much stronger in Mopugad than in Werdi Agung (e.g., .47 versus .12). In Mopugad the mean depth of water in the lower plots was significantly more sensitive to variations in TRWS than in Werdi Agung (e.g., .75 versus .14). However concerning the upper-end plots, in Werdi Agung their mean water depth is strongly correlated with TRWS (r=.67). In Mopugad the correlation is only .21. This means that whereas the depth of water in upper-end plots varied with TRWS in Werdi Agung, it remained more stable with variations in TRWS in Mopugad. This reflects the high permeability of the sandy soils in upper-end plots in Werdi Agung.

Table 6-1

Correlations (R) Between Depth of Water, TEWS, and PSPW

	Mopugad		Werdi Agung	
	TRWS	PSPW	TRWS	PSPW
Overall Mean Depth	.47	.59	.12	.35
Upper Plots Mean Depth	.21	.79	.67	.35
Lower Plots Mean Depth	.75	.80	.14	.70

These comparisons show that at lower levels of TEWS (e.g., below 1.0) fluctuations in TRWS constitute a significant influence in the depth of water coverage, especially in Mopugad. As TRWS increases above 1.0, fluctuations in TRWS quickly become less associated with depth of water in the fields.

In Werdi Agung the relative insensitivity of water depth in lower plots to variations in TRWS apparently is related both to the prevalence of return flow, lower infiltration rates in lower plots, and the somewhat higher average TRWS. In Mopugad, water depth in lower plots was highly sensitive to fluctuations in TRWS, reflecting the more severe water shortage and the singular dependence of these plots on water from the channels.[7] When we measure the difference between the mean water depth of upper and lower

[7]Scatterplots of the relationship between overall mean water depth and TRWS are in Appendix Three, Figure A6-5. Figures A6-6 and A6-7 in this Appendix display the weekly mean water depth for upper and lower-end sample plots. The area between the two lines is not correlated with TRWS in either system.

plots however, we find only low correlations between this upper/lower depth difference and TRWS. This upper/lower depth inequality has a correlation with TRWS with a coefficient of only .11 in Mopugad and .30 in Werdi Agung.

Therefore, it seems that both within the somewhat high range of TRWS in Werdi Agung and within the lower range of TRWS in Mopugad, that variations in TRWS do not strongly effect changes in the inequality of water depth in either system. In Mopugad degrees of water stress are based primarily upon distance from the top of the system (as will be seen in section five below). Hence the fact that increases in TRWS are strongly associated with increased water depth in lower plots, but not in upper plots, indicates that this is an equalizing process. This is so because the lower-enders appear to be benefiting proportionately more from increases in TRWS than the upper-enders. This was in a context where the average water depth of the upper plots was a slim .74 cms higher than that of the lower plots.

Referring again to Table 6-1, we see that in Mopugad the water depth in upper, lower, and all sample plots was strongly correlated with the proportion of the system covered with water (as estimated by the PSPW). This means that as the PSPW expands, water coverage tends to deepen, either among upper or lower plots or over all the plots. In Mopugad when PSPW contracts, the mean water depth decreases, either among upper or lower plots, or over all of the plots. In Werdi Agung the expanding or contracting of the area covered with water is only modestly associated wit water depth variation either overall or in the upper plots. However in the lower plots in Werdi Agung, the PSPW is strongly correlated with depth of water (r=.70).

It is interesting that in Werdi Agung lower-end water depth would be strongly associated with variations in the area covered with water but not with the relative amount of water (TRWS). This means that increases in TKWS were more inclined to lead to increases in water depth in upper plots than to direct increases in the area of the system covered with water. This seems to be due to two factors. First, TRWS varied only modestly and at higher levels in Werdi Agung than in Mopugad. Second, return flow in lower sections of the system in Werdi Agung acted as a buffer against the effects of TRWS variations on water depth. But when the proportion of the system having water did change, apparently the lower plots were the first to be effected. Hence the typically modest variations in TRWS in Werdi Agung were not as likely to effect changes in water depth in lower plots as were variations in the proportion of the system with water (which itself was significantly effected by only relatively dramatic changes in TRWS).

The average depth of water in the upper-end plots varied only between 2.5 and 3.5 centimeters. This is a rather shallow level which could quickly go to zero with moderate decreases in the water levels in the channels. That water depth in upper plots

was strongly correlated with PSFW means that as a greater proportion of the system had water, the water depth usually rose correspondingly in upper plots. If the depth in upper plots remained constant (but low) while PSPW increased, PSPW would be able to expand even more rapidly, permitting greater equity of distribution in the short-run (by allowing the same amount of water to spread more throughout the system). But over several days this "inequity" would disappear to the extent to which the deeper water above eventually reached lower plots in the system by return flow.

4.3 Intensity of Water Allocation Activity Because of the common occurrence of altering the division of water during either officially-designated periods of continuous flow or rotation, it was sometimes difficult to distinguish between the two forms of allocation in practice. Therefore, the total number of alterations around the system is used as an indicator of the intensity of water allocation activity, or more broadly, management intensity. This measure was taken at each field inspection and includes all alterations made at either the

[1] Levine has defined management intensity as the degree of porating and responding to seasonal information pertinant system operation (Levine, 1985; Martin, 1986:20). My operational definition of this term is consistent with Levine's to the extent that one follows Lindblom's notion of social interaction, which may involve limited and often symbolic information exchanges without central coordination.

level of plot intakes or channel division points. The terms levels and intensity of activity are used interchangeably.

Over all of the inspection for both seasons, the mean number of alterations observed per inspection were 14.72 in Mopugad and 18.75 in Werdi Agung. If we control for the difference in the number of channel meters in each site (e.g., 3,675 meters in Mopugad and 4,970 meters in Werdi Agung) we find only a slightly greater level of intensity of alteration activity in Mopugad than in Werdi Agung. There are .004 alterations per inspection per channel meter in Mopugad versus .0038 in Werdi Agung. Or controlling for the difference in the number of hectares per site (e.g., 28.5 hectares in Mopugad and 38.5 hectares in Werdi Agung), there were .516 alterations per inspection per hectare in Mopugad versus .487 alterations per inspection per hectare in Werdi Agung. However there are over twice as many independently irrigated plots in Werdi Agung than in Mopugad. This represents a difference in the relative potential number of locations to which such altering activity may be directed. This difference in numbers of plots is considered to be more important in affecting such alteration activity than is the difference in the total length of channel meters or number of hectares, because it represents a dramatic difference in the potential number of interacting parties. In Mopugad there were .433 alterations per inspection per irrigated plot. In Werdi Agung there were .240 alterations per inspection per irrigated plot.

Whether controlling for differences in length of channels, number of hectares, or number of irrigated plots, the mean level of intensity of alteration activity was higher in Mopugad than in Werdi Agung. As we have seen in Chapter Four, differences in percolation and seepage rates are more extreme in Werdi Agung than in Mopugad. Likewise there are relatively more differences among plots in the diversity of water sources available in Werdi Agung than in Mopugad. In Chapter Five, both kinds of factors were shown to be closely related to which plots borrow water more or less often, relative to one another. It could be hypothesized that the level of allocation intensity might be related to the degree of variation in infiltration rates and the diversity of available plot water sources. If so, the greater the variation in these factors, the greater the need to readjust for such differences— especially when the standard division of water is based virtually only on size of the irrigated plots. And yet the overall level of water division alteration activity was higher in Mopugad, regardless of how the comparison was standardized.

It seems that three factors are responsible for this difference in levels of alteration activity. The first factor is the level of TRWS. The seasonal mean TRWS in Mopugad was only .814 for the first season and 1.003 for the second season. In Werdi Agung the seasonal mean TEWS was 1.131 for the first season and 1.172 for the second season. Another way of comparing this is to say that in Mopugad the weekly mean TRWS was either at or above

1.0 for only three of the fourteen weeks measured (or twenty-one percent of the season) in the first season and for only seven of the sixteen weeks measured (or forty-four percent) in the second season.

The situation was much better in Werdi Agung, with nine of the twelve weeks (seventy-five percent) in the first season and fourteen of the fifteen weeks (ninety-three percent) in the second season having a weekly mean TRWS at or above 1.0. So water was more scarce and was scarce for more prolonged periods in Mopugad than in Werdi Agung. This alone could account for the observed difference in intensity of allocation activity between the systems. The system in Werdi Agung was a tertiary block in the middle section of the Kosinggolan Scheme and was drawing on a much larger watershed than was the Mopugad system. Being incorporated into this large system had its disadvantages, such as when the water supply to the Werdi Agung system was cut back considerably in the middle of the reproductive phase of its first season, because water was being redirected for land preparation to another part of the Scheme (see Figures 6-3 and 6-4).

However a second factor which seems to relate to the difference in the intensity of allocation activity is the much higher relative dependence upon the channels themselves as direct plot water sources in Mopugad. As we have seen in Chapter Four, a greater proportion of the irrigated plots in Werdi Agung rely on neighbor's drainage, groundwater return flow, and, alternative

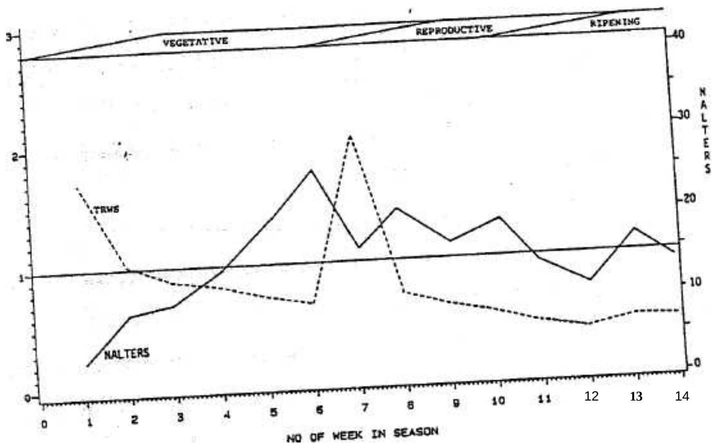
surface return flow sources (such as small ponds and streams). Such lesser dependence on the channels may act to diffuse the relationship which might exist between TRWS and intensity of allocation activity. However this is difficult to establish in Werdi Agung because there was only a modest degree of variation in TRWS, relative to Mopugad.

The third factor is really an aspect of the second one. This is the spatial configuration of availabilities of different plot water sources. As we have seen, the availability of water sources other than the channel is much more common in the lower sections than upper sections of channels in Werdi Agung. This helps diminish the need for lower-enders to frequently borrow water (as in Mopugad) and makes distance from the offtake a less important factor (relative to plot water adequacy). We will address this latter point in section five below.

Figures 6-7 and 6-8 show the variations in the levels of intensity of alteration activity and TRWS over the two seasons in both systems. The alteration activity, or intensity of allocation activity, was measured by recording at each field inspection all observed alterations in the standard division of water. Figures 6-7 and 6-8 show the weekly average of the total number of alterations observed in each system. Although the level of allocation activity obviously is not dependent solely upon variations in TRWS, the two variables do appear to have a generally

MOPUGAD

CROPPING SEASON (1 FIRST 7 SECOND) -1



1 2
3

CROPPING SEASON (FIRST, 2 SECOND)-2

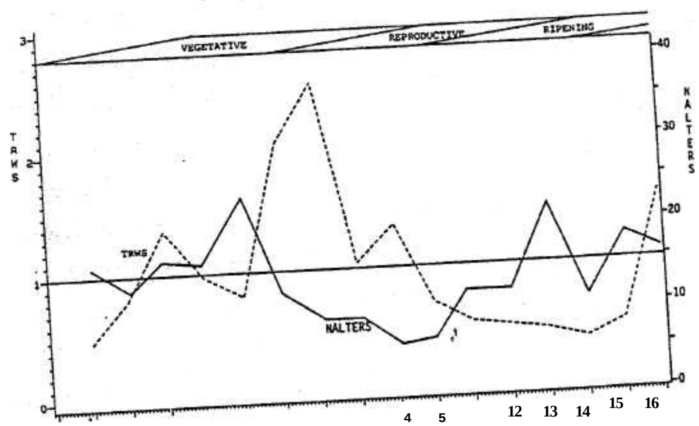
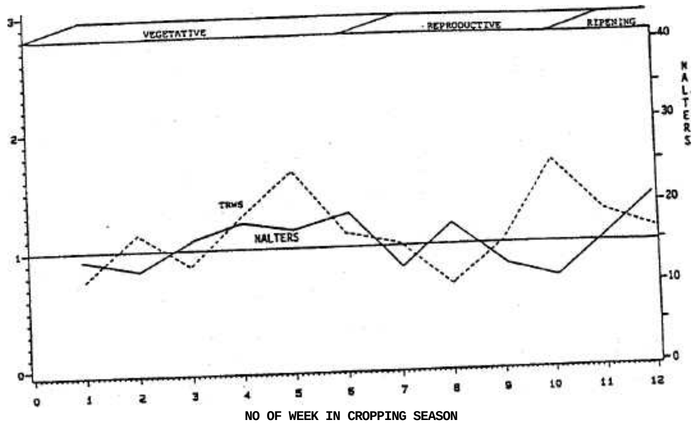


Figure 6-7 and Alteration Intensity,

AGUNG

CROPPING SEASON (1 FIRST. 2 SECOND) -1



CHOPPIN8 SEASON (1 FIRST, 2 SECOND) -2

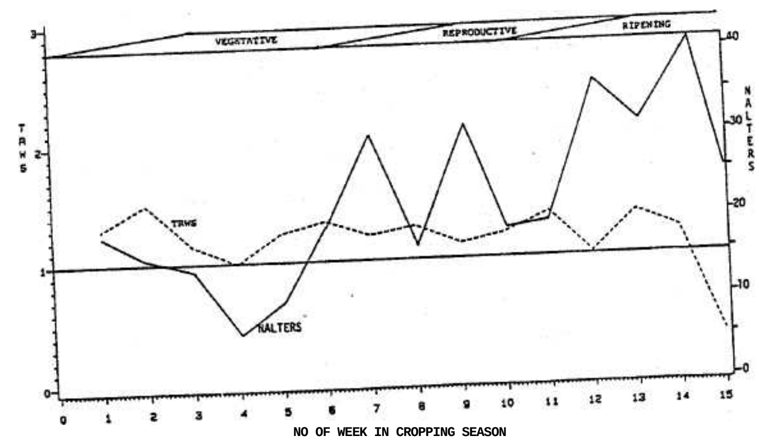


Figure 6-8. TRWS and Alteration Intensity, Werdi Agung

inverse relationship, with some exceptions which will be identified directly.

Figure 6-7 shows that in the first season a gradual rise in alteration intensity (abbreviated as NALTERS) occurred concurrently with a gradual decline in TRWS, through week six. This was followed by a sharp drop in alteration intensity with the occurrence of rain and a sudden rise in TRWS in week seven. When the TRWS dropped again, the alteration intensity went back to relatively high levels through week ten. Then it gradually declined through the remainder of the season, declining to very low levels of TRWS. This direct relationship of both declining TRWS and declining alteration intensity during the latter part of the season seems to be because of the especially low levels of TKWS. During this period farmers told me, "Denqan air sekecil ini mau bikin apa laai?" (which means, "With water this small what can one do anyway?").

In the second season, a decline in TRWS between weeks three and five was accompanied by an increase in alteration intensity. The higher level of TRWS between weeks six through nine was accompanied by a drop in alteration intensity for the same period. The drop in TRWS during the latter part of the season brought about a gradual return to roughly the same levels of alteration intensity as occurred during the latter part of the first season.

In Figure 6-8 we see a nearly perfect set of inverse variations between alteration intensity and TRWS during the first

season. The second season however, is not so straightforward. A parallel dropping and rising of both variables occurred from week two through six. From week six to fifteen the expected inverse relationship prevailed, but with quite pronounced fluctuations in alteration intensity and an average level of alteration intensity which was much higher in this latter period than in the first season.

There are two possible explanations for these patterns which occurred during the second season. The first one is the nature of staggering which occurred during this second season, as described in Section 3.2.2. The staggering of planting dates was not only spread over several weeks, but the staggering occurred along channels throughout the system. This caused early and late planters to be intermingled throughout the system, not like in Mopugad where staggering occurred in three discrete blocks. Apparently, during the first four weeks of the second season, as more and more plots were transplanted, the water was borrowed by or directed to the fewer and fewer plots which had not yet been transplanted, with those who had already transplanted granting borrowing privileges to those few who had not. This process may have caused a decline in the alteration intensity measure, despite the decline in TRWS.

At the outset of the reproductive phase (a period of critical water need) sharp increases and fluctuations in alteration intensity began. The scattered nature of the staggering caused plots throughout the system to go through critical water need stages at different times than many of their nearby and more distant field neighbors. This may have caused farmers to feel less inhibited about borrowing during these stages since there were numerous opportunities to borrow from neighbors who were not in stages of critical water need. Fanners said they felt malu about borrowing from channel neighbors whose padi was in a stage of crucial water need.

The scattered nature of the staggering may have contributed to there being more numbers of plot-level alterations throughout the system (as compared with a situation where crop stages and levels of alteration intensity might be more homogenous within the system). Another partial explanation for the high levels of alteration intensity in the second season was the making of new terraces at scattered locations (e.g., E5, K4, A2, H2, R2, F3, as mentioned above). Terracing and transplanting at these locations occurred after week six and prompted a considerable amount of water borrowing.

There are countless possible combinations of alterations which could occur at any level of intensity of allocation activity. Different configurations could effect the system in quite different ways. For instance, at a given level of alteration intensity there could be a high or low proportion of the alterations which are at channel division points, causing relatively more or less widespread effects throughout the system. Adjustments in the standard division of water may tend to be relatively more localized and interpersonal or more generalized and impersonal.

In distinguishing between alterations which occur at plot intakes from those which occur at channel division points, we are able to calculate the proportion of all of the alterations which occurred at channel division points, when this proportion is correlated with the number of alterations which occurred for the period, we get an indication of how readily increases in alteration intensity effect the higher parts of the system hierarchy. I used weekly averages for both the number of alterations and the proportion of alterations which were at channel division points. The arc sine logarithm of the proportion was used in the analysis, instead of the proportion itself, in order to remove the artificial mathematical effects of regressing a proportion on an integer, especially as values of the proportion approach either zero or 1.0.'

With these adjustments, the coefficient (r) of the relationship between this proportion and the total number of alterations was .63 in Hopugad and .52 in Werdi Agung. This indicates that in Mopugad there is a slightly stronger tendency for increases in alteration intensity to more quickly involve higher levels

•This logarithmic transformation extends the variance of the proportion values which are near zero or 1.0 to a scale similar to that of integers, so as not to introduce statistical artifacts into the least-squares equation (see Snedecor and Cochran, 1967, pp. 327-29 for a description of the arc sin logarithm).

of the system hierarchy (i.e., at channel division points or above) than in Werdi Agung. Of the total alterations observed through two seasons, in Mopugad thirty-two percent were at or above channel division points, compared with nineteen percent in Werdi Agung.[10]

Therefore in Mopugad, increases in alteration intensity led to a more quickly rising proportion of alterations at or above channel division levels than in Werdi Agung. With rises in alteration intensity the patterns of exchange more quickly become more distant or generalized in Mopugad than in Werdi Agung, despite the relatively greater number of channel division points per irrigated/plot in Werdi Agung (as was specified in Chapter Four). In other words, even though there are more channel division points per plot which are potentially alterable in Werdi Agung, there was a greater tendency to alter channel division flows in Mopugad. This difference seems to be due to both the near singular dependence of plots on water via channels and the lower levels of TEWS, which were characteristic of the system in Mopugad.

Together these factors mean that in Mopugad enough water to suffice for borrowers more often can only come by altering water flows between channels. The amount of water in the channels at one's own intake is less likely to be adequate for borrowing

[10] In Mopugad alterations of the intakes of plots Ml through M5 were included as higher level adjustments, since only lower-enders below the A/B and B/C division points borrow water from these intakes.

purposes in Mopugad than in Werdi Agung, because of the lower levels of TEWS. Therefore borrowers in Mopugad are more inclined to borrow water higher up in the system hierarchy, at channel division points. In section five we will see whether or not this tendency towards more generalized exchanges in Mopugad has an effect on the equity or spatial biases of the alterations.

5 Relative Water Adequacy and the Spatial Implications of Alterations in the Standard Division of Water

5.1 Relative Water Adequacy

We now turn to the question of the effects of the observed patterns of water allocation adjustments on the equity of water allocation, given the physical inequalities in the systems. With the information about water coverage for the sample of observation plots, I estimated the proportion of all field inspections for both seasons for which each observation plot had standing water. This proportion should be roughly similar to the proportion of days in both seasons for which the given plot had water coverage. The proportion of inspections wherein a given plot had standing water is a measure of what could be considered a plot's relative water adequacy. This measure is a rough approximation whose value is not so much as an absolute level as it is an ordinal ranking to be compared with other sections of the system. The values for these observation plots roughly represent the relative levels of water adequacy of their respective neighboring plots.

Figures 6-9 and 6-10 show for each observation plot the proportions of all field inspections wherein standing water was on the plot. In Mopugad (Figure 6-9) we can see a strong negative association between distance from the main offtake and the measure of relative water adequacy. There is a wide range, from an approximate ninety percent of field inspections with standing water at the top of the system to approximately only thirty percent at the bottom.

In Werdi Agung (Figure 6-10) the range of variation is between approximately only eighty-five percent and fifty-five percent. Relative water adequacy is lowest at channels P and R and in the lower part of channels G and J. In these few cases, distance from Gate Eighteen seems to be the main cause for this lower relative water adequacy. This occurs where distance from the main offtake is not offset by alternative water sources or low infiltration rates. Nevertheless the variation in water adequacy in Werdi Agung is less than in Mopugad.

5.2 Spatial Biases of Observed Adjustments at Channel Division Points

After observing the operation of water allocation over two planting seasons, I tabulated the total number of occurrences of each type and location of observed alteration in the standard division of water. This was done in order to obtain indications of the spatial biases or the directions of net gains and losses of water allocation among plots—as a result of such patterns of

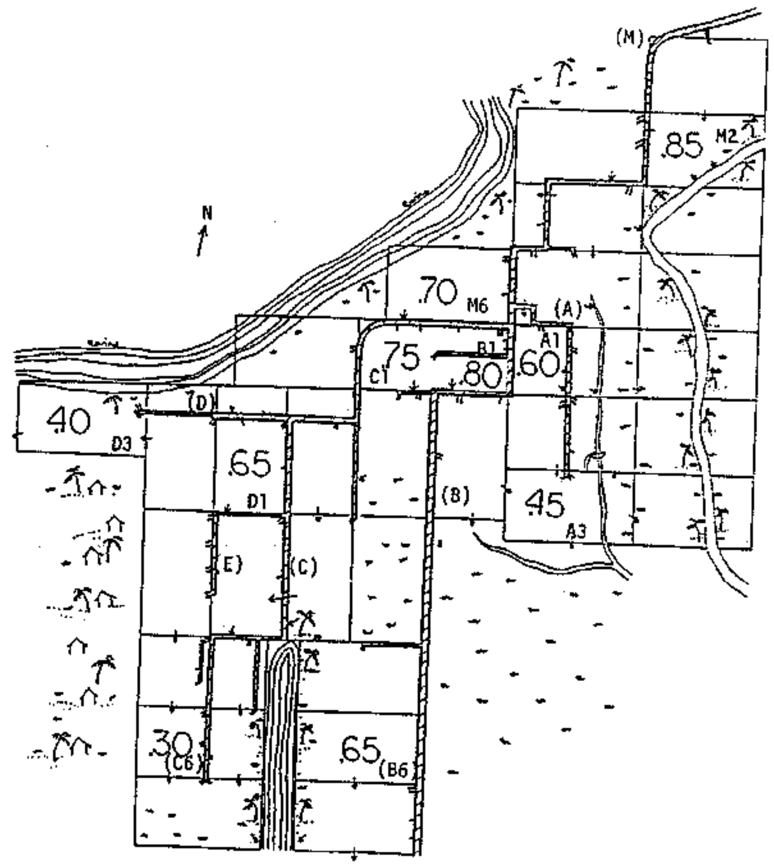


Figure 6-9. Relative water Adequacy: Proportion of Field Inspections with Water on Plot Hopugad

seasons observed.[11] Figure 6-13 illustrates the data for Mopugad. Circles indicate a net gain, triangles indicate a net loss, and squares indicate a rough balance in allocational effect, at the given locations. The numbers represent the proportion of all of the alterations at that location which added water to the plot. The symbols are in three sizes—large, medium, and small—representing upper, middle, and lower thirds in frequency of occurrence, relative to all observed alterations.

For plots with small symbols, the direction of net effect of alterations is less important than for plots with large symbols because the alterations were relatively few. it should be noted that as one moves down channel the effects of alterations tend to become less important since the flow is smaller and the number of those effected becomes fewer. The lower-enders tend to do a larger share of their borrowing higher up in the system. While a lower-end plot may have a triangle, designating a net loss, it may actually gain in the overall configuration of alterations up through the system. The symbol represents only what happened at the plot intake, not what the overall effects on the plot were of the total, system-wide set of alterations.

The predominence of triangles along the main channel at the top indicates a net bias in the observed alterations towards reducing the flow into these upper plots and directing it down

[11]The frequencies of observed alterations at each channel division point and plot intake are listed in Appendix Three, Tables A6-3 through A6-6.

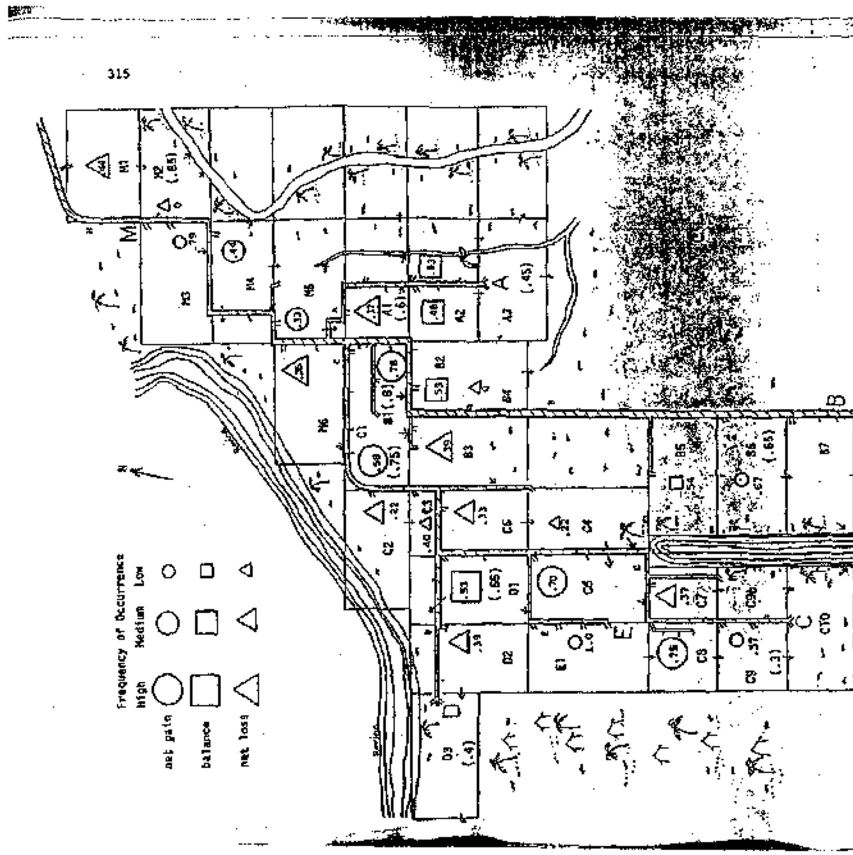


Figure 6-13. Frequency of Observed Alterations at Plot Intakes, Mopugad (Proportions of Inspections with Water in Parentheses)

channel. The one exception is the plot with the fish pond (M3). At channel A the top-ender has a net loss with a relatively high frequency of occurrence, perhaps reflecting the marked inadequacy of water down the channel. This net loss at his intake means that water was often being redirected down channel, meaning a net gain for lower-enders. The two plots in the middle section have a rough balance in the direction of the effects of adjusting the division. This makes some sense given the access which plot A3 at the bottom has to recaptured drainage from the small stream on the right.

The high frequency net gains at plots Cl and Bl seem to be related to the personal disposition of the farmer, as was mentioned in the previous chapter. The high frequency net loss (.39) at B3 seems to make up for the high amounts of drainage coming from Bl. The other plots are roughly balanced in their alteration effects, reflecting the pattern of relatively balanced water adequacy along the channel. Alterations at the bottom were not frequent.

Except for Cl, the upper-end plots of channel C had net losses which served again to direct more water down channel. Four of the five channel C plots which had net gains were in the lower section of channel C. This area, along with channel D, had the lowest levels of water adequacy in the system. Farmers of these plots often had to go higher up in the system in order to borrow enough water to make much difference. Alterations at the intakes were relatively less consequential than those at channel division points. However, we might wonder why D1, C6, and C8 were not net losers, given the critical conditions below them. There seems to be some opportunism by these farmers. And yet often there was so little water in the channels, at this lower part of the system, that these farmers sometimes blocked the channel below their intakes because there wasn't enough flow to reach the lower-enders anyway. I sometimes heard the sentiment expressed that it was better to use what little water remained in the channels, with the possibility of draining some of it, rather than let it go to waste in conveyance.

5.3.2 Werdi Agung Figure 6-14 displays the summary data on alterations at the plot-intake level for Werdi Agung. Looking at channels A and B first, we see that Z1, which is in the most favorable location in the system, had a net loss at a high level of frequency. This was partly due to borrowing by others from below and to Z1's tendency to close his intake intentionally when water was scarce. A1 and A3 are moderately frequent gainers and have high infiltration rates relative to the others in the area. A5 often closed his intake because of obtaining enough or sometimes too much water through drainage and groundwater return flow. B1 was a high frequency gainer, apparently because usually B1 used all of the water in the channel, with C5 using it as a supplement only rarely, since C5's official intake was at

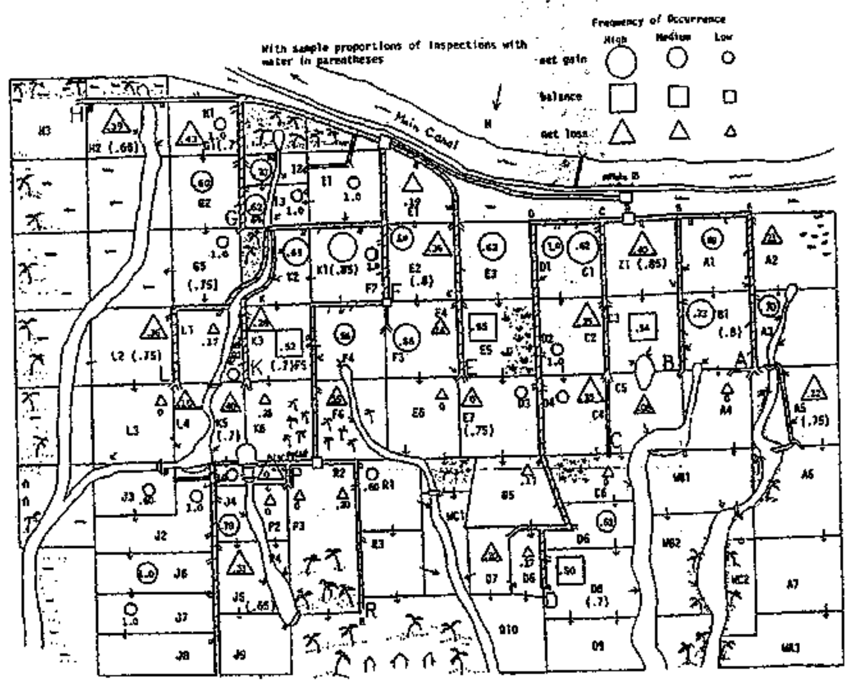


Figure 6-14 Frequency of Observed Alterations at Plot Intakes, Werdi Agung (proportions of Inspections with Water in Parentheses)

channel C and his plot received significant drainage from the depression in the upper center part of his field.

The large symbols along channel C indicate a high frequency of adjusting activity largely because of high infiltration rates. The highest were probably at C1, whose soils were quite sandy and whose land sloped markedly to the left. And yet the proportion of alterations at the C1 intake which were gains was only .62, indicating that the intake also was frequently blocked, sometimes by the owner but often by lower-end borrowers, especially C4. Below C1 the predominance [illegible] iangles indicates net losses at these intakes, so that the [illegible] ere again was towards sending water down the [illegible]

There are mostly small symbols along channel D because the channel itself is intended for those at or below D5, who are outside the official boundaries of the subak. Those above used it only for occasional supplements. So when lower-enders sought to borrow water they tended t[illegible] point. Alterations [illegible] on because of short-term intent[illegible] ntakes are often made mainly [illegible] drying. However the intake at D8 was frequently altered with a roughly balanced effect (with regard to the two bottom-enders, who in times of normal water supplies apparently sufficed with drainage from above). Above D5 all intakes were only temporary so only their opening was considered to be an alteration of the standard division of water. Hence the proportio[illegible] are 1.0 gains.

At channel E the high proportion of larger symbols reflects the relatively high level of altering at the channel. The high level of borrowing, according to the farmers, was because of the sandier soils there (which were part of the vein of sandy soils running along the upper section and down through the middle of the system, along channels C, D, and E). The high level of borrowing was also related to the general difference in infiltration rates between the plots on the right versus left sides of the channel (the higher rates being on the right). This borrowing pattern has the equitable effect of offsetting the differences in water demand between these plots, the net losses generally being on the left side and the more frequent ones being toward the top. At channels P, P, and R we see more frequent borrowing above and less frequent borrowing below (at the plot intakes). Fl and F5 were frequent borrowers despite having official permanent intakes at other channels. Both had difficulty irrigating the part of their plots near channel F because of landform. F5 was given permission to use the intake through the season while the water shortage prevented his obtaining any water via the aquaduct from F4. A few of his lower terraces were too elevated to receive water from his official intake at channel K.

At the bottom the only intake which was altered often was at PI, where it was most often closed. Ordinarily P1 obtained adequate water from the pipe placed under channel P from K6, which

brought drainage to PI. However, during the two dry planting seasons observed, the intake was frequently closed. The owner is an elderly man who said he was unable to come to the field often enough to control the water. During this time P3 was making new terraces and borrowing water often. The two small triangles at P3 and R2 mean that these intakes were rarely altered. But when they were altered it was apparently usually for intentional, short-term borrowing.

At channel J the levels of borrowing were relatively modest, reflecting the relatively lower degrees of dependence on the channel, largely due to groundwater return flow in the area. The large proportion of plots with net gains (circles) indicates an absence of borrowing from these intakes by lower-enders (with the exception of J5, whose intake was often shut for reasons unknown to this writer.

The symbols along channel K indicate more frequent altering in the upper part of the channel, with frequent taking of extra water by the two upper-enders. This pattern seems not to be justified by any of the criteria for frequent borrowing mentioned in Chapter Five (e.g., high infiltration, bottom-end position, new terracing, or keeping fish ponds).[1]* Perhaps the observed

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[2]Because of a period of uncertainty about which intakes at Kl were official or permanent* some of my notes did not distinguish many of the closings of the permanent intake from those of temporary intakes (the latter of which should not have been considered alterations from the standard division). Hence an exact proportion is left out, although we know that Kl was a location of frequent altering, with a net gain effect.

high frequency gaining at K2 is partly due to having a high infiltration rate near the ravine, while K3, which has a net loss, is further away from the ravine. K3 is in a bowl-like formation where it receives significant surface and sub-surface inflow.

Channel L has no net gains, indicating that adding water at the intakes was not common. The level of water adequacy was relatively favorable between the top two plots. These findings suggest that the top plots rarely added water and the lower plots tended to borrow from the upper plots.

At channel G all of the plots had net gains, three of which were of medium frequency. This indicates both a relatively frequent and a roughly balanced pattern of borrowing at each of the intakes, from top to bottom. Of course adjustments along channel G were often made in combination with altering the G/H and E/F/H division points, where the more significant increases in flow were obtainable. Intakes at H1 and H2 were frequently altered, with a modest net loss. These plots, with H3, had the lowest level of water adequacy in the G/H area. Apparently there was a tendency along channel H for the lower-enders both to close upper intakes along the channel and also to alter the channel division points, given their relatively less adequate water supplies.

In this chapter we have attempted to integrate some of the agronomic, physio-technical, and social components of irrigation in the two systems. We have seen that the intensity of allocating activity tends to vary inversely with TRWS. However, it was not the case in these systems that such activity ever dropped off entirely or was restricted only to conditions of pronounced water scarcity. However, the occurrence of staggered planting dates, a diversity of water sources available to plots, variable percolation and seepage rates, and the making of new terraces can significantly modify the directness or strength of the relationship between allocation intensity and TRWS—sometimes resulting in low intensity of allocation activity even when TRWS is also low. Although staggering helps diffuse the pressure of high water demand at the beginning of a season, it may encourage more water borrowing later in the season in a context where farmers with fields in a phase of crucial water need can readily borrow water from fields which are not in such a phase (e.g., vegetative or ripening phase).

In observing water allocation intensity we have distinguished between allocation arrangements occurring at the level of plot intakes from those occurring at the level of channel division points. The nature of the system design layout and the configuration of the dependence of plots on system channels seems to have an effect on whether or not increases in allocation intensity lead slowly or quickly to adjustments higher up in the system hierarchy (i.e., at channel division points).

We may call this relationship between the level of allocation intensity and the proportion of adjustments which are at channel division points the "hierarchical sensitivity" of a system. Systems which are more hierarchically sensitive than others are those where increasing levels of intensity of allocation activity more quickly lead to higher proportions of adjustments at the level of channel division points (analysis of_ those at plot intakes arranged between channel neighbors).

Systems which are "hierarchically sensitive" to variations in allocation intensity (such as the system in Mopugad) may find it organizationally more difficult to deal with the stresses of low water supply and high allocation intensity. This is because in such systems, at a given level of water scarcity (i.e., some given low value of TKWS), the hierarchically sensitive system draws more of the lines of allocational exchange, adjustment, or tension, across larger numbers of plots, in comparison with less hierarchically sensitive systems. Those sets of plots are more distant than sets of plots within terminal channels because adjustments at channel division points affect all plots along the effected channels. Therefore, the differences between the plots are more complex—with regard to temporary water division adjustment rights. In the two systems studied here, we have seen that

the important criteria behind such rights are channel location, soil permeability, and plot-level sources of access to water.

In our comparison between Mopugad and Werdi Agung the greater hierarchical sensitivity to allocation intensity in Mopugad was found to be caused by lower levels of TRWS and high channel dependence. This was so despite the greater number of channel division points per plots and the more dendritic design configuration in Werdi Agung.

We have seen the nature of the relationship between the proportion of the system covered with water, as estimated by the PSPW, and TRWS. The relationship was more direct in the lower ranges of TRWS and where there was a near absence of lower-end return flow, as in Mopugad.

The actual depth of water in lower and upper plots varied significantly with TEWS (although somewhat less so in Werdi Agung). In Mopugad, water depth was more closely associated with TEWS in lower plots than upper plots, whereas in Werdi Agung both were equally and less strongly associated than in Mopugad. This demonstrates the influence of return flow in lower plots and the somewhat higher levels of TRWS in Werdi Agung.

But water depth was strongly correlated with PSPW in both upper and lower plots in both systems, water depth, either in upper or lower plots, increased as the PSPW increased, even under conditions of water scarcity with a TKWS well below 1.0. And yet although changes in the PSPW generally led to parallel rises and falls in average water depth of upper and lower plots was not extreme in either system. The average difference in depth of water between upper and lower-end sample plots was .74 cms in Mopugad and .62 cms in Werdi Agung.

We have seen that the observed alterations of channel division points show a tendency in both systems in favor of areas of lower water adequacy. Adjustments at plot intakes show a simi lar bias, though with some exceptions and some evidence of opportunism among farmers. Channel division points seem to be less vulnerable to such opportunism than do plot intakes, as measured according to the effects of such patterns of adjustments on relative water adequacy. By our definition of equity, since relative water adequacy is a function of water supply and demand at the plot level, adjustments in the division of water which counteract relatively low levels of water adequacy are considered to enhance the equity of water allocation. So the observed prevalence of interpersonal water allocating in these systems has not meant disorder or a basic misallocation of water, by any apparent criterion. On the contrary, such practices generally are adaptations which roughly serve to counteract the effects of the physical inequalities among irrigated plots.

CHAPTER SEVEN

Conclusion

It has been the purpose of this study to examine rules and processes of water allocation in two new farmer-managed irrigation systems in the Dumoga Valley transmigration area of North Sulawesi, Indonesia. More specifically, the stated objectives of this study have been:

1) To identify the adaptive components of water allocation in the social and physical settings of irrigation systems,

2) To examine the formation of the social order of water allocation, giving special attention to the relative importance of social rules and processes of interaction, and

3) To examine the relationship between the social order of water allocation and efficiency and equity of water use. This relationship would be examined in a context of variation in water supply and demand, over time and space.

In order to achieve these objectives, I selected two systems which differed according to system age, incorporation as part of a large scheme, and the nature of the physio-technical setting. Ethnographic interviewing and direct observation were used to identify the adaptive components and to discover the local rationale for, and organization of, water allocation. During regular field inspections, data were collected on the actual division of water throughout each system. Through informant interviews, observations, and field measurements I obtained data on available water sources, infiltration rates, and farmer practices of water allocation at the individual plot level. In a similar manner, data on water demand and supply were obtained at the system level. These data enabled me to discover and test the logic of differential patterns of farmer behavior of allocating water. They also enabled me to relate such patterns to efficiency and equity in water use.

1 Adaptive Components of Water Allocation

Despite a prior expectation that the age of the systems might be related to the organizational development or learning stages of the systems, the modest difference in the ages of the systems (five years in Mopugad *versus* thirteen years in Werdi Agung) did not appear to be related to the nature or elaborateness of the formal organization, rhetoric, or behavior of the water users in either system. Wider differences in age (e.g., greater than those selected in this study) may provide a better opportunity to examine learning or developmental stages through which new irrigation systems pass.

It may be that one of the important aspects of the age of a system which irrigates rice is the transition to a condition of relatively stable terrace compaction. The occurrence of terrace compaction may be related to fundamental changes in the nature of formal rules, shares, and interaction among water users. As noted in Chapters Three and Four, most sawah terraces

in each system were not yet considered by farmers to be fully compacted. This created a climate of tentativeness about the current causes and future levels of soil permeability among plots. To receive an official, "permanent" enlargement of his intake, a fanner had to demonstrate to subak leaders that the cause of high water loss at his plot was not faulty terrace making or shoddy land preparation. Since soil compaction in terraces was not yet complete or widespread, it was possible that relative rates of percolation and seepage in some plots still might change somewhat over time. A subak leader in Werdi Agung noted that if too many farmers were granted permanent enlargements, some would be inclined to use water wastefully. Therefore the social response to current variations in soil water retention characteristics (except for a few cases) was to adjust the allocation of water among plots in an incremental, informal, and temporary manner. Future studies that examine developmental stages of irrigation systems might find it pertinent to compare systems which differ according to whether terrace compaction has occurred.

The fact that the subak in Werdi Agung had been incorporated into the Kosinggolan Scheme apparently had little effect on the nature of water allocation within the system. Incorporation did cause some alterations in system design and a change in the source of water, but water allocation proceeded through local control and interpersonal interaction.

Despite the different sources of water in the two systems (e.g., the farmer-built weir in Mopugad and the main canal offtake in Werdi Agung), the task of water acquisition was not a major one in either system. In Werdi Agung, farmers did not have significant control over the acquisition of water in their tertiary block. This was indicated by frequent complaints about water shortages and the frequent sharp decreases in water supplies to the block, even during periods of crucial water need. Thus, the eventual organization of either subak was based more on maintaining the system and allocating water than on acquiring water.

The physio-technical setting of the systems has had important implications for water allocation. Topographic characteristics within and between the two systems have influenced the spatial configuration of borrowing patterns and the conflictual or accommodative quality of social interaction among water users.

In Mopugad nearly all of the plots are highly dependent upon the channels. Variation in infiltration rates is less dramatic than in Werdi Agung, where the channel network is more unified and elongated. In Werdi Agung there is greater variation both in modes of access to water and in infiltration rates. Bottom-enders tend to have the advantage of return flows. Return flow and shorter channels tend to require smaller groups of interaction than is the case in Mopugad, where lower-enders are pitted against themselves (e.g., channels B versus C) as are

lower and upper-enders. The existence of return flow in Werdi Agung seems to be related to the lack of pronounced tension between upper and lower-enders, so evident in Mopugad.

In some locations relative agreement or accommodation about water allocation exists between water users. Elsewhere relations are more strained and conflictual. Such differences seem to be more related to the difficulty of comparing physical inequalities among plots than to the degree of physical inequality among them *per* se. Where plots differ in only one physical trait, such as soil permeability, even when the difference is dramatic, the recognition of needs and rights to borrow water is straightforward. Common understandings and mutual accommodation evolve easily. Where more than one kind of physical difference exists between plots, the comparability of needs and rights to borrow water becomes more difficult. It may not be obvious to two water users whether a bottom-ender whose soils have low permeability has more need to borrow water than a top-ender whose soils have high permeability.

In the model of allocational behavior presented in Chapter Five, we saw that the primary basis for the difference between relatively frequent versus relatively infrequent borrowers was a small set of commonly recognized physical components. Such components included water retention characteristics of soil, the configuration of surface and sub-surface water flows, the relationships between landform and the hydraulic design of the systerns, and particular land uses with high water demand, such as keeping fish ponds and making terraces.

The social order of water allocation in the two subak emerged with distinctive social characteristics. Some characteristics appear to be related to the style and structure of water allocation in the two subak. The Balinese cultural style of interpersonal interaction seemed to influence the informality and self-effacing style of discourse among farmers. The functionally-specific and independent character of Balinese social collectivities may have helped to separate matters of irrigation from social matters beyond the subak. The relatively homogeneous social setting seemed consistent with the development of an equitable distribution of water which was not significantly biased by factional, class, or patron-client relationships. The same may be said for kinship relationships. Padi, both as a subsistence and commercial crop, gave value to both relatively large and small holders. The scale of interactions in both subak was small enough to be interpersonal. Such aspects of the social context appear to be congruent with the nature of water allocation in these two subak. However, the extent to which such "kinds" of components may be necessary or sufficient conditions for the emergence of "similar" interactive processes and results elsewhere is a question which can only be addressed by future comparative research.

2 Rules. Processes, and Negotiating the Social Order

At the time of establishment of each of the two subak, rules were enacted for allocating water to the creators of the systems based on shares proportional to land size. After several seasons of irrigating, a few permanent exceptions to the basis of the shares were made to adjust for pronounced inequalities in soil permeability and the availability of water sources.

In both systems, rights of access to the shares were granted to all those who had invested labor and money in the creation and maintenance of the system. Those who were not original members and who later wanted to obtain permanent shares had to purchase land in the existing system and become members. In Mopugad this meant paying a joining fee, estimated to bear a fair share of the original and subsequent costs of system construction and repair. In Werdi Agung, since the water was now supplied by the government scheme, no joining fee was required of new members except for a small amount to help cover the costs of a small subak meeting building. Apparently this building had some symbolic importance to the original members who had constructed it. Temporary rights to shares could be obtained through sharecropping or renting land and paying seasonal water rental fees.

However, such shares were only a preliminary approximation in the allocation of water. Except for the few cases of permanently enlarged shares, members of the two subak generally coped with the water-related physical inequalities within the systems through incremental, ad *hoc,* and interpersonal means. Fanners responded to inequalities by temporarily and repeatedly adjusting the standard division of water. They justified their behavior to one another by referring to a set of water-related physical characteristics which were a part of the local rhetoric of negotiating water allocation. Despite the localized and sometimes controversial nature of such processes, these interactions result in a more equitable distribution of water for the whole system than would be created by the proportional shares alone.

Following Heath's distinction between types of conceptions about justice (1976), we note that the share rule that establishes the standard division of water rests on justice conceived as "the established rights of others." The shares are a common, established or traditional right for all members. The adjusted division of water, however, is based on intra-group distinctions which have as their basis the notion of justice as the "distribution of benefits according to need." Needs for water vary according to differences in the landform, farming activities (such as terrace making), and growth stage of the crop.

This study has found that social order is constituted by, and emerges from, the interplay between sociocultural rules and processes of interaction between individuals. The respective

interests, strategies, personalities, and actions of individuals shape the nature of social interaction as do generally-shared norms, sentiments, and symbols. Action, however, is not simply dyadic or idiosyncratic. It is influenced by a socially recognized set of justifying criteria, a social repertoire for structuring interactions. Yet the repertoire itself arises from the social interactions of allocating a collective resource.

We have seen that variable individual circumstances and interests can give rise to contradictory uses and interpretations of social rules. In the interplay between rules and processes of social interaction, new rules (or new conceptions of them) are created as patterns of social expectations and behavior evolve.

The flexible and interpersonal style of water allocation in the subak provided settings whereby needed new conceptions about resource allocation could be created through comparing experiences and negotiating. For example, as a result of antagonisms encountered when borrowing water, farmers in both systems developed rules that distinguished which plots could have their intakes closed completely when water was being borrowed, from those which could not. This distinction related to the growth stage of crops and the configuration of water sources available to plots. In Mopugad an informal understanding or rule developed whereby lower-end borrowers did not need to reopen the intakes of upper-enders from whom they borrowed water. No such notion developed in Werdi Agung, apparently because channel distance was not so important a factor in water adequacy and because the infiltration rates were often much higher among upper-end plots. In Werdi Agung the issue of the basis for membership rights and obligations was being tested at the same time the subak was deciding whether or not to admit all of the lower plots into the subak. The issue had emerged because of the incorporation of the system into the larger scheme and the resultant transition from membership rights and obligations based on individuals (e.g., the creators of the system—each of whom originally had only one irrigated plot in the system) to membership based on irrigated plots (where now some members owned more than one plot—each with distinct rights and obligations).

These processes of incremental adjustments and interpersonal negotiations stand in contrast to the images of the subak conveyed in the writings of Liefrinck, Grader, Geertz, and others. Whereas earlier writings on the subak were limited to descriptions of formal rules and group-level practices, this dissertation has examined the uses of rules and the nature of intra-group interactions. We have formed a different view of social order in the subak from that depicted in the earlier writings. Rules are not a tightly consistent logic which directly shape group behavior. We have seen substantial differences between alloca-tional rules or distributional policies and actual behavior. Much of this difference arises because of various physical and social complexities which render a given rule too approximate to "satisfice" for many of the water users. Even so, such rules may continue to be used as standards which enable comparisons among irrigators and orient negotiations and adjustments.

In a recent study on small-scale irrigation in Nepal (Martin, 1986), two types of allocational rules were related to the efficiency and equity of water use, "purchased shares" and "landsize proportionality." It was concluded that the greater "flexibility" and "transferability" of purchased shares permitted greater water use efficiency and equity. Allocational rules and distributional methods were reported, but not measurements of informal interactions among farmers to adjust the allocation of water (if these occurred) nor measurements of the actual division of water over time.

By contrast, this study of two new subak suggests that interpersonal interactions among farmers dividing water may introduce considerably more flexibility into the process than is nominally implied by formal allocational rules. Without measurements of observed farmer practices and their direct allocational results, it is difficult to know about possible divergences which may occur between rules, practices, and results. Despite a proportional share rule in the two subak under study, continuous incremental adjustments in the division of water introduced considerable flexibility and transferability of water use. The proportional shares were used only as a preliminary approximation—or as a negotiable point of departure in the practice of allocating water.

Levine and Coward (1985:4) have noted that many irrigation systems have what they call "dual personalities," where "the nominal system".(the rules) differs considerably from "the reality of its operation" (the process). This study of two new subak confirms the suggestion that such differences occur. However, such differences should not be considered as necessarily deviant, pathological or incoherent, as is implied in the phrase "dual personalities." in the social allocation of resources in complex environments, the relationship between rules and processes of interaction is one of both complementarity and tension.

Whether negotiations involve disagreement over facts relative to rules which are agreed upon, or disagreement over the application of rules to facts which are agreed upon, discourse by farmers is based on a mutually shared rhetoric which is used in negotiating the allocation of water. This is why the farmers in this study saw rules both as behavioral constraints and rhetorical resources, it seems, therefore, that any analysis which asserts a social preeminence for either rules or interaction is likely to create a simplistic reconstruction of social order.

3 Management. Control, Efficiency, Equity

Levine (1982b:13) has noted the "growing realization that efficient use of ... water can be obtained only through increased control and management." As noted earlier, Levine defines increasing management intensity as the increasing incorporation of information about, and responses to, the operation and environment of the system (Levine, 1985; Martin, 1986:20). This definition leaves open the possibility of having management intensify either through authoritative/analytical or incremental/interpersonal modes of action.

As we have seen, management intensity need not imply the incorporation and analysis of information, nor the responses to it, through formal channels. We have found that the level of interpersonal water-borrowing activity tended to increase as the water supply decreased. Such activity may be considered as a form of management intensity, according to the above definition.

The finding about the relationship between the frequency of borrowing practices and levels of water supply is consistent with other findings that management intensity is inversely related to relative water supply (Martin, ibid.; Svendsen, 1983). These studies have used formal organizational structure or official allocational policies as operational definitions of management intensity. However, interpersonal interaction among water users may be not only more prevalent in certain settings but may be more effective than is often perceived by outsiders. Despite his reliance on formal indicaters of management intensity, Svendsen (ibid.) suggests that similar processes of informal interaction to allocate water regularly occur at the field channel level of irrigation systems (Svendsen, ibid.). But such processes have not been examined in sufficient detail to determine their affects on the equity or efficiency of water allocation. In his field research in Central Luzon, Svendsen (ibid.: 196-97) characterized water management by farmers below the turnout level as "individual, private arrangements among farmers." He noted the commonness of "informal'water sharing arrangements ... made in casual conversation by pairs, or possibly small groups . . ."at the tertiary level. He describes the "individual and informal character of sub-turnout water sharing arrangements, and the general inefficacy of past attempts at more formal water sharing organization" at this level of the system.

To the extent to which "engineering principles," scientific management, and "expertise" imply an authoritative/analytical approach, that approach may not be appropriate in small systems or at the terminal levels of large systems, as is implied in the following statement by Walker and Coward (1984 :vii): engineering principles are not easily applied

> oversized. Fields are small, level and often irregularly shaped. Major hydraulic issues do not often come into play. Management therefore is more of an "art" than a "science" and experience becomes more valuable than expertise. The result is that irriga-tors may be more adept and efficient than, say, engineers or agronomists in small-scale system operation and management. This is particularly true at or below the tertiary level of the distribution system and, depending on size, may also be true at the secondary level.

In accordance with Simon's argument about human limitations of decision making, Lindblora's argument about the capacity of partisan mutual adjustment to allocate resources, and the findings of this study, it can be asserted that incremental/interactionist approaches involving decentralized, piece-meal adjustments may be capable of achieving equity and efficiency in water allocation, at least at the level of field channels. The patterns of water allocation in these two subak had the effect of directing some water away from those plots which had abundant water supplies relative to demand (making them somewhat less abundant) and towards those which had low supplies relative to demand (making their supplies somewhat less inadequate). This reallocation was not so dramatic as to cause any water stress in those plots where water was generally abundant. Hence, such informal processes enhanced both equity and efficiency—beyond what would be achieved by a simple reliance on the proportional shares rule. Furthermore, we have seen that the efficiency of water use tended to increase under conditions of lower levels of water supply.

Further research is needed to address the question of at what scale or level of systems or under what conditions incremental approaches tend to be utilized, and if so, how productively. It may be that the requirement for, or viability of, authoritative/analytical control may be related to: 1) how social and hydrological factors spatially or temporally concentrate decisions about equity and efficiency and 2) how much flexibility is required in such decisions. Authoritative/analytical approaches may be unable to cope at local or small-scale settings where important physical and agricultural variations occur and where rapid adjustments are required.

The Social Order in "Underorganized" Systems: Implications for the Development of Water Users Associations

In developing countries, considerable programmatic efforts are underway to establish and improve water users' associations.[1] It is hoped that this study of two new subak will contribute to the growing understandings about both the capacity of farmers to manage water and the nature of the process of farmer water allocation.

How can government agencies enhance the functioning of water users' associations or assist in the creation of them? Clearly, outside assistance must correspond to local organiza-

tional realities. The realities observed in this study seem to suggest four basic principles by which agencies ought to support the development of water users' associations, especially in newly irrigated areas. These principles are: a task orientation, detached support, phased continuity, and flexibility.

4.1 Task Orientation

The organizational requirements of irrigation tasks are highly variable. Water acquisition, water allocation, staggered planting, channel maintenance, etc. invoke interaction among different sets of water users at different times, at different spatial loci, and with different implications for flexibility and control. Landform, hydraulic design, and the nature of interactive environments may also shape how tasks are or should be handled, whether by farmers or civil servants. For example, the presence of groundwater return flow in the lower reaches of the system in Werdi Agung apparently was related to a reluctance on the part of some lower-enders to join equally with upper-enders in channel maintenance. Rather than emphasizing the formal establishment of "canned organizational packages" (Duewel, 1985), or standard forms of water users' associations (such as the P3A model in Indonesia), agencies should try to first identify needed tasks in systems and then ascertain their organizational implications. Organizational structure is contingent upon the nature of tasks and their environments.

4,2 Detached Support

The term "detached support" refers to the nature of a relationship between government agencies and water users' associations. This relationship is one where the agency provides technical, financial, or other forms of assistance without taking control over local processes of identifying needs and implementing efforts to manage water. There should be direct agency control no further down to local levels than where farmers are capable of managing. Below this level agencies should indirectly encourage or strengthen local capacities. Chambers (1977) argues that bureaucracies seldom have the capacity to effectively manage water down to the terminal or field level of systems. Agencies should not supplant local initiative or responsibility by imposing external control where local discretion is needed. It has been asserted that agencies ought to consider themselves as water "wholesalers" who supply water down to the level where farmer organizations then take over and distribute the water by themselves. Local organizations should be kept independent or be "de-coupled" from the main system as far as possible (Walker and Coward, 1984) Coward and Ophoff, 1985) . It is not likely that agencies could be involved in either of the two subak in this study at the level of field channels. It is not plausible that they would allocate water with as much sensitivity to local variations as did the water users.

In comparing numerous settings of irrigation agency/farmer interactions, Levine and Coward (1985:54) conclude that

> irrigation departments rarely have the authority or the power to effectively impose their will very far into the water distribution subsystem; implementation and utilization, therefore, is a cooperative venture and should be recognized as such.

In the two subak in this study, equity of water distribution was defined in response to micro-level inequalities which agencies could not perceive or with which they could not cope. This supports the assertion by Levine and Coward (ibid.:53) that irrigation agencies should "avoid subsystem designs whose equity outcomes are dependent upon agency operation at that level." There is a need for agencies to respond to such limitations by regarding water users' associations as independent collectivities to be strengthened and assisted, rather than as the bottom rung of a bureaucracy.

It has been proposed that irrigation agencies would do better to assume more of a service role than an authoritative/implementing role at the level of farmer organizations (Korten and Uphoff, 1981). Thereby agencies would offer technical and temporary financial assistance to the associations, in response to local needs. Mediators between agencies and farmers, such as community organizers, have been used in the Philippines, Sri Lanka, and Indonesia to facilitate, two-way information flows between the farmers and agencies, to support farmer organizing around specific tasks, and to help channel farmer requests to agency personnel (F. Korten, 1982? Uphoff, 1986; Morfit, 1983).

Occasionally farmers in the two subak spoke about the need for short-term design changes or repairs which involved concrete weirs, division boxes, or channels. I was solicited by farmers more than once to be an intermediary with the government's public works department to enlist the help of an engineer in providing funds and advice in making design improvements in concrete structures. In such conditions a comprehensive plan was not needed, but a medium to facilitate variable agency-farmer interactions,

4.3 Phased Continuity

D. Korten (1980) has argued that organizations evolve through a series of phases of learning to be effective, efficient and to expand. Coward and Uphoff (ibid) have noted that farmer organization for irrigation tends to be more effective and lasting if farmers are involved in the earliest stages of irrigation development. Fanner participation and investment in system design has been shown in the Philippines to affect the viability of farmer organizations in performing later operation and maintenance functions (Bagadion and Korten, 1985).

Each phase of irrigation development, from project identification and design to system operation and rehabilitation, creates both organizational constraints and possibilities for following phases. In Werdi Agung the difference between those who made terraces with bulldozers <u>versus</u> those who used draft

animals constituted a distinction which influenced the rhetoric and practices of allocating channel water and access to drainage among channel neighbors for years into the future. Moreover, new, faulty-designed, concrete division boxes in werdi Agung were superimposed upon the prior farmer-built system. At first the farmers were reluctant to alter the structures themselves, since they considered the structures to be government property, which they were. However, after a period of experiencing chronic problems and experimenting with adjustments and making repeated appeals to the irrigation department for assistance in redesigning the box outtake levels, farmers felt that they had the right to redesign the boxes themselves. A new precedent of control over the structures was established and the borrowing patterns of affected farmers were henceforth altered as well.

Such constraints and possibilities which evolve from one phase to the next relate to specific needs and tasks. Different phases in the development of an irrigation system may require different kinds of agency support for water users associations. It might be fruitless to attempt to impose a standard distributional form on water users when they are learning to adapt to local social and physical variations. Phased continuity means the existence of long-term agency/farmer relationships which adapt as the capacities and needs of both the agency and the local organization evolve.

4.4 Flexibility

The fourth principle for assisting in the development of water user associations is flexibility. The intricate patterns of water allocation in the two subak continually passed from various configurations of continuous, rotational, or otherwise adjusted divisions of flow to others, both at different times and at different levels of the systems. Agencies should appreciate that there may be more than only one or two reasons for farmers to use any given variation on a distributional theme. Given allocational practices or organizational forms may be related to a variety of local physical, agricultural, or social conditions (Duewel, 1985). In some settings, the availability of return flow to lower-enders may cause channel maintenance at the lower levels to be unnecessary either for conveyance or drainage. This diversity suggests that agencies ought to be flexible in what they expect of, or impose upon, water users' associations which have to adapt to local complexities. Civil servants should be careful not to discourage farmer initiative by the use of agency categories, quotas, and time-frames. In working with farmer irrigators, agencies may disable indigenous processes in the name of introducing "rational" organization.

In the two new subak studied in this research, farmers allocated water largely through processes that are not conventionally considered to be rational management (e.g., centralized information-gathering, planned schedules, direct compliance with

standard rules, hierarchical decision-making). Instead, water was allocated mostly through the give-and-take of mutual assertion and accommodation among channel neighbors. A visiting outsider, especially a civil servant, might perceive such irrigator groups to be organizationally underdeveloped, if not anarchic. An appreciation of the capacity of such incremental interaction to allocate resources is obscured by the fact, as Lindblom and Cohen (ibid:25-26) have noted, that it often "produces both outcome and implementation together," without the necessity of official decisions and often without the articulation of problems as such, or their solutions.

Nevertheless, while the two subak may appear to be under-organized, they are not without order. Instead of hierarchy, there is "heterarchy," by which is meant a relatively unstratified social network of mutual constraints and individual assertions. Adjustments in the division of water in these systems often were made without consideration of the implications of such acts, singly or together, for the whole system. However, such processes enhanced overall equity and efficiency of water use in the systems.

In summary, in this examination of two new irrigation systems in North Sulawesi, Indonesia, we have found that social order of water allocation is based on an interplay between rules and processes of interaction among water users. Both systems exist in landforms which created complex physical inequalities

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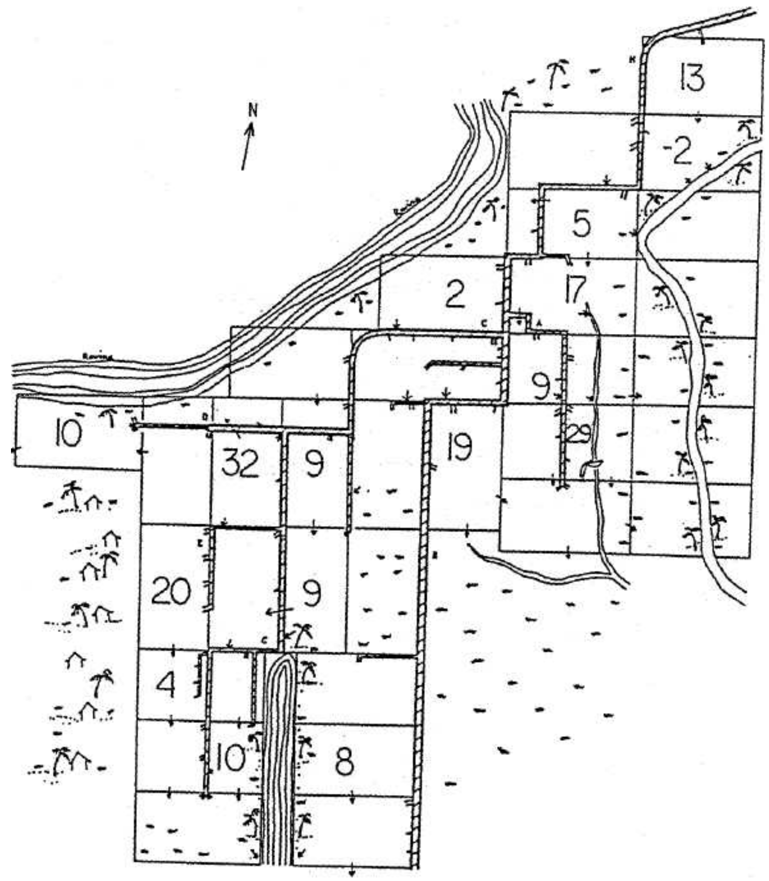
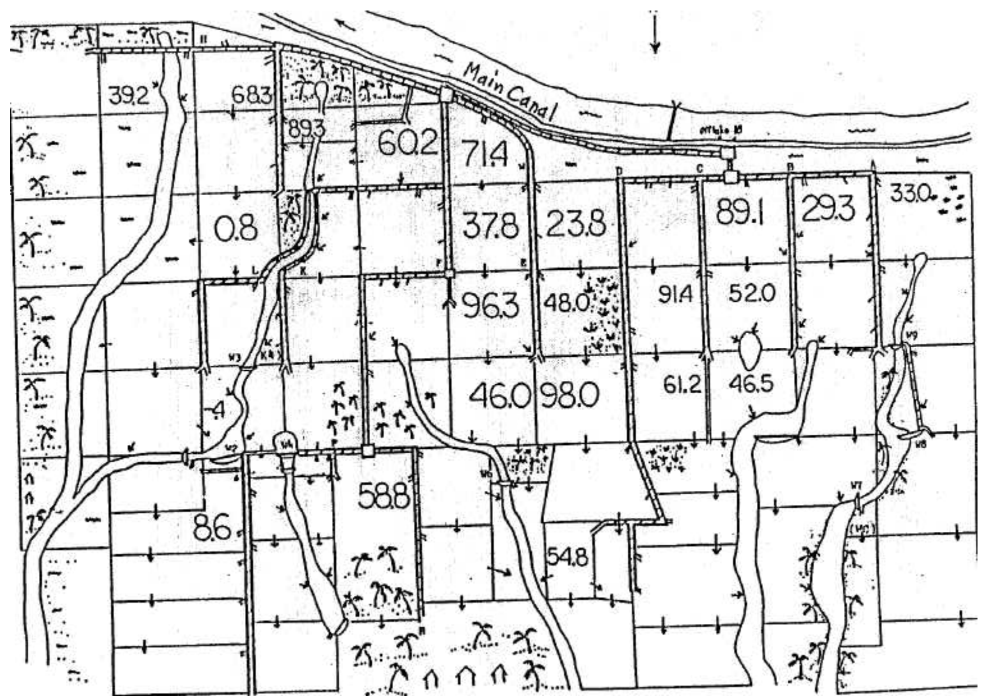
between irrigated plots. The rule of proportional shares was too simple to suffice for allocating water in such complex environments and fanners commonly adjusted the standard division of water through interpersonal negotiations and adjustments. Over time a discerning order of allocation emerged which counteracted the complex physical inequalities within each system. Our capacity to understand and assist farmer-managed irrigation systems largely depends on the ability to distinguish between outward forms and local order.

Figure A4-1. Locations of Plots Measured for Infiltration Rate,



Infiltration



Main Canal
39.2
68.3
89.3
60.2
71.4
0.8
37.8
23.8
89.1
29.3
33.0
96.3
48.0
91.4
52.0
46.0
98.0
61.2
46.5
4
58.8
8.6
54.8

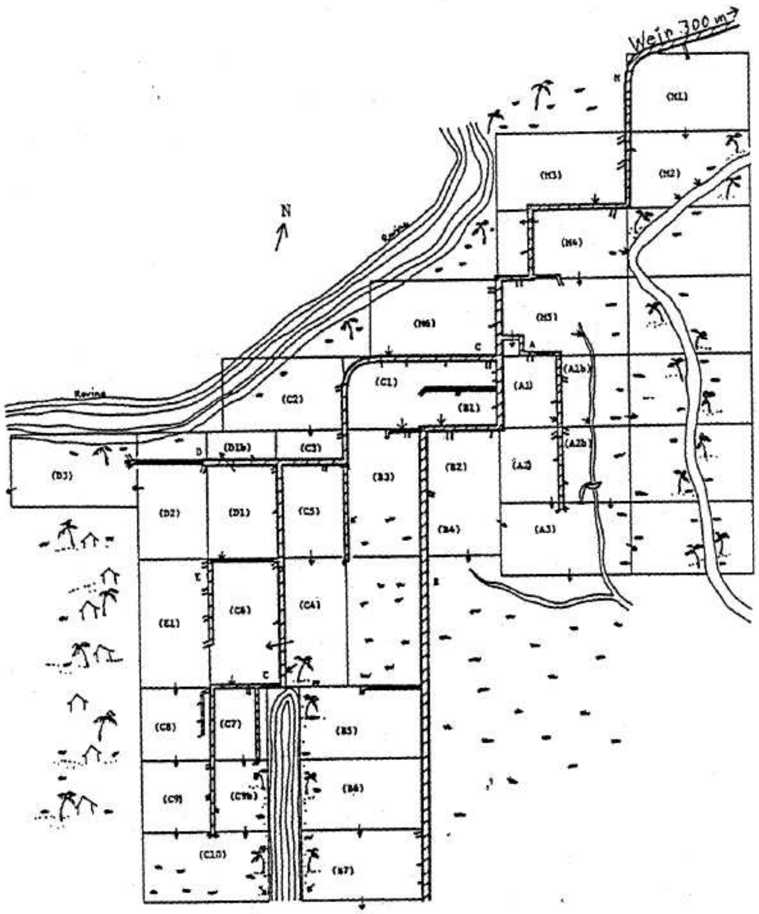


Figure A5-1. Irrigation System in Mopugad

twelve hours at a time and only if

they had dry terraces. M6 said that they generally didn't musyawarah every time there was a need to borrow water, unless he happened to be in his field when D3 came up to close his intake temporarily.

Upper-enders usually do not talk to the lower-enders first before borrowing water. But the lower-enders often talk to the upper-enders first because they have to go up to their plots and directly shut their intakes. But the upper-enders, when borrowing water, can simply widen their own intakes, at an easy distance from the lower-enders. However the farmers have an informal rule or understanding that while there is a stated restriction of twelve hours for borrowing water, it is up to the owner himself to reopen his own intake which had been shut by a lower-ender. In this system such a rule works against the upper-enders if they do not go to their fields daily. This helps to slightly counteract the obvious spatial advantage of the upper-enders.

One day I approached M6's plot as he was reopening his intake which had been shut through the night. He felt sure that D3 had closed it, although other lower-enders often borrowed from him. When asked if he considered that stealing, he refused to call it stealing despite not having given permission to the borrower in this incidence. He made the point that it was he himself however, that had had to reopen his intake that morning, and that the borrower had not done it. And although he said D3 had done it, he said, "Don't I also take water from them?" And so he avoided the distinction between borrowing or stealing (which I had invoked in my question) and posed the issue as one of a matter of balanced or unbalanced reciprocity. He also reposed the lines of interaction from one between himself and D3 to a more generalized image, with the use of the plural pronoun mereka (them).

During the first season after observing M6 frequently widen his intake, Maning (whose field borders W6), in his capacity as subak secretary, placed a temuku with the standard ten-centimeter division, in place at M6's intake to restrict the flow. Formerly it was just an earthen intake. In response to this official imposition, three days later M6 constructed a wooden block in the channel just below his intake. He fixed a twelve-inch board supported by two sticks at a diagonal downstream angle, to make it slightly more tolerable in appearance to lower-enders. He said this was necessary in order to raise the water just enough to get enough flow, since his field was high relative to the channel. He also said that his plot had the highest water loss in the system. The others he said, who also had high losses, were those who likewise bordered the ravine (with the exception of B3 and C9). In his experience it was being near the ravine that contributed the most to high water loss and justified

[2]My own measurement of percolation and seepage rates, which were done in the middle of the plot, did not confirm this, but showed a low rate of only two mms per day. However the rate is no doubt much higher near the ravine.

frequent taking of supplements. Other users elsewhere, due to their different situations, would mention the texture of soils as the cause for high water loss, because this was the prominent factor in their experience.

M6 was not prone to give up when he felt he had a strong excuse for obtaining extra water. Just after he had transplanted for the second season a formal rotation was established. At this time his sawah was partially moist and partially dry but without standing water. Since it was during the initial rooting phase he felt justified in borrowing additional water temporarily from channel A, which was getting its turn. So in the middle of the day he placed half a banana stalk over the channel to bring water from channel A, just below its offtake, into the lower terrace in his plot. His normal intake however, was shut,as was the case with the other upper-enders. Upon occasion M6 would permit his drainage to be directed exclusively to Cl by the use of a bamboo water bridge which crossed over channel C. Sometimes when water in channel C was low because of a diversion of water into channel B, Cl could make up the difference from M6 in this manner. The water for plot M6 came from the intake which was above both the channel A offtake and the B/C channel division point. Ordinarily, such drainage was for all channel C users. But the proximity and personal relationship occasionally permitted such exceptions, which allowed Cl to avoid some of the ill-consequences of the tamperings of the B/C division point.

1.2 Channel B

Of the seven plots along channel B, only plots B3 and B6 did not have the channel as their sole primary source of water. Plot B3 obtained substantial drainage from Bl, via a small aquaduct over its field channel. B6 obtained groundwater recharge in roughly the same amounts as its intake from the channel, when under conditions of roughly normal water supply. All of the plots except Bl, which is at the top, had similarly moderate water infiltration rates. Bl had a relatively low rate.

The head of the subak, Pak Sulawa, had been the head since its inception and operated the field which comprised plots Bl and Cl. In my observation and according to other farmers, he took extra water more than anyone else in the subak. At most of our bi-weekly inspections of the system his plots had additional intakes opened. The field has a diagonal ridge running through it and therefore has divergent paths of water flow. He would sometimes shut channel B to add to channel C, and vice versa, depending on to which side of his field he wanted to send extra water. One farmer up channel from his field said to me once that maybe only ten members of the subak hadn't yet been invited by him to fight.

Shortly after channel B was built, disagreement developed over whether or not the channel should be relocated to run above, rather than below, the farm road which ran between plots Bl and

B2 and plots Al and A2 on the downslope side. Some wanted the channel to be moved to the upslope side of the road so that it would collect drainage directly and the road would not be muddy all the time. Sulawa refused to permit it to be moved since it would use up some of his land. But after an inspection by the hansip dfisa (the village justice of the peace) the channel finally was moved above the road.

This was not the only problem associated with the channel. Plot B2 was dependent completely on the channel since he received no drainage. Plot Bl drained his excess water out into channel B just below where B2's intake was. Sulawa (owner of Bl) was related to the owners of plots B3 and B6 and he wanted to make sure they received a good supply of water since both of them were still making new terraces. B2 was not. B2 often altered the B/C channel division and this escalated in frequency early in the second season as lower-enders of channel C began more frequently to borrow water by shutting channel B. Sulawa also often tended to add water along the channel C side partly because the long side of his plot ran in that direction. He would often either block channel B himself or just take advantage of what altering the channel C lower-enders did at the division point.

In all of the borrowing back and forth which occurred at this spot, as elsewhere, farmers hoped that a reasonable balance of give-and-take could be approximated through direct or inter-personal means. One day as I was walking past this point with

Pak Waning, the subak secretary, we paused to look at Sulawa's intake. Both channels B and C had been blocked substantially by logs to increase the flow into his field. By then it was mid-morning and it was obvious that it had been done overnight, since Sulawa had not yet arrived. Maning dismantled the logs, so that no water could enter the additional intake, but only enter the legitimate intake at the top of channel B. However, as if to downplay the formal significance of this he said, "HJ apa kalau pinjam air" ("It doesn't matter if one borrows water").

During the early part of the second season, when the upper three-fourths of the system had just transplanted and the remainder was six days away from getting its staggered water delivery turn, the water supply was still inadequate to serve the entire system by continuous flow. B2 had just transplanted his padi and the fields were already dry again and the soil was cracking. At night he blocked channel C to borrow water, he said, for only two hours. But after only one-half an hour Sulawa arrived, saw the arrangement, dismantled it, and said that B2's water supply would be cut off. At the time he didn't say for how long. B2 referred to the additional intakes Sulawa was frequently using (at Bl and CD and this only further angered Sulawa and he cut off channel B above B2's intake, so that it was rerouted through the last row of terraces in his own field just about where it turned at the corner of his field. He had it drain back out partly into plot B3 and partly into channel B

where it was too low for B2 to get water. However the flow to lower-enders was not disrupted. With this added water supply B3 decided to make three new terraces. However the water supply proved not to be enough to plant that season.

Sulawa said that the sanction of closing off all water to B2 was applied because he had altered the water distribution in his favor "too many times." It was not said that he stole water once or a certain number of times but that he took water "too many times," implying that what was wrong was that the give-and-take had gotten too far out of balance, not that a formal rule had been broken. Sulawa, like Maning and the other water users, did not speak in categorical or absolute terms when refering to formal rules. Improper behavior was seen not so much as a breach of a formal rule but rather as a pattern of excessive, self-interested actions which either disrupted the mutuality among users or else which could not be justified by any recognized criteria for needing more water. It was only when the baku tarik (give-and-take) got so far out of balance and the health of the padi of some fields were threatened by water stress that formal sanctions would be considered. (And yet of course it was ironic that in this case the one imposing the heavy sanction was generally recognized as a more blatant abuser of informal subak borrowing practices than was B3.) Furthermore, sanctions were supposed to be assigned by the group, not just by one of the officers.

Over the next twelve days the kfipala. desa. (village head) tried to summon Sulawa to his house three times, but without success. Sulawa remained adamant and after three weeks without any water, B3 arranged with sympathetic channel A users to have a temporary intake ditch made to supply water for occasional soakings from channel A. This arrangement lasted through the season despite Sulawa ruining two terraces of padi in his own field as a result of having too much water in them all season, due to channel B being redirected through his field. One month before harvest the members of the subak finally formally relieved Sulawa of his position and made Maning the new head. The change however, did not take effect until the following season.

Plot B6 was the first to request and use channel B, as an extension from where it originally had just reached plots B2 and B3. Plots B5 and B7 also began terracing after the channel was extended. Relations between these original upper-enders and the new lower-enders typically were casual and tension between the two were generally avoided by Bff's practice of tending to prefer either to borrow water at the B/C channel division point or to borrow from B5 or B7. One morning during the early part of the first season observed I met B2 at his intake while he was checking the channel just below his intake. When he saw me he asked how B6's water supply was, demonstrating an air of concern about the fields of those from whom he was borrowing, apparently in order to justify himself. Again the implication was that unilateral borrowing was permissible without negotiating as long as it was mutual or the field of the other wasn't dry. If it were dry, then an explicit arrangement should be made to rotate, in theory. As long as the water supply permitted informal borrowing from fields that mutually had standing water, then negotiating wasn't thought to be necessary. However B2 had not bothered to inspect B6 or seek permission first before borrowing the water.

Some thought about the conditions of other fields sometimes may pass through the minds of those borrowing water. Informants and personal observation told me that such considerations may invoke some deference from the borrowers about how or where to tend to take extra water. But they are not very central to the question of how often to take extra water. When it comes to the question of whether or not, or when, to take extra water, the condition of one's own plot and the need to avoid water stress are the main considerations. As three farmers told me one day, farmers generally don't care about, or give attention to, the soil types or water needs or availabilities of others when they decide to seek additional water. The soil and water conditions of their own plot is foremost in their minds, the farmers told me. However, this was not an entirely ego-centered orientation. The fanners were concerned with presenting themselves legitimately before their field neighbors and did so when discussing water allocation among themselves. When direct negotiating is necessary in order to obtain extra water (perhaps because of the presence of others in their fields or the existence of a more rigid rotational arrangement), they consider not only the merits of their own need for extra water but also how valid the immediate request appears to others involved. Frequent borrowers are testing the toleration of others and are quick to point out their reasons for needing to borrow water often.

The lower-enders of channel B frequently borrowed water from among themselves since they all three still were making new terraces. Since they were immediate field neighbors and saw each other more often than others further up channel, and since they were mutually in a vulnerable situation, they tended to negotiate often together and make explicit arrangements for borrowing water. As one fanner put it, "You've got to be careful with those who border your fields, because it would not be very pleasant to have to keep seeing them while you work in your field if you had a dispute with them."

1.3 Channel C, D, and E

Channel C, with its short off-take channels of D and E, comprises the longest channel in the system and the one with the most plots which most often run dry. The two unusually dry seasons in 1982-83 prompted tensions and coordinated efforts which hadn't been experienced before, along the channel. For instance before this time, C4 was content to get by with water supplied only from drainage and groundwater recharge from plots

B3 and C5. At the outset of the second season C4 decided to pay the seasonal water fee so that he would have the right to his own intake. He then built a channel extending from channel C, between plots B3 and C5, to his plot. He mentioned that this was necessary not only because of the dry weather but also because of the gradual increase in the number of ways in which water was being divided, due to the growth of the system. He was thus both reacting to and adding to this phenomenon.

There was a high rate of conveyance loss along the short stretch of channel D, since it was near the ravine. While plots D2 and D3 experienced many days in both seasons without standing water in much of their fields, there was a marked difference in plot D3, which had extensive cracking and several terraces with dying padi. The condition in plot D3 was even slightly worse than that in plots C8, C9, and C10. D3 often would borrow from D2 or Dl by shutting their intakes and making holes under the channel side of their temuku. Sometimes this worked both ways, since I occasionally saw holes under both sides of the temuku. Dl and D2 also borrowed water from D3, feeling that at least they had a right to an occasional soaking, despite D3's condition.

One day after D2 had just soaked his dry fields, I saw him closing up his own intake with mud. He said that he had gotten enough water, under the circumstances, and that plot D3 was dry. I then met the owner of plot D3, Pak Wena, who said that the day before, in the morning, he had made a hole underneath the channel

D terouku at the C/D division point. But within two hours lower-enders of channel C had come up and shut the hole. If he didn't contact the other users of channel C his borrowing arrangement would often be dismantled before it had made a difference. During the second season, D2 and D3 said that nearly every day during the reproductive phase, someone from below (mostly C7, C8, and C9, but also C6 and El) shut the flow of water to channel D. They complained about how much time they had to spend coming to the field just to check the water division. On one occasion, D3 said that in the evening he was going to shut Cl's intake. He said that he was taking turns shutting M6's, M1's, or someone else's intakes on different nights, so as to spread out the burden of his borrowing. But if those up channel also had dry fields, they were less willing to agree to borrow with him than were fellow lower-enders who had dry fields.

On one occasion he met and asked the owner of plot C4 if he could borrow water from him by temporarily closing his intake. The owner refused, saying that most of his own field was dry, (which it was). It was understood that D3 had no direct way of reciprocating with C4 since to add to C4's supply would decrease the supply of not just D3 but of all of those below C4 along channel C. Often it was easier for the three users of channel D to make an agreement with the lower-enders of channel C to rotate water. Direct arrangements with individual plots up channel generally were not adequate by themselves for a group

of lower-enders. It was difficult for lower-enders to reciprocate and upper-enders often were reluctant to agree unless their own plots at least had water flowing through the terraces.

At the lower portion of channel C, borrowing among immediate neighbors was frequent, especially between C6 and El but more especially between C7, C8 and C9. Plots C7 and C8 were operated by brothers. During land preparation each field would take the water of the other for a full day and plow and harrow three or four terraces. The next day the water went to the neighbor. During the first season, given the water shortage, the relationship between C7 and C8 on the one hand, and C9, became strained, as there often was hardly enough water to flow past C7's and C8's intakes, if they received any at all. C9 felt that C8 received more water than he did. All he (C9) obtained was "just drainage."

So C9 built a channel to his plot from channel C, just where it turned the corner at the bottom of plot C6. It ran along the right edge of plot C7, just to the left of a small ravine, which was owned by the owner of plot B7. C7 and C8 agreed to the new channel but B7 complained because he felt that the infiltration from the new channel would contribute to waterlogging in his sawah rawah (deep water, or marshy rice fields) in the ravine. Nevertheless he deferred to C9, whose need apparently was more important. Thereafter C7 stopped draining to C9 and directed his drainage to C8, his brother's field. This was because C9 now got his water above C7's intake. Under this conception C9 no longer had a right to C7's drainage since C9 now was drawing his water up channel from C7, due to the new field channel. This rather unusual circumstance illuminated the underlying notion that access rights to drainage are for those whose intakes are below the intakes of the one who is draining, regardless of whether or not the plot itself is below the plots of the one who is draining.

The few new terraces comprising plot CIO were not constructed until the second season and the operator relied only on drainage from above for his supply and the efforts of C7, C8, and C9, the more experienced members of the subak, to expend the energy to try and borrow water as much as possible, draining it his way. They frequently went up, mornings or evenings, to borrow water. Borrowing from top-enders often was done without immediate prior discussion. Borrowing from those who were closer was more likely to involve verbal communication. One day during the vegetative growth phase in the second season, I met the owner of plot C9 just after he had gone up channel to borrow water. He had shut full the intakes of plots M6 and Cl, but had shut the intakes of channel D and plot Dl only by three-fourths. He said that this was because he talked to Dl about it first and agreed that the shortage of water to channel D was serious as well, certainly more so than that of plots M6 and £1, which were higher up in the system. The proximity, greater frequency of reciprocity between these farmers, and the obvious serious water shortage

at channel D all combined to invoke greater discretion in borrowing from channel D users, as opposed to when borrowing from M6, Cl, or others further up the channel.

2 Discord and Deference in Werdi Agung

2.1 Channels A and B[3]

There was a conflict which developed between A6 and A7. A6 and A7 made sawah in 1971 and received water from drainage, groundwater, and the marsh on the left. The marsh had a lot more water in it before 1976, when the government canal was built. In 1977 they tried to make a branjong (small brush and stone weir) across the marsh but it soon washed out and the marsh became too deep. Then they built a channel through A5 to bring water to A6 and help drain it past A5. This helped A6 more than A7, although water was usually just enough for A7 until the dry years of 1981-83. Tension between the two increased when some young cattle belonging to A7 (which were too small to be strung from the nose) happened to eat some of A6's padi. A6 arrived and chased them all the way up to the main canal, with A7 following behind to get his cattle back. While this incident didn't cause

[3]The reader may refer to Figure A5-2 for the location of plot and channel codes.

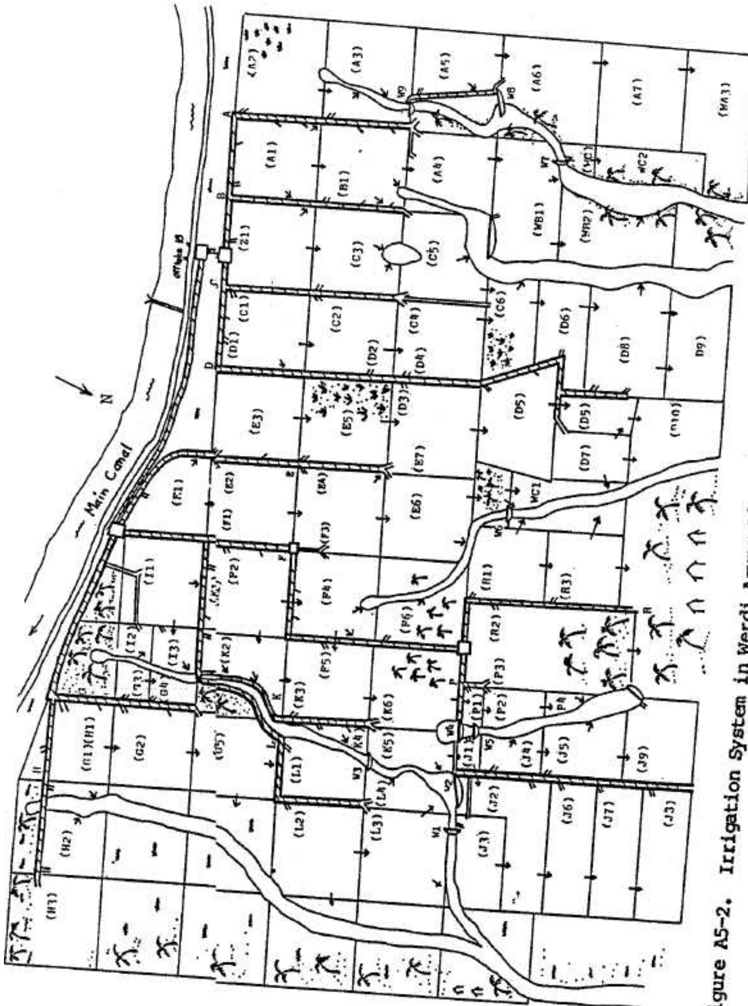


Figure A5-2. Irrigation System in Werdi Agung After Incorporation Into Kosinggolan Scheme

a water dispute, it heightened tensions and gave A6 cause to feel begrudging towards A7.

During the recent dry seasons, A6 drained water into the depression or gully on the left, instead of down to A7. A7 had three large terraces which didn't get planted, he said, because of not getting the drainage from A6 to which he felt he had a right. (This water, as it was being drained, was not reused below.) In an argument, A6 told A7 that he would drain water to him only if there was an excess, indicating that in order to be obligated to drain water to him (which might not be as easy to do as just let it drain into the gully), there would have to be a significant excess. A7 thought that this was a lame excuse and that A6 was exaggerating the lack of excess water. Finally A7 petitioned that a channel be built extending down to his boundary. The head of the subak agreed that he had a right to this, given the water shortage, even if it meant using up even more of A6's land, which was already partly taken up by the gully. A6 refused to permit extension of the channel on grounds that it would use up too much of his land, which was already partly used up by the gully, and that A7 usually received enough water from drainage under normal conditions anyway. The head of the subak reasserted A7's right to a direct link with a channel however and he threatened to cut off A6's channel intake if he did not grant right-of-way to the new channel. However, the threat lacked force because A5 needed the channel also, for drainage, and A6 usually got substantial amounts of groundwater and direct drainage even without direct access to the channel. The issue was at an impasse through the second season observed.

2.2 Channels C and D

C4 usually borrowed at the C/D division point or Cl's intake. C5 and C6, who had soils with somewhat lower infiltration rates, tended to rely on C4 to bring more water their way (as free riders), since C4 needed to borrow more often than they did and he usually did so up channel. However C4 and C5 often shut the intakes of C2 and C3, usually directing water to both C4 and C5 at once. In turn C2 and C3 most often added water by blocking the channel just below their own intakes. Only occasionally did they shut Cl's intake, who they knew had the highest infiltration rates of them all. according to C3, he borrowed water about ten times during the June-September season. His neighbor, C2, borrowed water about twenty times, due to his slightly higher infiltration rates, he said. The main concern expressed by C2 and C3 about the water allocation relations was that the teenage children of C4 and C5 so often made holes underneath the channel temuku at their intakes (rather than just shutting their intakes with mud), making *it* bothersome to have to keep repairing them.

Toward the onset of the reproductive phase, when the water supply was short (during the December-March season), Cl blocked

channel C for about twenty-four hours, until C3 arrived and changed the arrangement to his advantage. "We're taking water turns now," C3 told me at the time, although he indicated that no set arrangement formally had been negotiated. Farmers here also generally only negotiate directly if they happen to meet others in the field or if a prolonged rotation on a scale above the quarter nary level is to be recommended. If they come to the field alone and see a borrowing arrangement in place which adversely effects them, they would be likely to readjust it back to the standard division or even alter the division in their favor, if their own plots were dry. But often this would not be without some rough estimating of how long his neighbor had had a turn, perhaps leaving it alone for awhile if it appeared to have been just arranged. These farmers said that they usually did not get very mad at each other over water borrowing, although they occasionally became irritated temporarily. Deliberations were infrequent due to the cumbersome efforts that would be necessary, and not easily agreed upon, to schedule frequent alterations in the standard division of water.

There seems to be more potential for serious tension to flare up during periods of water shortage when formal arrangements have been set up and then breached, than when someone is excessive in borrowing water during the regular giving and taking of water supplements. The former situation may invoke a fight, the latter, only complaints. Also, under abnormal conditions customary both of ragie borrowing "alliances" easily can break down. For example, plots C2 and C3 commonly borrowed from each other or often arranged to borrow together from others (especially from plots down channel). Lower-enders often borrowed from both *of* them together. However, once during an explicitly arranged rotation along channel C a conflict arose when a rotation arrangement set the two plots at odds £ach water fcurn tfag given to two pIots. c2 was raatched with cl for fche rotation/ instead of with C3 this permitted Cl's drainage to C2 (if there were any) to be a part of C2's supply during the turn. C2 slept in his field the night of the turn. In the night he woke up and noticed the water had stopped running in the channel. He went up and saw a piece of wood blocking channel C above, with the water being redirected through plot Zl to plot C3. Later when he met C3 he confronted him about it and threatened to hit him with a hoe.

Occasionally channels C and D rotate or stagger water deliveries, as a block, with channels A and B. During the December-March season they staggered deliveries during land preparation and rotated to individual plots within each block. But later in the season, during and after the reproductive stage, channel C users all proposed rotation with channels A and B. Channel A and B users refused since their water supply was more adequate than that of channels C and D (this was so partly because of a design fault At the division box and partly because of the physical reasons mentioned above). So the channel C plots rotated among themselves every twelve hours, for about two weeks.

2.3 Channel E

Both the right and left sections of the system also occasionally staggered or rotated water deliveries, usually only at land preparation. During the June-September season Pak Mustika, the subak secretary (and owner of plot E4), closed the offtake to the right-side section three times. He did the same thing five times early in the even drier December-March season. These actions were taken after the plots in the right section already had been transplanted but while plots in the left section were still preparing land. Such borrowings were only for a few hours or sometimes over night, each time. Sometimes Zl closed the right section offtake after all those in the section had transplanted and when the left side was short of water.

A three-hundred-meter channel conveys water to the left section where it is divided into three directions at the left section division box. This was a point of frequent altering due to what the farmers said was a faulty design feature which sent too much flow down channel F and too little down channels E and especially G/H. Channel E has seven users. All but El at the top receive a neighbor's drainage.

There had been some tension between E6 and E7 over the issue of rights of access to their neighbors drainage. When they constructed their sawah, E6 paid for a bulldozer to help level his land. This helped his soils become tightly compacted. E7 levelled his land with draft cattle. Channel neighbors said that this was the main reason that E6 had much lower infiltration rates than E7. Nevertheless E6 demanded the right to receive all of his upper neighbor's drainage, just like E7 had a right to all of his upper neighbor's drainage. However because E7 often experienced water shortage and because of the pronounced difference in infiltration rates between E6 and E7, he formally requested and received access to part of E4's drainage, by way of a hollow log tunnel under the channel. This effectively denied much of E4's drainage to E6. While both E4 and E7 thought that the infiltration inequality was a valid criteria for gaining rights to an additional supply of drainage water, E6 disagreed. E4 and E7 prevailed partly because E4 was the subak secretary and because it would have been too brazen for E6 to have destroyed the tunnel which was lodged on the property of two of his neighbors.

Those who most frequently borrowed water were plots E3, E5, and E7, those along the right side of the channel. According to farmers these three had the highest infiltration rates. According to E4, water was temporarily borrowed by one or more of the three nearly daily. Sometimes it was borrowed for only two to four hours. Sometimes the borrowing arrangement is left until another farmer arrives to change it. All fanners are

expected regularly to inspect their own plots themselves so as to help make sure the borrowing doesn't become too one-sided.

According to E7, he borrowed water about three times a week, usually at nights and without getting explicit permission. Often he shut the intakes of upper-enders by about fifty percent and sometimes shut channel F to add to channel E. He said that he preferred to borrow from lower-enders, rather than from top-enders, when this would suffice. This was done either by enlarging his own intake or by blocking the channel just below it. He preferred to borrow water in this way because, as he said, the lower-enders also often borrowed water (meaning that they also depended on reciprocity with him). Also they happened to be more often in the fields than did the upperenders, so E7 could more easily talk to them about borrowing water. He said that the upper-enders less often borrowed water (implying that they would feel less beholden to him if he wanted to borrow water from them). He also said that the upper-enders were less often in their fields and he did not want to take water from them very often because someday they would arrive and catch him doing it and assume he was always doing it. He would be too embarrassed if this happened, he said. E3 and E5 usually borrowed water at their own intakes.

E4, who is at the middle of the channel, also preferred to borrow water from lower-enders, unless he "needed a lot." During season two, after about one month after transplanting, he said he had already borrowed water more than eleven times (including during land preparation) because of the water shortage. He said that he usually borrowed water only two or three times per season of normal water adequacy, this being perhaps at land preparation and transplanting or reproductive stages. Usually he said, borrowing was done freely and without the need to negotiate directly, due to the common understandings about each other's excuses and needs for borrowing and due to the patterns which had developed over several seasons.

Top-enders El and E3 were also recognized as having high infiltration rates. Nevertheless since they were at the top end they were more prone to negotiate before borrowing, according to E4. E6, who is known to have the lowest infiltration rates along the channel, also was more prone to negotiate directly (i.e. get verbal permission) before borrowing water, than were others like E3, E5, or E7—who had more obvious and compelling excuses to borrow. The latter had less need to keep reasserting the rhetoric of valid criteria for borrowing because of the climate of expectations which had developed. When those without visible excuses to regularly borrow water wanted to borrow, they would tend to feel more compelled than the others to need to negotiate directly in order to avoid rasa, main (embarrassment) and obtain some tolerance from those from whom he or she would borrow.

2.4 Channels K and L

The offtake to channel F sends water down channel F to where it branches off to the left, to channels K and L. At the bottom, channel F branches into two short channels, P and K. Channel P enters a small pond which provides some of channel J's supply, to the left.

Channel K serves six plots, all of which have low infiltration rates, except for K2 and some terraces of K4 and K5 which are next to the small gully, which have medium rates. K4 and K5 were relatively frequent borrowers, because of their higher water loss rates, due to the gully. However Kl also was a frequent borrower whose behavior was not explained by his channel neighbors other than that he "didn't want to be governed." Kl frequently opened up temporary intakes from channel K where it ran along the top of his plot. Interestingly though, it seemed to be a common practice to often open up temporary, additional intakes where channels ran along the top of a plot. This was the a case with plots Al, Cl, F4, H1, H2, and Kl.

Some tension periodically arose among the three users at the bottom (e.g., K4, K5, and K6). K6 felt that K5 too often stole water from him because of his higher infiltration rate. K6 told me once that although most of his plot usually got enough water just from drainage and groundwater recharge from above, he still had two terraces which relied solely on the channel for water. K5 just "didn't yet understand," said K6. Since K6 lived farther away it was hard for him to inspect his intake often enough and return the water to the standard division. He felt K5 should take this into account. K6 said that he himself only borrowed from upper-enders if their fields were already watered. During the December-March season K4 began making two new terraces and so borrowed water more frequently than usual. In order to help diffuse tensions among the three lower-enders, K4 arranged to have a substantial amount of K3's drainage redirected to his own plot (via a wooden aquaduct) and began borrowing water from higher up channel. In this case the shift to seeking extra water from upper-enders or from the channel division point, relocated the lines of water conflict to more distant users and included his immediate lower-end neighbors as the benefactors.

Despite tensions which arose over what was perceived to be occasional excessive borrowing by some (e.g. K5 and Kl), expectations about who among them had valid reasons to borrow more or less often were commonly understood. K6 had the least reason to need to borrow water, because of the substantial drainage and groundwater recharge he received. Because of these common expectations among his neighbors he was reported to be most likely to negotiate before borrowing water. My informant in this case, who was the subak secretary, said there was a tendency among farmers whereby those who borrowed the most were the least likely to bother to negotiate first. Those who borrowed the least were the most likely to negotiate before borrowing. This was

because of the visible, physical circumstances which created their need for either frequent or occasional borrowing. Those without recognized excuses to need water supplements would be more inclined to negotiate before borrowing.

If channel neighbors had developed common understandings about what were the conditions and accepted criteria for access to water supplements among the group, then the more frequent borrowers could rely on their visible or recognized excuses without having to negotiate as often. Farmers along these short quarternary channels often said, regarding water borrowing."<u>semua sudah sadar</u>" (i.e. everyone already understands). Those who did not have visible or recognized excuses for regularly needing to borrow water would feel malli (embarrassed) to borrow water and so were more inclined to negotiate or make explicit agreements with fellow users, when taking exception to the pattern of expectations. The personal encounter was an attempt to invoke some deference, which might not otherwise be granted.

Channel L irrigates four plots and gets its water from drainage from upper plots which collects in a natural depression. Its users requested from channel K the right of access to drainage water from channel K, when there was excess water available. Channel K users agreed, but during the relatively dry two seasons observed an offtake from channel K to channel L was seldom open. And yet the water adequacy generally was better in channel L than in the lower portion of channel K. Relations among the four channel L users was relatively stable, without considerable channel altering activity being observed. However, a conflict had at least once arisen between fanners at L3 and L4, over L3's unwillingness to let L4 borrow water as much as he wanted to. *IA* had a few terraces with high infiltration rates next to the small gully running through his field. L4 chased L3 away one day when the latter tried to restore L4's intake back to the official or standard division. The owner of L4, who was also the owner of plot K5 (both being parts of the same field which are separated by the gully), was felt by channel neighbors to be rather hot-tempered and unreasonable. This case was similar to the relation between plots K5 and K6, where conflict developed between the two bottom-enders. One of them exaggerated the amount of drainage and groundwater available to the other and emphasized his much higher infiltration rates.

2.5 Channels F, P, R, and J

Along channel F only F4 and F6 have channel F as their main, permanent water source. They have relatively low infiltration rates and borrow water rarely. Other plots occasionally opened up temporary intakes for borrowing. However during the second season F4 began using channel F to make new inferences on the left side of his field which couldn't be reached by channel E5 because of a small ravine in his field. Plot K3 occasionally opened up temporary intakes for the lower right portion of his field (F5)

due in part to an elevated terrace which was difficult to irrigate from channel K. Finally he got official permission from the subak authorities to have a permanent aquaduct over channel F to direct F4's drainage to the terrace. F6 was already getting enough drainage and channel water for his small plot without needing much from F4. This permission meant that the aquaduct could only be removed by F5, the receiver. F4 also was granted personal drainage rights from F2 (meaning that instead of it draining into the channel it was drained across it exclusively to plot F4). This helped ensure a stable supply, ensuring drainage to F5. The use of these aquaducts also were meant to help prevent excessive tapping of channel F water which was originally intended to supply water for plots at the bottom, along channels P and R.

The lower-enders generally received adequate water supplies, partly because of direct drainage, groundwater recharge, and some small diversions of collected water in the depression on the right and left sides of the channel. Since these plots were officially outside of the subak and since they weren't highly dependent on the channel alone, as with upper-enders of the channel, they neglected to help clean channel F with the upper-enders. The upper-enders complained that sometimes due to the weedy channel, drainage was inhibited. P1 said he never borrowed or even negotiated to borrow water from channel F plots above because they wouldn't give it. If the water were short at his plot then it was also short above, he said. They knew he obtained most of his water from drainage and seepage and that he only partly or occasionally needed water from the channel.

Regarding groundwater recharge, an interesting conception about rights to such water developed between Rl, R3 and WC1. WC1 had built a diversion weir over the small gully running through his plot. This was his primary but not only source of water, since he also received drainage from E6 above. However since he built the small diversion structure by himself, and since it was outside the subak boundary, he considered not only the structure but the water as his "own personal property." Since Rl and R3 asked for use of this empounded drainage water and since it had been nearly always more than enough for his own plot, WC1 permitted their use of it as long as there was at least enough for his own plot. If the water was either not enough for him, or just enough, he would deny access to the two petitioners.

However during the dry seasons in 1981-83, Rl and R3 were getting used to depending upon the water, since they were making new terraces and felt that they had a right to use it together with WC1, as long as they helped maintain the weir. WC1 was defensive about this and emphasized strongly that the water was pribadi (i.e., private or personal) and was his to oblige or not. He assumed that building the weir himself and being the first to use it, constituted valid criteria for claiming the weir and water as his own property. He said he would maintain

the prerogative to deny others access to the water if this should ever be needed to guarantee enough for his own use.

Channel P runs into two small ponds which were dammed up by the seven farmers which own plots along channel J. From the ponds the water then entered channel J. The two small earthen embankments were constructed to help irrigate these plots because the farmers perceived that water from channel F would not be enough. As a result, four lower terraces (about twenty square meters) in plot K5 became inundated with water. K5 wanted reimbursement for the land he said was no longer useable. The ponds helped irrigate 7.5 hectares and the seven users refused to agree to pay for the twenty square meters but they indicated a willingness to pay something. One of them somewhat insincerely asserted that if the two ponds were abolished then their fields would become marshy and they would have to demand reimbursement from K5. The controversy had still not been resolved during the period of this study. K5 occasionally chased away channel J users if they tried to weed or repair the embankments while he was present in his field. However, K5 was not bold enough to destroy the embankments altogether.

Channel J originally was built to serve both conveyance and drainage functions. Over time and with practice it was found that all of the plots except Jl, J2, and J3 received more water from surface and sub-surface drainage than from the channel. The bottom three plots usually didn't even need to use the channel. During the driest part of season two, the channel was closed below the *36* intake and the lower-enders did not directly use the channel at all. Upper-enders, who needed the channel more, used it and drained water to the lower-enders. This was the same logic as that of channel F users, where recharge at the bottom also was substantial. All of the users of channel J agreed that if they needed to borrow water, either by blocking upper intakes or by blocking the channel just below their own intakes, they should only block the intakes or channels up to fifty percent. According to two of the fanners (J5, J7), the farmers of the plots other than Jl, J2 and J3 generally only borrowed water when plowing or when restoring water after drying for weeding and they were more likely to negotiate before borrowing water, than were the more frequent borrowers.

2.6 Channels G and H

Frequent water borrowing occurred along these two channels. Plots Gl, H1, G3, and G4 have high seepage and percolation rates. Plots G2 and especially G5 have low rates. G3 and G4 have a small ravine running through them, as does H2. There is a half-bowl shaped terrain which directs drainage from plots Gl/Hl, G2, G3, and G4 into G5. However during water short conditions these upper plots generally have little water to drain because of the long channel with inadequate gradient which feeds them.

This is the least secure part of the system. G3 and G5 were recognized to be the most frequent borrowers, G3 because of the ravine and G5 because of being at the bottom and without substantial drainage or recharge. G4 also had high infiltration rates but the others in this group had allowed him a second intake because of having the ravine cut through his land. He also received drainage from G3. Therefore he did not need to regularly borrow water. Part of the reason for this tolerance to G4's extra intake was because G5 received some of his drainage. Staggering plowing dates was a regular seasonal practice among the seven farmers in this group. G5 said that he usually waited till the upper-plots were finished plowing before he started, so as to limit the commotion of too much borrowing back and forth.

The most frequent borrowers were along channel *G.* Under the dry conditions of the two seasons observed the frequency of borrowing from channel H caused frustration for H2 and H3. They often complained that Gl and others too often took water from them without asking. They recognized that most did not ask permission before borrowing but that rather than do it so much that it made the other plots go dry, they should be talking about it with the other farmers. Because of Gl's upper terraces being too high relative to the channel in order to get adequate flow (when the flow in the channel was below normal) he frequently made a hole under his intake temuku. This would cause a noticeable decrease in the flow down channel G and so G5 would often come up and put a hole under the channel side of this temuku. This would still suffice for Gl but it would no longer permit the water in the channel to rise enough to enter channel H, which was ten meters up channel from the Gl intake.

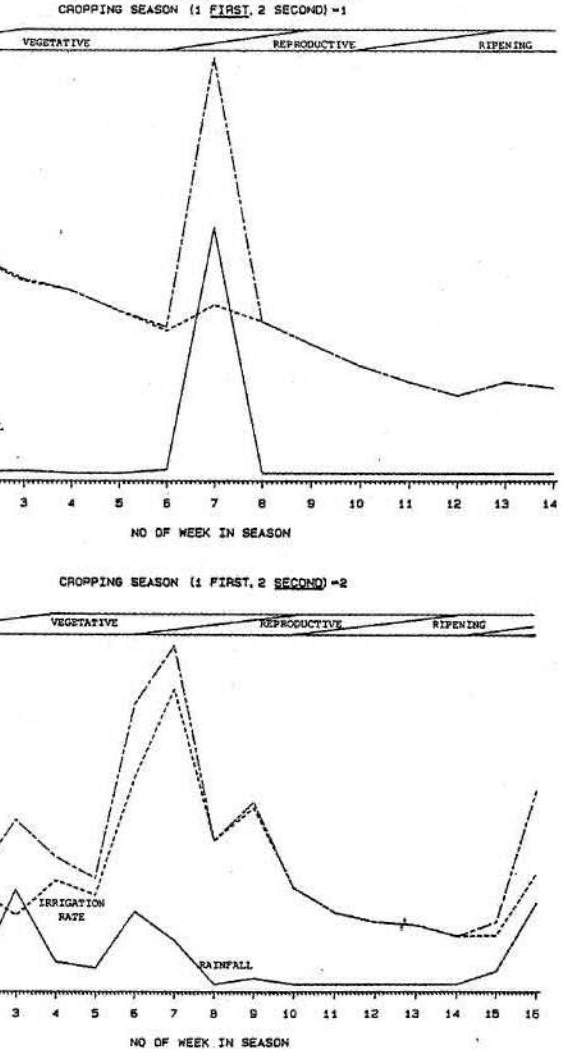
So with the onset of the June-September season, which was unusually dry, a tense pattern began where the holes would regularly be made and H2 or H3 would regularly fill them up again. One day I met H2 while he was filling up the holes with mud and sticks and he said he would fight G5 or Gl if he caught them doing it. After filling in the holes the water immediately rose and began entering channel H. Another morning I arrived again to see holes made under both the Gl intake temuku (the notched proportioning log) and the adjacent channel temuku. But this time H2 had removed entirely the intake temuku for channel H, in order to permit some flow into channel H.

Shortly thereafter Gl moved his intake up to be at the same division point as the intake to channel H (instead of ten meters below). A new farm ditch connected the new intake with the first terrace. This increased the head flowing into Gl without the need for a hole under the intake temuku. Such a change had not been made earlier because it was the dry weather that first brought the problem on. Thereafter borrowing usually was done with the use of only partial, instead of full, blocking.

Farmers at channels G and H also frequently went to the division box for channels E, F, and G/H. They would usually partially block the channel F offtake and this would raise the water entering both channels G/H and E. It was commonly recognized that the base of the channel F offtake was built too low, so as to cause too much water to enter channel F, whose farmers below were known to get supplies from drainage reuse anyway. Channel G/H had inadequate gradient at the top and was often not getting enough water. Channel E plots had very sandy soils. When the G/H farmers came to block channel F they rarely also blocked channel E, recognizing the need of channel E users for extra water also. In return, channel E users very rarely blocked channel G/H although they often blocked channel F.

APPENDIX THREE

TRWS and Water Distribution



Water Supply Components, Mopugad

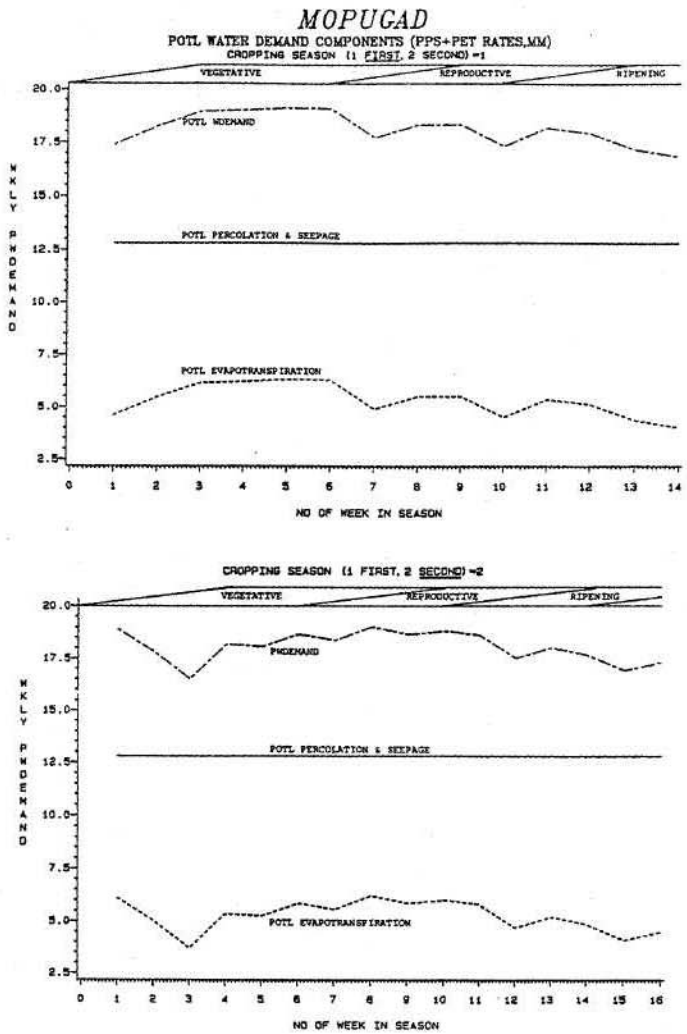


Figure A6-2. Potential Water Demand Components, Mopugad

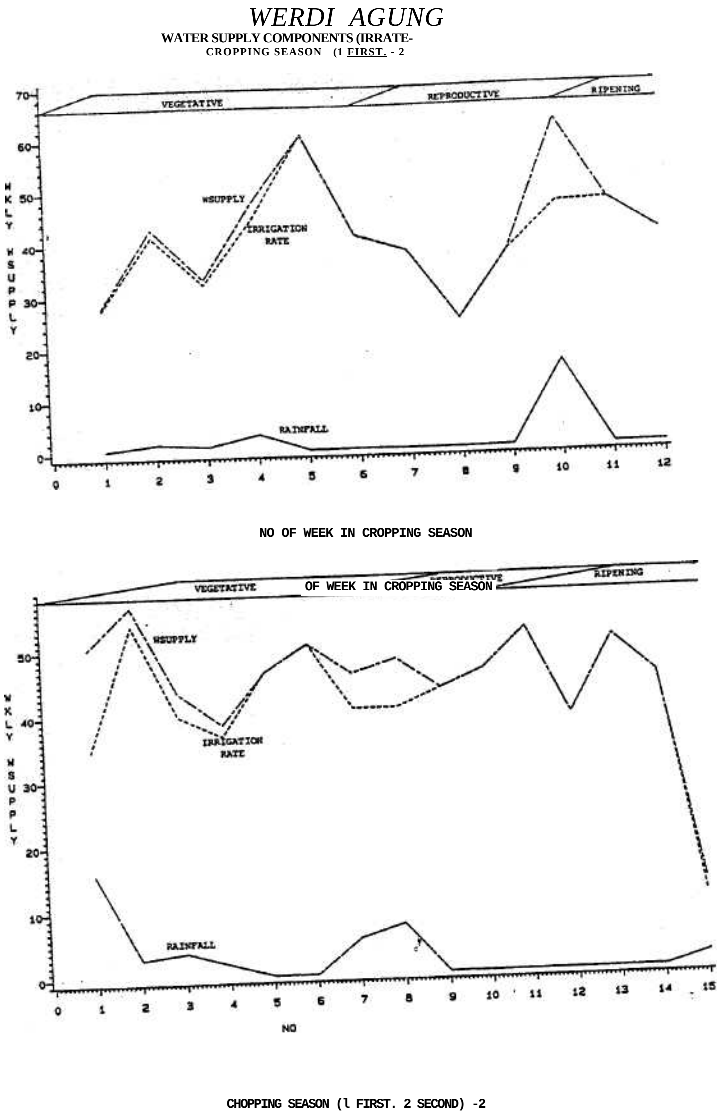


Figure A6-3. Water Supply Components, Werdi Agung

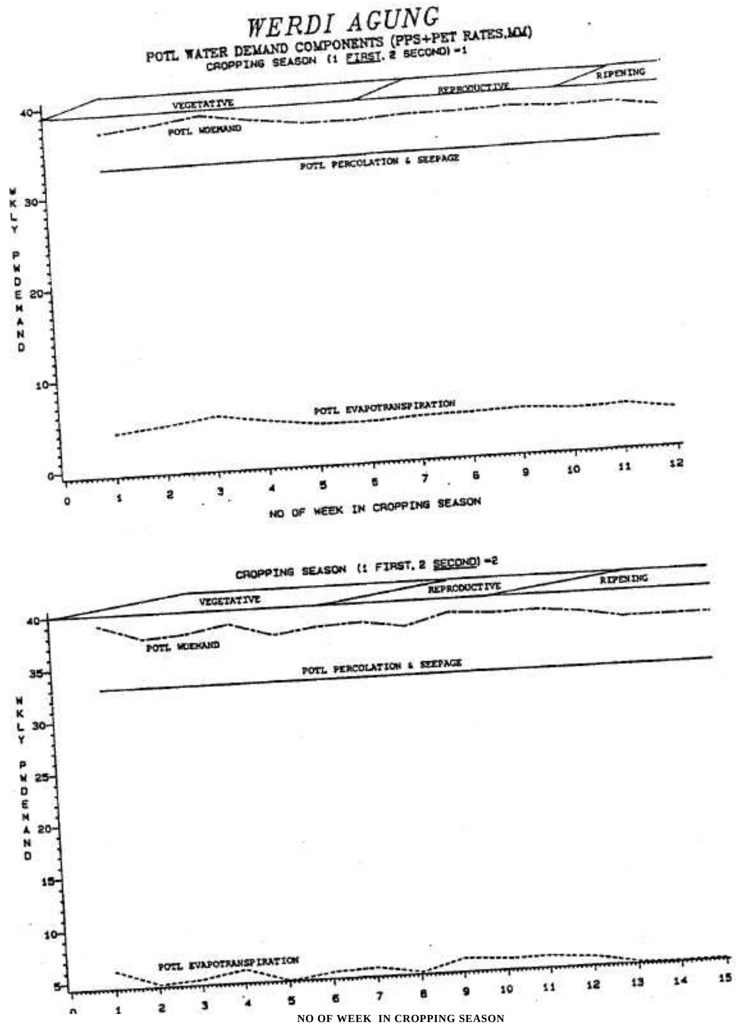
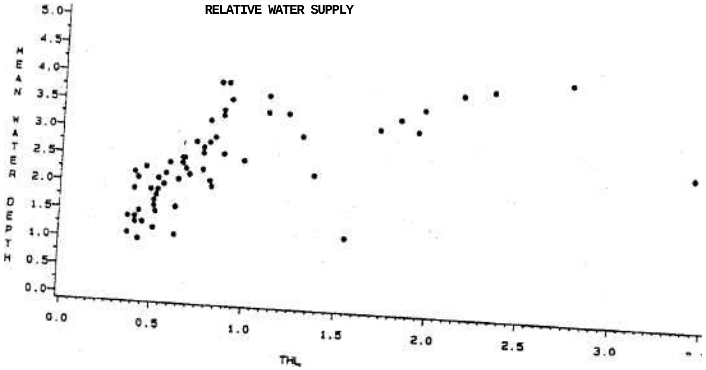


Figure A6-4. Potential Demand Components, Werdi Agung

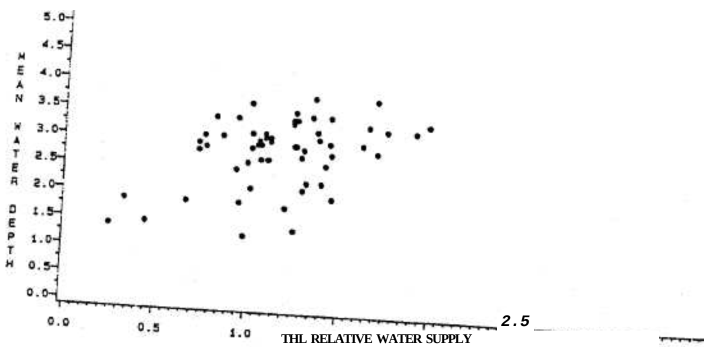
MQPUGAD

MEAN WATER DEPTH BY THE REL WATER SUPPLY
—OVER ALL OBSERVATION PLOTS—
RELATIVE WATER SUPPLY



WERDI AGUNG

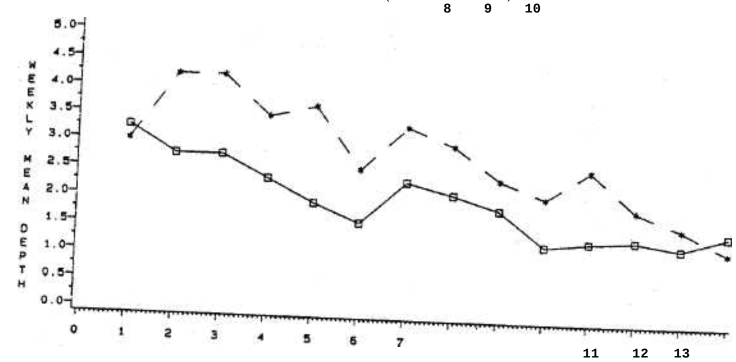
MEAN WATER DEPTH BY THL REL WATER SUPPLY —
OVER ALL OBSERVATION PLOTS—



of

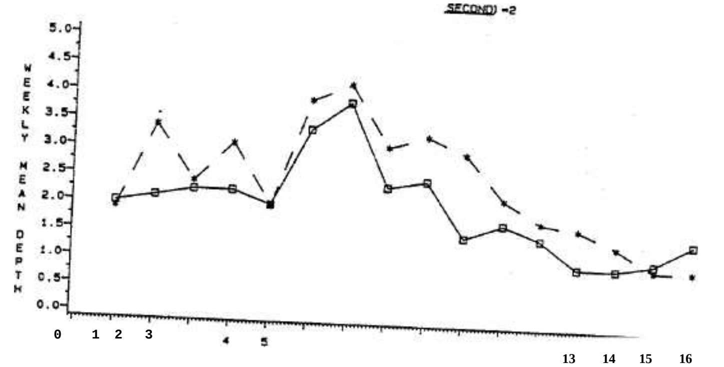
MOPUGAD

UPPER VS LOWER OBSV PLOTS WEEKLY MEAN WATER DEPTH
CROPPING SEASON (1 FIRST. 2 SECOND) -1



NO OF WEEK IN SEASON

LEGEND: POS ----



6 7 8 CHOPPING SEASON (1 FIRST.2
9 10 11 12

NO OF WEEK IN SEASON

LEGEND: POS

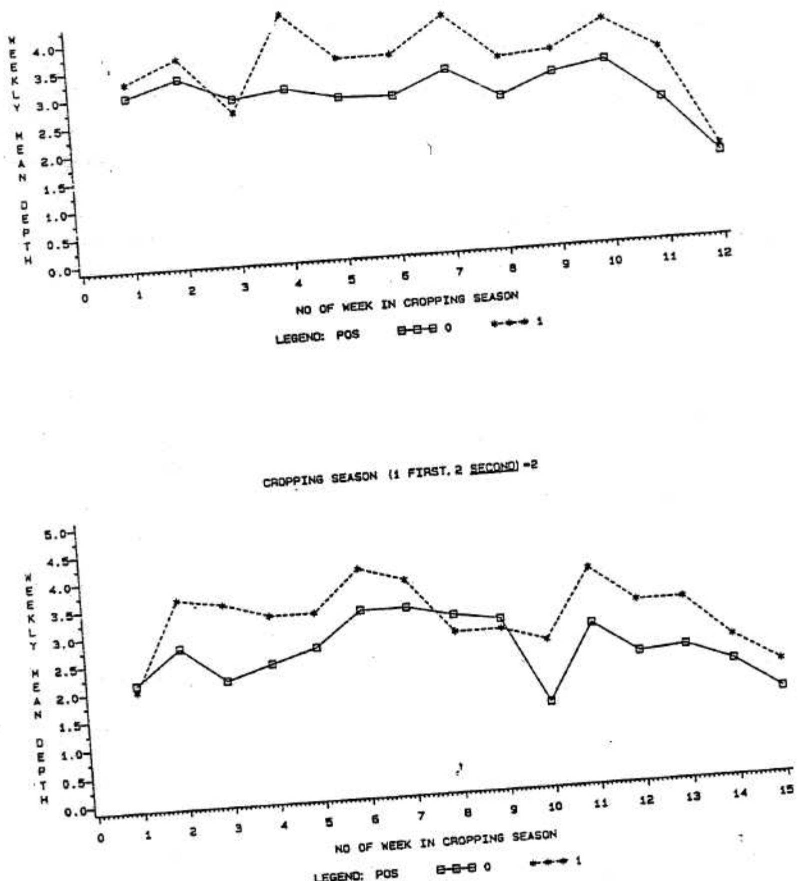


Figure A6-7. Weekly Mean Water Depth in Upper and Lower Observation Plots, Werdi Agung (in cm)

Table A6-1

Weekly Components of TRWS (mm/24 hrs)
Mopugad

First Season

Week*	Irri Rate	Rain	Water Supply	PS Rate	PET	Water Demand	TRWS
1	23.3	6.5	29.8	12.8	4.6	17.4	1.71
2	18.4	0.2	18.6	12.8	5.4	18.3	1.02
3	16.4	0.2	16.6	12.8	6.1	18.9	0.88
4	15.7	0	15.7	12.8	6.2	19.0	0.82
5	13.9	0	13.9	12.8	6.3	19.1	0.73
6	12.2	0.3	12.5	12.8	6.3	19.1	0.66
7	14.4	21.1	35.5	12.8	4.9	17.7	2.04
8	13.0	0	13.0	12.8	5.5	18.3	0.71
9	11.0	0	11.0	12.8	5.5	18.3	0.61
10	9.2	0	9.2	12.8	4.5	17.3	0.53
11	7.8	0	7.8	12.8	5.3	18.2	0.43
12	6.6	0	6.6	12.8	5.1	17.9	0.38
13	7.8	0	7.8	12.8	4.4	17.1	0.45
14	7.3	0	7.3	12.8	4.0	16.8	0.44

Second Season

Week*	Irri Rate	Rain	Water Supply	PS Rate	PET	Water Demand	TRWS
1	8.7	0.3	8.9	12.8	6.1	18.9	0.48
2	13.1	1.3	14.3	12.8	5.0	17.8	0.81
3	9.5	13.0	22.5	12.8	3.7	16.5	1.36
4	14.3	3.2	17.5	12.8	5.3	18.2	0.97
5	12.3	2.3	14.5	12.8	5.3	18.0	0.81
6	28.3	10.1	38.3	12.8	5.8	18.6	2.05
7	40.4	6.2	46.5	12.8	5.6	18.3	2.54
8	19.7	0	19.7	12.8	6.2	19.0	1.04
9	24.1	0.9	25.0	12.8	5.8	18.6	1.34
10	13.3	0	13.3	12.8	6.0	18.8	0.71
11	10.0	0	10.0	12.8	5.8	18.6	0.54
12	8.7	0	8.7	12.8	4.7	17.5	0.50
13	8.3	0	8.3	12.8	5.2	18.0	0.46
14	6.7	0	6.7	12.8	4.8	17.7	0.38
15	6.8	1.8	8.7	12.8	4.1	16.9	0.52
	[illegible]	[illegible]	26.6	12.8	4.5	17.3	1.54

gation
Percola
Potenti

Table A6-2

Weekly Components of TRWS (mm/24 hrs)
Werdi Agung

First Season

Week*	Irri Rate	Rain	Water Supply	PS Rate	PET	Water Demand	TRWS
1	27.5	0.5	28.0	33	4.0	37.0	0.76
2	41.2	1.6	42.8	33	4.6	37.6	1.14
3	32.0	1.0	33.0	33	5.3	38.4	0.87
4	44.5	3.1	47.7	33	4.5	37.5	1.28
5	60.6	0	60.6	33	3.9	36.9	1.65
6	40.9	0.2	41.1	33	3.8	36.8	1.12
7	37.9	0	37.9	33	4.1	37.1	1.02
8	24.7	0	24.7	33	4.2	37.2	0.67
9	37.6	0.2	37.8	33	4.3	37.3	1.01
10	46.5	16.2	62.6	33	4.0	37.0	1.69
11	46.8	0	46.8	33	4.2	37.2	1.26
12	40.6	0	40.6	33	3.4	36.4	1.12

Second Season

Week*	Irri Rate	Rain	Water Supply	PS Rate	PET	Water Demand	TRWS
1	34.7	15.7	50.4	33	6.0	39.0	1.29
2	53.8	2.8	56.7	33	4.6	37.6	1.50
3	39.8	3.7	43.5	33	4.9	37.9	1.15
4	36.6	1.85	38.4	33	5.6	38.7	1.00
5	46.4	0	46.4	33	4.4	37.4	1.24
6	50.6	0	50.6	33	5.0	38.0	1.33
7	40.6	5.4	46.0	33	5.2	38.2	1.21
8	40.6	7.4	48.0	33	4.5	37.5	1.28
9	43.4	0	43.4	33	5.6	38.7	1.12
10	46.2	0	46.2	33	5.4	38.4	1.20
11	52.3	0	52.3	33	5.5	38.5	1.36
12	38.9	0	38.9	33	5.2	38.2	1.02
13	50.7	0	50.7	33	4.5	37.5	1.35
14	44.9	0	44.9	33	4.5	37.5	1.20
15	10.7	2.0	12.7	33	4.5	37.5	0.34

*Full headings of columns are as follows: Week of Season, Irrigation Discharge Rate, Rainfall, Total Water Supply, Potential Percolation/Seepage Rate, Potential Evapotranspiration Rate, Total Water Supply, Theoretical Relative Water Supply.

Table A6-3

Observed Alterations in the Standard Division of Water at Channel Division Points
Mopugad

Division Location Ch1	Ch2	No. of Alts.	As % of All Alts.	% Gain at Ch1*	% Gain at Ch2*
A	M	39	3.9%	41.0%	59.0%
B	C	37	3.7	24.3	75.7
C	D	21	2.1	61.9	38.1
C	E	17	1.7	64.7	35.3
C	F	6	0.6	50.0	50.0

Total Alterations at Channel Division Points = 120

*These two columns are the percentage of alterations which were observed at the given channel division point which benefitted the respective channel (i.e., either Channel 1 or 2).

Table A6-4

Observed Alterations in the Standard Division of Water at Channel Division Points
Werdi Agung

Division Location			NO. of	As% of	% Gain	% Gain	% Gain
Chi	CbZ	Chi	Alts.	Ml ALfcfi	at Chi*	at Ch2*	at Ch3*
A	B		19	1.9%	57.9%	42.1%	
C	D		39	3.9	64.1	35.9	-
E	F	X	30	3.0	16.7	20.0	83.3
F	K		17	1.7	35.3	64.7	
G	H		13	1.3	46.1	53.8	-
I	X		9	0.9	22.2	77.8	-
K	L		10	1.0	80.0	20.0	-
P	R		8	0.8	50.0	50.0	-
KN	KR		4	0.4	50.0	50.0	-
AB	CD		6	0.6	33.3	66.7	

Total Alterations at Channel Division Points =155

*These three columns are the percentage of alterations which were observed at the given channel division point which benefitted the respective channel (i.e., either Channel JL or 2).

Table A6-5

Observed Alterations in the Standard Division of Water at Plot Intakes
Mopugad

Location	Number of Alterations	As % of All Alterations*	% of Alts. Which Benefitted Plot
Ml	41	4.9%	43.9%
M2	9	1.1	0
M3	14	1.7	78.6
M4	32	3.8	43.7
M5	30	3.6	33.0
M6	42	5.0	35.7
Al	60	7.2	36.7
A2	23	2.7	47.8
A2B	19	2.3	52.6
A3	0	0	0
Bl	67	8.0	77.6
B2	19	2.3	52.6
B3	33	3.9	39.4
B4	3	0.4	0
B5	13	1.6	53.8
B6	12	1.4	66.7
B7	0	0	0
Cl	74	8.9	58.1
C2	18	2.2	22.2
C3	10	1.2	40.0
C4	9	1.1	22.2
C5	18	2.2	27.8
Dl	36	4.3	52.8
D2	18	2.2	38.9
D3	0	0	0
C6	37	4.4	70.3
El	2	.2	100.0
C7	28	3.4	39.3
C8	44	5.3	75.0
C9	7	0.8	57.1

Total Number of Alterations at Plot Intakes = 834

♦Percentage of total of all observed alterations, both at channel and plot levels (n=954)

Table A6-6

Observed Alterations in the Standard Division of Water
at Plot Intakes
Werdi Agung

Location	Number of Alterations	As % of All Alterations*	% of Alts. Which Benefitted Plot
Z1	25	2.5%	40.0%
A1	16	1.6	68.7
A2	14	1.4	21.4
A3	10	1.0	70.0
A4	5	0.5	0
A5	18	1.8	22.2
A6	0	0	0
B1	26	2.6	73.1
C1	29	2.9	62.1
C2	20	2.0	35.0
C3	28	2.8	53.6
C4	17	1.7	35.3
C5	12	1.2	8.3
C6	1	0.1	0
D1	14	1.4	85.7
D2	4	0.4	100.0
[illegible]	[illegible]	[illegible]	0.0
[illegible]	[illegible]	0.5	80.0
D5	6	0.6	16.7
D6	13	1.3	61.5
D7	10	1.0	20.0
D8	24	2.4	50.0
E1	16	1.6	18.7
E2	36	3.6	36.1
E3	26	2.6	61.5
E4	14	1.5	14.3
E5	20	2.0	55.0
E6	1	0.1	0
E7	7	0.7	0
F1	10	1.0	80.0
F2	11	1.1	9.0
F3	18	1.8	55.5
F4	9	0.9	55.5
F5	21	2.1	52.4
F6	13	1.3	15.4
I1 (at F)	1	0.1	100.0
G1	40	4.0	42.5
G2	15	1.5	60.0
G3	10	1.0	70.0
G4	13	1.3	61.5
G5	2	0.2	100.0

Table A6-6, continued

Location	Number of Alterations	As % of All Alterations*	% of Alts. Which Benefitted Plot
H1	6	0.6	100.0
H2	23	2.3	39.1
H3	0	0	0
J1	1	0.1	100.0
J2	3	0.3	100.0
J3	5	0.4	60.0
J4	9	0.9	77.8
J5	24	2.4	33.3
J6	7	0.7	100.0
J7	3	0.3	100.0
J8	0	0	0
J9	0	0	0
K1	28	2.8	10.7
K2	17	1.7	64.7
K3	29	2.9	27.6
K4	5	0.5	60.0
K5	10	1.0	40.0
K6	4	0.4	25.0
K (at I3)	1	0.1	100.0
L1	6	0.6	16.7
L2	25	2.5	36.0
L3	5	0.5	0
L4	10	1.0	10.0
P1	23	2.3	0
P2	6	0.6	0
P3	1	0.1	0
R1	5	0.5	60.0
R2	5	0.5	20.0

Total Number of Alterations at Plot Intakes = 846

*Percentage of total of all observed alterations, both at channel and plot levels (n=1001)

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