4. THE ENVIRONMENT OF SMALLHOLDER IRRIGATION SCHEMES

4.1 General

In chapter 3 it has been suggested that conventional irrigation planning and management has been largely influenced by cybernetic systems concepts adopted from engineering approaches to infrastructural projects. Such concepts are basically "inward-looking", i.e. they are mainly focused on the subsystems within the system itself and on the functions which these subsystems are supposed to perform in order to adopt input-output relations to preconceived goal levels. The environment is mainly perceived in terms of input provision and output absorption. Such approaches implicitely assume that a clearly defined systems boundary exists between the system and the environment.

In line with such systems-thinking conventional irrigation planning with respect to the environment concentrates on the study of topography, soils, climate, hydrology and other determinants of input provision and considers market- and communication-characteristics with respect to the system's future outputs. People involved in and effected by the irrigation scheme are tended to be regarded either as "human production factors" within the organization and under its control or to be outside of the system and consequently not to be of direct concern. This means that socio economic and institutional factors of the environment are largely considered to be beyond the project's spere of influence - "outside of the system's boundaries" - and hence are either neglected or taken as given and uncontrollable facts.

HARRISS remarks with reference to this point:

> 'Some of those concerned in designing and running irrigation systems seem sometimes to have expected that irrigation systems should function rather like bits of machinery and produce certain outputs for given inputs of energy and have apparently failed thereby to take into account that some of the parts are people with different interests and different perceptions of the same situations. Several sets of social actors are commonly brought together in the irrigation "machine": farmers, administrators, engineers and politicians, all of them with different objectives.' 1)

The poor performance of many irrigation schemes especially in

---

1) HARRISS (1976) p. 1

Africa[1] has heightened the awareness that irrigation projects are more than infrastructural engineering works and that they have to be perceived in the context of a "social arena" [2] where people with different interest and expectations and subject to different institutional constraints interact and largely influence the achievement levels that can be reached.

Such considerations stress the "openness" of the irrigation system and point to the need for open systems concepts that have been described in chapter 2 and that take the dynamic, flexible and permeable nature of the boundary between the irrigation scheme and its environment into account.

SMITH et al adopt such an approach by subdividing the organisation's environment into three major levels[3] :

a) the "controlled" environment containing all those elements within boundaries that define the organization's own internal environment. The organization has more or less direct control over these elements.

b) the "influencable" environment consisting of entities external to the organization whose activities can influence organizational and management performance.

> ' Such entities have ongoing relationships with the focal organization; for example they provide inputs or receive outputs. The basis of the relationship is a source of mutual influence between the focal organization and the external entity.'[1]

The farmer and his family, water user groups, landlords, money lenders and credit institutions, input suppliers and marketing institutions, technical advisers and other government agencies all belong to this "influenceable" environment that is subject to the influence of an irrigation organization but outside of its full control.

c) the "appreciated" environment that includes institutions that effect project performance directly or indirectly but can neither be controlled nor influenced by the organization. This means that the organization can only respond to the impact of these

---

1) emphasized especially by the "Berg-report" of the World Bank
2) HARRISS (1976) p. 1
3) SMITH LETHAM and THOOLEN (1980) p. 9
4) ibid.

elements but not directly influence them, e.g. political, social, economic and cultural institutions of various kinds.

Such considerations imply the need for integrating, "outward looking" perspectives in irrigation planning and -management and hence an increased focus on local institutions.

With reference to MC.INERNY the term "institution" used in the following considerations is meant to embrace

'a variety of formal and informal human groups; behaviour patterns; social, legal and administrative systems; and established practices in social, political and economic activity that have an important bearing on the workings of rural societies.' 1)

The above mentioned perception of environmental "regions" beyond the managements direct control which however impinge on the projects performance, indicates that 'no amount of pre-planning, preparation or organization in project work can ensure that changes will follow a prescribed and desired pathway.' This requires that "self-learning processes" have to be built into the various project stages with a ' continuing reactive capacity .... to respond to changes as they occur.' 2)

Open systems approaches as suggested in chapter 2 may be able to consider such requirements in smallholder irrigation in a better way than cybernetic based approaches have done so far.
Given the limitations of space, the following sections will focus on only one - albeit crucically important - element of the above described partially influencable, partially only appreciable environment: the smallholder, his decision making behaviour, his potential objectives and the institutional constraints he faces in the context of irrigation systems.

4.2 The farmer's goals and decision making

In para 3.2.5.1 attention has been drawn to the fact, that farmer's objectives and decision making behaviour have been largely neglec-

---

1) MC INERY (1978) p. 17
2) ibid., p. ii

ted in irrigation planning till to the recent past.
The attemps made to account for farmer's reactions to irrigation have mostly concentrated either on descriptive studies of farmer's behaviour under location specific circumstances or on formalized prescriptive models aimed at optimization of allocative efficiency in water use or cropping patterns.

Concerning the farmer's actual decision making and the corresponding role of risk avoidance and profit maximization, perceptions in the 1960's and early 1970's were dominated by a largely inconclusive debate between "formalist" and "substantivist" schools of thought. Formalist approaches were based on the conceptualization of the farmer as a rational decision maker, who made his decisions independently of the circumstances in which he acted. Decision making analysis tried to formalize different concepts of optimizing decision behaviour. The most widely advocated of such concepts, the expected utility theorem assigns cardinal utility values to consequences of action in such a way that the expected utility of a certain action allows to rank it in comparison with other actions according to the individual's preferences.[1)]
However, such utility maximization theories that where based on concepts of probabilities, subjective expected utility and simple binary comparisons of alternative choices, have been opposed on various grounds. Substantivists e.g. argued that 'concepts as rationality and maximization are culture bound and distort the reality of non-Western, non-market economies... ' and substantivists 'define the economy as the process of material means provisioning for society and focus on the institutions that structure this process... '[2)]

In the course of the 1970's however, perspectives changed: substantivist perspectives joined largely with formal analysis in problem oriented research approaches that stressed that ' the decisision making environment includes the decisions made by others - the social environment of decisions'. [3)]

In the context of this enhanced awareness of the importance of social constraints and opportunities, BERRY argues, that the poten-

---

1) ROUMASSET (1976) pp 19/20
2) BARLETT (1980) p. 7
3) ibid., p.9

tial conflict between goals of profit and risk avoidance have been overstressed and that full and accurate consideration of the individual farmer's opportunity costs can sufficiently explain his choices and preferences. 1) While the importance but also the difficulties involved in measuring actual opportunity costs have been acknowledged, the underlying premise of maximization subject to constraints has been reflected in formalized concepts, such as lexicographic "safety-first"-models where profit maximization goals are subject to the prior satisfaction of safety constraints. If the constraint of risk avoidance is violated, then the decision maker's 'level of aspiration begins to adjust itself downward so that, unable to keep risk down to the acceptable level, he may, for example minimize risk' 2).

In accordance with such lines of thought on farmer decision making, BROMLEY specifies the following goal hierarchy to represent the lexicographic ordering of the small farmer's decision behaviour:

' a) assure survival - the <u>subsistence</u> goal
b) cautious optimizing - the <u>safety</u> goal
c) acquire cash for consumption and savings - the <u>surplus</u> goal
d) profit maximization - the <u>speculative</u> goal' 3)

The decision making process in the context of this lexicographic order, according to the above considerations, will be largely determined by the fact that 'some people's actions constitute other people's constraints' and that 'one cannot study individuals' behaviour in isolation - in the language of normal economic analysis, one cannot ignore externalities'. 4)

It is from this point of view that some aspects of the smallholders decision making behaviour in the context of irrigation schemes are examined in the following paragraphs.

---

1) BERRY (1980) p. 328
2) ROUMASSET (1976) p. 47
3) BROMLEY (1982) p. 37
4) BERRY (1980) p. 331

4.3 Irrigation and the environment of the smallholder

4.3.1 General

Studies undertaken by the International Rice Research Institute[1] have stressed that factors affecting farm level yields and hence farm production can be broken down into three set of variables: environmental factors outside human control, potentially controllable factors (difficult to influence for a farmer, but possible by action of groups or the society) and managerial (within the control of an individual farmer).

This means, that a perception of the farmer's environment may be adopted similar to the one suggested by SMITH et al. for the environment of organizations, which has been outlined above[2].

The important point is that the farmer has to face environmental factors which are only "influencable" or "appreciable" and which are beyond his full control and that he has to try to minimize such uncertainties if he is to achieve his individual goals.

The particular attractiveness of irrigation from this point of view is its potential to reduce climatic uncertainties, so that CARRUTHERS, as mentioned above, refers to it as a "low risk, high productivity system"[3]. However, irrigation, at the same time may increase another dimension of risk in the farmer's decision making environment: institutional uncertainty.[4]

Engaging in irrigation, the farmer is subject to various externalities: the upstream neighbours at the supply canals, the agency personnel managing the water distribution, the input suppliers, the extension works, the water user groups, the landlord etc., all re-

---

[1] quoted in ORAM (1980) p. 58

[2] see para 4.1

[3] CARRUTHERS (1982) p. 6

[4] The term "risk" is sometimes distinguished from "uncertainty", when the former is used to refer to situations in which the outcome is not certain, but where the probabilities of alternative outcomes are known or can be estimated, while with respect to the latter no such probabilities can be known (UPTON (1973)). However the terms are used interchangeably, in accordance with most of the literature.

duce the individual control of the farmer over his farm production system and all are potential sources of uncertainty over the fulfilment of institutional arrangements.
Given the multitude of interrelationships that charcterize the farmer's decision making in irrigation in the context of his institutional environment only some of the major considerations in relation to such interactions can shortly be discussed in the following.
Regarding the relationships between the smallholder's decision making and institutional conditions constraining him, the dynamic systems interactions outlined in chapter 2 have to be kept in mind.

4.3.2 Institutional uncertainty - a look at farming systems

Farming systems[1] in an area where no irrigated agriculture exists represent the organizational and technical momentary "best fit" solution in a dynamic process of systems adaption to environmental conditions - i.e. resource- and institutional constraints - and the farmers objectives. In practice such farming systems may comprise a great number of different subsystems. KORTENHORST e.g. refers to the Sudan Zone of West Africa, where one and the same farming system may include all of the following subsystems[2]:

Cropping system 1.	Family "farms", under the responsability of the head of the family, mainly for the production of staple food crops
Cropping system 2.	Cash crop "farms" of individual family members, usually men
Cropping system 3.	Special "women's fields" for kitchen and local-market crops; the market proceeds are for the women concerned
Cropping system 4.	Home-yard cropping, which - except perhaps for heavy soil preparation work (if applicable) - is usually looked after by the women and the aged family members
Livestock system 1.	Livestock keeping (in areas free of trypanosomiasis), with grazing mainly on communal

---

1) In the context of this discussion, the term "farming systems" is ment to include not only the farm production system, but all productive activities undertaken by the farmer and his family, including off-farm employment.

2) KORTENHORST (1980) p. 126

	village range grounds, often looked after by young boys
Livestock system 2.	Small livestock and poultry-keeping, in the home-yards
Collecting system 1.	Food gathering and hunting, on communal range grounds
Collecting system 2.	Fishing, in communal waters
Off-farm activity 1.	Home processing and handicrafts
Off-farm activity 2.	Petty trading, almost exclusively by women
Off-farm activity 3.	Seasonal or part-time wage-earning elsewhere" if outside the village, almost exclusively by men
Consumption system 1.	Household and family care (women)
Consumption system 2.	Homestead construction (men)
Consumption system 3.	Social and cultural activities '

The type, composition and importance of these subsystems reflect the corresponding constraints of the physical and institutional environment as well as the farmers aspirations in the framework of the above mentioned hierarchy of goals.

The introduction of irrigation in such a gradually developped and well balanced farming system set up represents a 'jump in technology' as RUTHENBERG[1] expresses it and a change in the systems balance which is particularly radical if irrigation is to replace the entire previous farm-production system: Physical interdependancies with other farmers by means of the distribution system require group-related instead of individual actions; highly diversified cropping- plus animal-husbandry systems, particularly suited to satisfy food security and safety goals are replaced by a few or even a single high value cash-crop; labour requirements, loosely timed and well spread out over the calendar year give way to rigid irrigation schedules and high peak-labour-requirements; low input demands and a close production consumption link are substituted by capital intensive "packages" of inputs and high sale of product ratios; generation-old expertise in farming practices has to be traded for unknown skills... The list indeed seems endless and it is needless to say that new ways of life will be asked for as well.

The question remains then whether or not this "jump in technology" can pay off for the smallholder and result in a corresponding leap in the hierarchy of his goals. Or whether a slow and gradual incorporation of irrigation into existing farming systems that allows for

---

[1] RUTHENBERG (1980) p. 179

a gradual systems adaption may be a more feasible and viable approach.

The crucial considerations from the point of view of the smallholder relate to his subsistence and safety goals.

One of the predominant features of traditional farming systems is that they minimize risk by means of diversification. Some of the risk spreading "design characteristics" of tropical farming systems are listed by RUTHENBERG:

> ' Diversification of production to grow a range of crops...; planting of a particular crop at different times over an extended period..; combination of different species in crop mixture; and the culture of small areas of especially reliable though non-preferred crop... '1)

Such practices respond to uncertainty that surrounds farming processes in the form of climatic variations, outbreaks of diseases and other random events and which are refered to as "technical uncertainty"2) or "ecological uncertainty". If one interprets the term "farming systems" in a wider sense, as is done in this context (see above), one has to be aware that the farmer spreads risk even further: to combine crop-production with animal-husbandry and to combine farming-activities with off-farm employment can be perveived as strategies partially aimed at risk minimization by diversification.

From this follows that the important question when looking for "appropriate" irrigation design is not whether either a farming system based approach or rigorously intensive cash-cropping would be preferable or viable. Irrigation planning for the smallholder based on the above considerations will have to ask, to what extend irrigation is bound to introduce new uncertainties into the farmer's decision making environment and to what extend such uncertainties may or may not be acceptable to the farmer and how they can be minimized in the context of the system design. One has to be aware of a potential partial substitutability between risk-spreading farming practices and risk.minimization by means of improved management control, a trade-off that has to be balanced within the total system context. Doing so, it is important to realize, that

> 'the relationship between the type of technology and institutions required is close and that financial and manpower constraints may

---

1) RUTHENBERG (1980) p.26
2) BROMLEY (1982) p. 30

prevent complex institutional arrangements.'[1)]
The crucical point is that "appropriate" irrigation has to be deviced such, that institutional uncertainties that go with it do not exacerbate the already uncertain economic environment in which the smallholder lives.

4.3.3 Institutional uncertainty - physical interdependencies

It is an unescapable characteristic of irrigation that it creates physical interdependencies between the farmers that are linked by a watercourse. Even potential exceptions from this rule - private tubewells - reveal to be subject to this rule in case of water-scarcity: interdependencies will then become evident through aquifer drawdowns that effect neighbouring farms and increase pumping costs.

The control an individual farmer can exert with respect to his access to water in a surface water system is usually a function of the number of other irrigators located upstream on the same watercourse as well as a question of his political and economic power. BROMLEY et al [2)] stress this point with the introduction of the term of "real location" as opposed to "nominal location" as an indicator of the degree of a farmer's relative access to water. They illustrate this by way of a schematic diagram as given in FIG.3.6 , representing an irrigation system consisting of the main canal, two laterals and some sublaterals. With unlined laterals and a lined main-canal, farmers in zone C, although roughly equidistant from the water source, would be less advantageously situated as farmers in zone E, since they may have to accept severe transport losses. Positions in zone D with respect to such losses would be more favourable, unless differential seepage losses due to varying soil conditions exist. The "nominal location" with respect to access to water indicates the widely discussed "tail-ender-problem", where irrigator A_1 would be most favourably, irrigator C_3 least favorably located if one assumes that the greater the number of irrigators upstream of a given location, the less advantageous the location.

---

1) NORMAN (1976) p. 185
2) BROMLEY, TAYLOR and PARKER (1980) ,p. 376

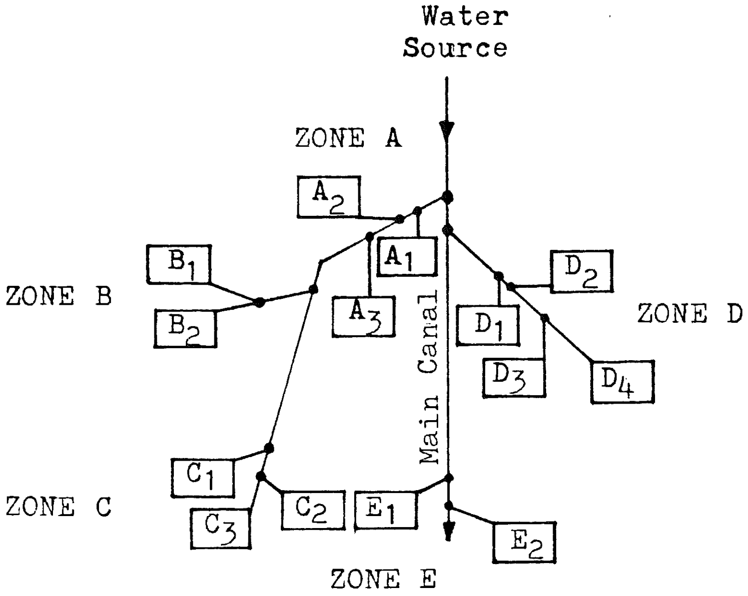
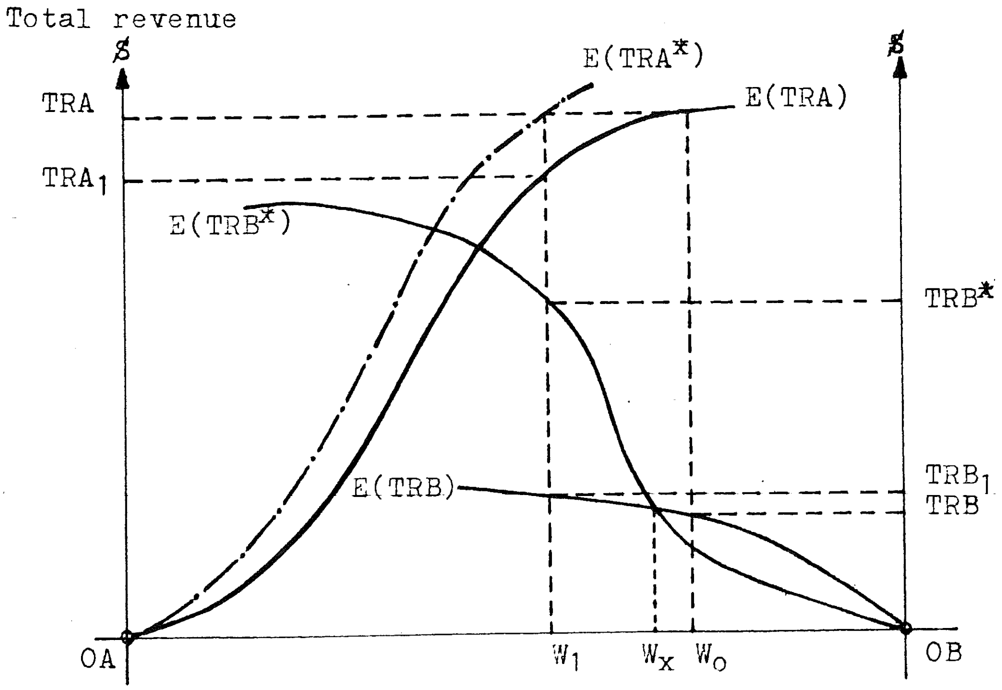


FIG. 3.6 - Schematic representation of farmers' "nominal" location in an irrigation system.

Source : BROMLEY et al. (1980)

FIG. 3.7 - Economic effects of uncertainties arising from physical interdependencies in irrigation

Source : adapted from PARKER (1980) and WALKER (1981)



The term of "real location" that BROMLEY et al propose however relates the degree of relative access to water to socio political realities. Whether individual C_3 will really have the least favourable position will largely depend on the political power he can command in the context of the institutional environment of the irrigation scheme.

The actual consequences brought about for a less advantaged irrigator in connection with his "real location" are analysed by PARKER[1] (see FIG. 3.7):

If the total quantity of irrigation water available for two farmers A and B is OA - OB and if the advantaged farmer A receives the allocation OA - W_o then the amount OB - W_o is left for farmer B, if transaction-losses are neglected. This allows A to cultivate a high yielding crop-variety with a production-function represented by E(TRA) while B will cultivate the traditional variety E(TRB) which has a flatter production-function and which at low water inputs below W_x may yield higher revenues than the high yielding crop E(TRB^*) he might choose as an alternative.

The total value products under these conditions are given by TRA and TRB respectively.

If A can be induced to reduce his water allocation from W_o to W_1 with a relatively small loss in revenue from TRA to TRA_1, then B would have the chance to adopt the high-yielding crop-alternative E(TRB^*)[2]. This would result not only in substantial production increases for B but -since production increases for B from TRB to TRB^* are higher than reductions for A - also the overall project production would rise. Hence, in this case, productivity- and equity-goals would be complementary. In reality however, the only way to achieve water use reduction by A may be to increase his allocative efficiency - moving to a new production function E(TRA^*) - since due to his political status, A will be unlikely to accept any reduction of his value-product.[3]

The important point to note with respect to the smallholders situa-

---

[1] PARKER D. (1979) as quoted by DAVIES (1983)

[2] Whether he would actually change varieties would depend not only on adequacy but also on reliability of allocation (see para 4.3.4)

[3] WALKER (1981) p. 107

tion is that inherent physical interdependencies in irrigation will result in a stagnation or even deterioration of his economic position - given the above mentioned opportunity-costs he incurs with irrigation - if the institutional environment allows others to make use of their locational advantages in "nominal" or in "real" terms. Since socio-economical and political differences are desicive with respect to real location his weak economic position compoundsthe smallholders vulnerability to the institutional uncertainty of water-allocations in the context of irrigation schemes.

4.3.4 Institutional uncertainty - the role of water reliability

The predominance of the subsistence- and safety-goals in a presumed lexicographic order of the farmer's objectives as mentioned in chapter 4.2 draws attention to the fact that his risk-taking depends on the distance from some "disaster-level" 1) as a motivational threshold.

Judged from this point of view, the disadvantages of physical interdependencies as outlined in the previous chapter prevent the smallholder from participating in substancial benefits from irrigation and hence from achieving his surplus goals but their negative effect with respect to subsistence and safety-goals will be limited, as long as the situation remains predictable . He will then retain his risk-diversifying traditional farming-practices in order to satisfy his priority security goals.

A different situation arises, when water allocation is linked with a lack of reliability both with respect to quantities supplied and to timeliness of allocation.

Unreliability of water delivery makes water supply unpredictable and hence makes it impossible for the farmer to properly plan his farming operations.

If water quantities vary then farmers may choose to irrigate either 'larger than optimum' areas with scarce and unreliable supplies, as reported by REIDINGER with reference to farmers in West-Pakistan 2),

---

1) ROUMASSET (1976) p. 52
2) REIDINGER (1980) p. 266

thus constantly underirrigating their crops or they may spread water over 'less than optimum'areas as mentioned by ABEL and CHAMBERS 1) and thus overirrigate and cause yield depressions as well.

Whatever the individual reaction is, the lack in supply reliability particularly induces the farmer with the more favourable "real location" to take more than his share if and when he gets it. And it is this insecurity which makes it a rational choice for the disadvantaged smallholder not to adopt more water-responsive crop varieties as indicated by the potential transition from production function $E(TRB)$ to $E(TRB^*)$ in FIG. 3.8

BROMLEY 2) illustrates both the inefficiencies and the equity problems related to such unreliable quantities of water supply in a diagram shown in FIG.3.8 , which depicts the shared use of water quantity $AA^1 = BB^1$ between users A and B, where A is more favourably located in real terms. The crucial point is, that farming operations have to be planned before actual water allocations are known and hence farmers have to choose according to supply predictions the levels of accompanying inputs that are functions of water-receipts, i.e. seed varieties, application rates and -times of fertilizers and certain labour inputs related to on-farm water distribution. The inputs purchased by A and B are indicated with an aggregate index I on the vertical axes in FIG. 3.8

If water allocation is unreliable, then A has to plan his input use on the basis of previous experience, and, being cautious may choose the levels W_p^A and I_o^A, with an envisaged production level at M. However, if he gets the water, being in a favourable position he is likely to apply some more than the quantity corresponding to his input-use, as mentioned above. Assuming he takes W_o^A, his production level will be at K.

User B on the other hand has to take into account both dependencies and unreliabilities of supply and will hence be particularly cautious in choosing input-levels W_o^B and I_o^B , intending to operate at point N. However, since A took only W_o^A he may apply more water ($W_{\#}^B$) and hence produces at level J. If the line L-M-N represents

---

1) ABEL and CHAMBERS as quoted in BROMLEY et al (1980) p. 370
2) BROMLEY (1982) p. 10-14

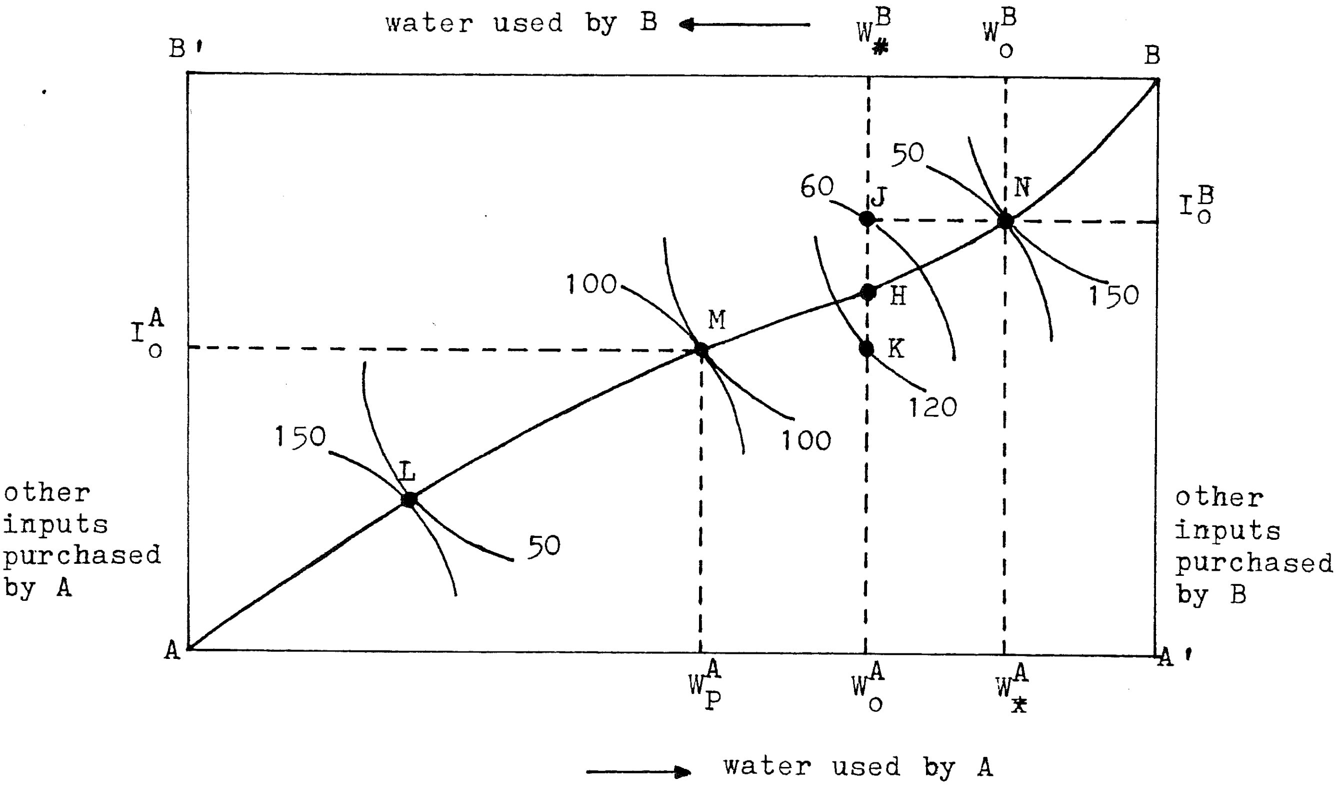


FIG. 3.8 - Economic effects of uncertainties arising from both unreliable and inequitable water-allocation

Source : BROMLEY (1982) p. 13

the contract curve, i.e. the locus of productive efficiency, it becomes apparent, that production of both farmers taken together is less than it could be with efficient operation at point H. BROMLEY points to the related problem which would have even more serious consequences with respect to the smallholders safety goals if his situation is represented by B: if he underestimates the water taken by A, then parts of his purchased inputs will be wasted which may result in net benefit decreases through irrigation.

Apart from the fact, that the resulting inefficiencies, if aggregated over the whole irrigated area, are extremely costly, the above considerations stress the point that

> 'unreliable irrigation supply from surface and groundwater is probably the major cause of variations in yield. More importantly in the medium and long term, unreliability causes farmers to cut investment in high-value crops, fertilizers, sprays and so forth and is a major contributer to disappointing irrigation performance.' 1)

The above analysis also makes it clear that the high uncertainty that a lack of water-allocation-reliability introduces into the smallholders water-use-decision making compounds the disadvantages arising from physical interdependencies in irrigation.

4.3.5 Institutional uncertainty - access to land

4.3.5.1 General

With respect to land-tenure and irrigation, RUTHENBERG notes that

> 'it must... be borne in mind that production techniques and land tenure are interrelated. Whereas in shifting and fallow systems communal land ownership with established rights of usage prevails, we generally find in permanent farming individual land-ownership with owner-farmers or tenants. In irrigation farming, landlord-tenant relationships, provided that they have not yet been abolished by land reforms, are even more typical than in upland farming'. 2)

These observations point to an essential area of considerations related to smallholder irrigation. Questions about the possible implications of irrigation on the land tenure situation of the small

---

1) CARRUTHERS (1982) p. 8
2) RUTHENBERG (1980) p. 187

farmer must clearly be of prime importance if the above mentioned goal system of the farmer (see para 4.2) is to be of any concern in the context of irrigation planning- and management. Since 'technologies and social relations are intimately linked' 1), the introduction of irrigation into an area of rainfed agriculture is likely to bring about substantial changes in the tenurial status of the smallholder. Therefore, questions relating to the nature and trends of such changes and to the factors and situation-variables involved appear to be of particular relevance to smallholder irrigation planning. However, empirical evidence related to such questions is rare and has to be seen in the dynamic context of differing socio economic structures. And with respect to theory relevant to such problems, BROMLEY notes that 'while there is an extensive theoretical literature on landlord-tenant relations, we do not have anything comparable in irrigated agriculture'.2)
However, since the focus of this chapter is directed towards the qualitative nature of potential trends rather than towards detailed analyses of the changes involved, the following general considerations may be sufficiently conclusive although they refer to mainly one single study for empirical evidence.3)
The particular viewpoint adopted here in order to point to the issues involved is to limit the discussion on the interaction of the goal systems of landlords and tenants under varying production conditions. Moreover, the role and importance of incentives as well as of risk and uncertainty in the framework of such interrelationships is given particular attention in accordance with the smallholders premised concerns and preferences.

4.3.5.2 Land tenure and potential impacts of irrigation

With reference to the role of risk in the context of landtenure arrangements, GRIFFIN remarks, that 'there is no necessary connection between ownership of land, entrepreneurship and risk taking.

---

1) PEARSE (1980) p. 6
2) BROMLEY (1982) p.3
3) BHARADWAY and DAS (1975)

He who makes the decisions, bears most of the risks, but he who bears the risks need not own the land'.[1] GRIFFIN illustrates this point by representing the three basic tenure systems in a schematic form where arrows point toward those who bear the risks of production:

1.	owner-operator	wages $\boxed{\text{workers}}$	$\longrightarrow$	profits $\boxed{\text{landlord}}$
2.	sharecropping	crop share $\boxed{\text{tenant}}$	$\longleftrightarrow$	crop share $\boxed{\text{landlord}}$
3.	leasehold	profits $\boxed{\text{tenant}}$	$\longleftarrow$	rent $\boxed{\text{landlord}}$

However, it is essential to realize that the kind of risk, GRIFFIN refers to is what has been labelled as "technical uncertainty" in an earlier context (see para 4.3.2) i.e. uncertainties related mainly to physical and biological factors of production. However, as far as uncertainty is determined by the socio economic context, GRIFFIN's statement no longer holds: e.g. "institutional uncertainty" may well effect the wage-labourer in a worker landlord relationship if unemployment is high and if he risks to loose his job. Accordingly, in a share cropping arrangement the tenant security may vary widely according to the degree of institutional uncertainty that prevails.

In order to assess potential changes irrigation may bring about for the tenurial status of the smallholder it may be sufficient to concentrate on sharecropping which is the most pervasive and persistent of the above mentioned basic tenure systems. Leaving aside theoretical considerations about resource allocation and productive efficiency that dominate the literature about sharecropping, it may be useful instead to consider the situations in which this tenure system is the preferred arrangement.

With reference to PEARCE[2] the essential situation parameters that favour the persistence of sharecropping may be defined as follows:

1. where decisions concerning the nature of the contract lies with the landlord, but where the costs of supervision are potentially large, i.e. where production conditions are such that under owner operator arrangements with wage labour much time and effort

---

1) GRIFFIN (1979) pp 23-24
2) PEARCE (1983) p. 65

would be needed to ensure an acceptable outcome.

2. ' where the tenant is in a position to have a decisive influence upon the contract and where the tenant is also insufficiently endowed with resources to allow him to discount income variance as a decision variable '[1]

3. where differences in resource endowments are less pronounced and where both landlords and tenants are existing close to the margin of survival.

If one looks seperately at each of these sets of given "environmental" conditions and if one superimposes the introduction of irrigation on each of them, potential systems interactions point to the following resulting trends:

Scenario 1 : landlord dominant - supervision costs high

Since the landlord is dominant, conditions will largely be determined by his decision making and by the tuning of his goals to environmental characteristics that change with the introduction of irrigation.

a) Change from rainfed agriculture to irrigation entails increases in labour requirements and the need for timely and skilled execution of predetermined tasks. This means, that supervision costs that are already high, will further increase if the landlord opts for wage labour arrangements. Hence, basically, he may be interested to continue on a sharecropping basis and security of the tenant may be enhanced.
This hypothesized trend has been observed by BHARADWAJ and DAS in India[2]. In surveys of village based irrigation schemes in Orissa it was found that traditional paddy varieties - in contrast to high yielding varieties (HYV's) - continued to be grown on a crop sharing basis with "conventional" shares of 40 to 50 %.

b) However, if the advent of irrigation is accompanied by introduction of HYV's, then another trend of changes may be likely as well: the profitability in relation to units of output as well as on capital invested may rise such, that cultivation becomes attractive to landlords themselves who have been uninterested

---

1) PEARCE (1983) p. 65
2) BHARADWAJ and DAS (1975) p. 233

or absent before. This may lead to tenant eviction or to changes from sharecropping to wage labour contracts.[1]

c) PEARCE points to the fact that the same circumstances - introduction of irrigation and HYV's - may result in yet a different outcome if the landowners perceive the rewards of the "new" technology to be substantial but if they are aware at the same time that in the short run uncertainty is increased. Uncertainty may be augmented, because new varieties ask for reliable water supplies and the complete and well dosed "package" of inputs if they are to be cultivated successfully. Neither water reliability nor the necessary managerial skills of the water users can usually be expected in new irrigation schemes.
A "rational" choice for the landlord under such conditions will be to share such risks through cost share leases or 'to off-load them entirely through fixed rent tenancies'.[2] Evidence of the latter option again is reported by BHARADWAJ and DAS in the above mentioned study who noticed that in village schemes, where irrigation and HYV's where newly introduced, tenure arrangements 'changed over almost entirely to fixed rent basis'.[3]
One might assume in line with GRIFFIN's perception of tenure systems (see above) that such leasehold contracts will enhance the tenants decision making freedom and hence reduce institutional uncertainties he has to face. However, the surveys of BHARADWAJ and DAS lend little support to such expectations, since they revealed that another feature accompanied the change-over from crop sharing to fixed rent arrangements: the fact that terms of leases got considerably shortened. The researchers interpret this fact as follows:

> '...to fix the rent in kind or cash provides an incentive to the tenant to cultivate intensively since what remains after paying rent accrues to him. However, by making the lease contract short enough and/or insecure the landlord can raise fixed rent to capitalise on the preductivity gain for each new tenant or for the old tenant under threat of eviction. This quick turnover of tenants, even when actually involving eviction, may not parti-

---

[1] for empirical evidence see e.g. BERRY and CLINE (1979) and PEARSE (1980)
[2] PEARCE (1983) p. 64
[3] BHARADWAJ and DAS (1975) p. 235

cularly harm productivity, if gains in productivity are mainly being achieved through the tenant's circulating capital rather than through asset formation. If the main asset, irrigation, is provided by public works, as in our present case, this may be an easily workable strategy.' As a result, 'in this region... insecurity, especially for small tenants, has increased.' 1)

Scenario 2 : enhanced bargaining power of tenants

Situations where tenants have increased influence on tenurial arrangements may arise in various circumstances: First, tenants may be landlords themselves, or may have more favourable resource endowments so that negotiating positions are less unequal. Second, landlords traditionally may not be cultivators or may be engaged in other activities so that supervision costs and/or labour shortages may induce them to seek share cropping arrangements.

a) If under such conditions irrigation and HYV's are introduced in an area, then the ensuing increase in related labour- and input-costs if borne by the tenant alone, and the fact that the tenant receives only a part of the total product may decrease the tenant's net revenues below minimum income needs and hence reduce his incentives to cooperate. Given his favourable bargaining position, he may induce the landowner to increase tenant crop shares or to pay part of the input costs, while maintaining the sharecropping contract.
BHARADWAJ and DAS confirm such trends for areas in their survey where irrigation has been practiced for a long time and where "traditional landlords" prevailed, that where partly engaged in occupations other than cultivation. In such circumstances the introduction of HYV's into irrigated agriculture was accompanied with increases in tenants share to 75% of gross-output with costs entirely borne by the tenant. 1)

b) The same researchers point to the fact, that in village -schemes where irrigation had been newly introduced and a transition from share cropping to fixed rents was the rule - see point c) in scenario 1 - a large part of the tenants were migrants from

---

1) BHARADWAJ and DAS (1975) pp. 236, 237
2) ibid., p. 235

neighbouring regions. Since these tenants were better off and hence had a more favourable bargaining position, they were able to negotiate longer term leases: 'while the small tenants were faced with intense insecurity, the large tenants obtained leases (orally) for three to four years.' 1)

Scenario 3 : equal bargaining position and low resource endowments of landlord and tenant

Situations with highly differential bargaining power between landlord and tenant, e.g. when large landowners lease out small parcels of land to numerous tenants are by no means the rule in share cropping. In Bangladesh e.g. where up to 50% of all farmers are engaged in crop sharing arrangements most of the tenant farms are cultivated by "mixed tenants", i.e. those who own some land and hire in some more to increase their landholding 2). At the same time total holding sizes remain small. 3)

Under such conditions, the introduction of irrigation with demands for more, timely and skilled labour inputs and the continuing risk aversion of both parties may increase needs for share cropping arrangements and hence make tenancy arrangements more secure for small cultivators.

The above considerations have been meant to demonstrate that the interplay between environmental conditions and the goal systems of landlord and tenant may be strongly influenced by the advent of irrigation and that the institutional uncertainties a poor tenant smallholder has to face may sharply increase in such circumstances.

If the interests of the small farmer are to be given protection then issues of land tenure relations and related problems of institutional uncertainty must be of key-importance in smallholder irrigation planning.

---

1) BHARADWAJ and DAS (1975) p. 237

2) HOSSAIN (1977) p. 300; PEARCE (1983) p. 45

3) In the rural household surveys in Bangladesh referred to by HOSSAIN (1977) 60 per cent of the households owned areas smaller than 3.5 acres.

4.4 Conclusion

The foregoing considerations of the potential decision making behaviour of small farmers as irrigators in the context of their institutional environment were supposed to illustrate the importance of environmental factors on farmer-decision making and hence on project-performance.
This lends support to the hypothesized need for open systems approaches to smallholder irrigation.
It has to be stressed that the above mentioned aspects concern only a very limited, although crucial, area of interactions in the "social arena" in which an irrigation scheme is supposed to function. Other important and largely neglected interrelationships concern the decision making behaviour of irrigation staff in the context of institutional structures and reward systems relevant to them, the interactions between the structure of national irrigation institution and the systems performance etc.etc..
If it is accepted that the boundary between the socio technical system of an irrigation scheme and its environment is a dynamic region 1) rather than a distinct line, then smallholder irrigation planning will have to give more attention to aspects like those outlined above.

---

1) compare chapter 2.

5. PROJECT DESIGN FOR SMALLHOLDER IRRIGATION

5.1 Context and goals

The foregoing chapters have indicated substantial deficiencies of conventional irrigation with respect to its suitability for smallholder irrigation. Given that there is a complex and dynamic interrelationship between people, technology and institutions, "a priori" quantification of project goals is bound to encounter difficulties. And given the fact that the institutional environment of irrigation organizations is only partially controlleable, planning- and management procedures that are based on rigid and static input-output-considerations appear to be highly inadequate.
The fact that institutional components of the project's and the farmer's environment are only "influenceable" or "appreciable" but not fully controllable as has been premised above, cannot mean, that they are to be neglected. This may be possible in short-term infrastructural projects that are geared to produce a specific output and which may be able to engage the prevailing institutional powers to that common end.
The success of smallholder irrigation however depends crucially on human and social factors i.e., on the collaboration of the projects users and on their participation in the pursuit of the projects goals. However, SMITH et al. stress that

> ' participation in organizations is always partial and conditional. It is partial to the extent that what the individual achieves through the organization is only a part of his total purpose. It is conditional on the organization being able to continue to supply the inducements necessary to his continued contribution. '[1]

Such inducements depend upon the degree of synchronisation between the project's goals and the goal system of the individual farmer. Chapter 4 has attempted to demonstrate that the smallholder's objectives and decision making are largely influenced by the institutional environment in which he lives.
This means that well defined, quantifyable and hence "operational" objectives for smallholder schemes, that are definitely needed if

---

[1] SMITH, LETHAM and THOOLEN (1980) p. 15

projects are to be rendered "manageable", have to be determined in a process of systems-adaption to the ecological and institutional environment and hence to the "real" objectives of the people and interest groups involved.

At the same time overall "final" objectives - "increase in agricultural production", "improvements in living standards" etc. - are important as broad long-term guidelines for irrigation schemes, however "they are to be used to give direction and legitimacy to project selection and not to specify their goals."1)

With reference to the so-called "COPENHAGEN WORKSHOP"2) different hierarchy levels of goals may be classified in the following way:

degree of operationalization ↓

Final goals:	project impact (degree of achievement of superior goals, e.g. improvements in living standards of the intended beneficiaries)
1st order goals:	project effect (consequences resulting from use of project-outputs)
2nd order goals:	project-outputs (consequences resulting from project-inputs and -activities)
3rd order goals:	project-inputs (amount of resources to be used and activities to be undertaken)

It follows from the above considerations that an open systems approach to smallholder irrigation would have to attribute explicitely different degrees of goal-operationalization to each of the levels of this hierarchy, increasing in the direction of the indicated arrow. In the short run only goals of the 3rd order may be specified and quantified, taking into account existing environmental constraints.3) Goals of the 2nd and 1st order will then assume the nature of medium and long term guidelines. In the course of the dynamic process of systems adaption 2nd and 3rd order goals may assume a higher degree of operationalization the more the system approaches a steady state.

Such a procedure would be in stark contrast to current practice

---

1) SMITH et al (1980), p. 35

2) Copenhagen Technical Workshop on Monitoring and Evaluation of Rural Development Projects (1976) as quoted in JAHNKE and von Oven (1980) p. 714

3) This corresponds to a pilot-stage of operation

in irrigation planning: in conventional irrigation, the "project cycle" and its conventions determine the degree and the timing of goal-quantification. At the end of the identification- and preparation-stages, 2nd and often 1st order goals are "identified" and quantified and finally "sanctioned" through project-appraisal. At that stage, very often, the institutional environment of the appraised project including its structures, potential sources of uncertainties and its reward-systems is largely unknown and hence also the environmental constraints the project has to face.

In consequence, an open systems approach to irrigation would need to be started from a different procedural basis. It appears that instead of "irrigation-projects", "irrigation-programs" might be adequate. This means that long-term and continuous commitments by governments and potential aid-donors to "project"-activities of initially small and gradually increasing scale might be preferable to short-term, large scale investments which by necessity - due to the open systems character of irrigation schemes - are bound to encounter substantial difficulties.

However, an open systems approach to smallholder irrigation would have to be distinct in a further respect.

The brief considerations in chapter 4 have indicated that in the context of institutions the poor smallholder occupies a least favourable position. This becomes evident in his highly vulnerable land-tenure status as well as in terms of his disadvantaged "real location" [1] related to access to irrigation water. Both materialize in a high degree of uncertainty for the smallholder and hence reduce his willingness to cooperate and to participate.

It seems hence to be of prime importance to introduce risk minimization considerations as planning imperatives and priority-criteria into smallholder irrigation. The process of systems adaption which has been suggested here must hence be subject to improvements in the farmer's safety-position if the overall project is to be viable. In the same way as SANDERS has demonstrated the irrelevance of fertilizer- and credit-programs in Brazil in cases where farmers operated at high levels of risk avoidance[2], irrigation development

---

[1] compare explanations on chapter 4.3.3

[2] SANDERS (1979) p. 79

may prove to be useless to the smallholder if similar conditions prevail.

5.2 Planning approaches

An open systems approach to project planning and management as suggested in this chapter may at first glance appear to be hardly applicable to project activities like irrigation where infrastructure components inevitably play an important role. After all, decisions about infrastructural details have to be taken, financial arrangements are to be made and the process of systems adaption in planning will thus have obvious limitations.
While this is so, it has to be realized that once infrastructural project-components are started irreversible commitments are made and institutional adjustments or attempts to initiate new institutional designs may then appear to be difficult or impossible.

> 'When the institutional arrangements are not well established at the time the new technology creates ... new income streams ... some farmers will be able to expropriate for themselves some of the income streams made possible by the innovation. If this is allowed to continue for several crop seasons, those fortunate few who were able to appropriate the new income will come to think upon their good fortune as "legitimate". Then, it will become difficult - if not impossible - to rectify the situation.'[1]

The fact that a major problem many rehabilitation projects have to face consists in the well-entrenched and de facto-legalized rights to excess water use by the top-enders, supports such views.
Such considerations again ask for increased emphasis on identification- and preparation stages in the project-cycle, as has been mentioned before. However considering practicability and cost effectiveness they may also ask for different methodologies in project preparation as well as for more flexibility and adaptability in project design and implementation.
Overabundant data-collection in surveys related to project preparation which is often linked with a lack in actual information may

---

1) BROMLEY (1982) p. 36

have to be limited. The quantity of data collected in such surveys and the narrow confidence limits that are normally required, often involve higher costs than can be justified by the incremental benefits they generate over those arising from more rapid, loosely structured investigations. Techniques of "rapid rural appraisal" that stress the importance of knowing what is not worth knowing and emphasize the appropriateness of an "optimal level of ignorance"1) may hence be of importance. CARRUTHERS notes with reference to irrigation planning:

> ' Indeed, if a cost effective iterative design process is to be followed in practice, and not merely advocated in principle,...the adoption of some techniques of rapid appraisal will be essential. ' 1)

If open systems approaches to irrigation planning are to be practicable and cost-effective and if they are to give more attention to the environment, then planning procedures concentrating on <u>constraints priorities</u> appear to be essential. To keep design concepts simple inspite of the above mentioned complex systems interrelationships, the major constraints and conflicts which inhibit the intended synchronozation of goal systems, environment and design need to be identified and related cause-effect chains need be explored. Only if scarce resources are identified and evaluated in terms of their opportunity costs <u>prior and during</u> the planning process, can economically inefficient project designs be avoided. And only if institutional constraints are exposed and analysed in the framework of social structures and reward-systems will there be a chance to estimate their potential impact on project-performance and to search for ways to alleviate them.

The foregoing considerations suggest moreover that smallholder irrigation needs to be flexible and dynamic in response to socio economic changes. However due to the "lumpiness" of the infrastructural project-components this may be difficult to achieve, since such a flexibility would call for divisibility at the same time. Moreover, since the development of water resources usually is extremely costly, especially in the case of schemes that make use of surface waters, increasing returns to size can be expected up to a certain

---

1) Departmt. of Applied Statistics, Univ.Reading, "Surveys of the small farm sector in the Third World - synopsis" (1983)

2) CARRUTHERS (1979)

project-scale.

On the other hand, declining per unit costs of water supply that result from larger project sizes may well be counter-balanced by benefits foregone due to the impossibility to minimize planning-errors by way of adjustments to ongoing improvements of information-levels. Moreover, opportunity-costs involved for not being able to synchronize project- and institutional developments may in reality be high.[1] The problem is that estimates about differential benefits between "full" and step-by-step development are impossible to make in the ex-ante situation and that therefore full development and divisible project alternatives can only be compared from the point of view of costs. Such comparisons however, due to economies of scale in construction and due to high costs of water resource development will unduly tend to disfavour "divisible" design proposals.

Such consideration point to the importance of pilot schemes in cases where "divisible" project alternatives cannot be justified on the basis of cost-comparisons and they indicate subtantial comparative advantages of small-scale irrigation.

By its very nature however, open systems planning cannot be prone to ready made "solutions" as some advocates of small-scale irrigation seem to imply.

5.3 Designing for risk avoidance

5.3.1 Prospects and procedures

Conventional project-preparation, appraisal- and evaluation procedures in irrigation appear to be highly insensitive with respect to issues of risk-avoidance relevant to the farmer. Designing irrigation schemes for risk avoidance in current project practice is predominantly understood in terms of minimizing the risk that the

---

[1] ZAPATA (1979) p. 16

project may not cover the opportunity-cost of the capital invested in it.[1] Procedures of cost-benefit sensitivity-analyses and probabilistic approaches of risk analyses are in use to evaluate this type of risk in project-appraisal. Occasionally only, tests are made with respect to the farmers situation, e.g. to estimate effects of a delay in project-benefits on his cash-surplus-position.

To comply with the requirements of open systems planning however, modifications in the application of such procedures appear to be necessary:

Firstly, sensitivity analysis would have to be used in the context of ongoing design-adaptions to goals and environment and hence would need to check upon project components throughout the planning period.[2]

And secondly, sensitivity analysis would need to be applied for ongoing assessment of financial impacts of design adaptions on farm model budgets.

Moreover, it would appear to be necessary to reflect institutional uncercainty as far as possible in farm budget preparation. BROMLEY e.g. thinks in this direction when he suggests that farm budget studies should be conducted 'with an eye to a farmer's location within the system' and proposes that different farm budgets should be established for the head-, middle- and tail-reaches of a water course.[3] Not only are yields likely to be lower in tail than in head-regions[4] but also the opportunity-costs of water-use to the farmer are higher due to higher transaction-costs and due to increased labour inputs for maintenance of supply canals and farm-ditches to ensure conveyance of largely dimished flows.

Only if such differences clearly show up in farm-model-budgets[5], will project measures to relief such constraint situations become more stringent for decision makers.

With explicit reference to institutional uncertainty a recent program-evaluation-study on irrigation development carried out for a

---

1) e.g. BOTTEMLEY (1979)
2) compare CARRUTHERS (1979)
3) BROMLEY (1982)
4) compare para 4.3.3
5) this is not meant to say that institutional uncertainties in general can be reflected in farm budgets.

major bilateral donor agency states that 'we recommend that evaluations examine the question of risk in irrigation and consider policies which will minimize risk in the design and implementation of future irrigation projects'.[1)] However, the same report considers risk minimization for the farmer as one amongst 73 (!) evaluation criteria for irrigation activities without any reference to priority orders.
This points to the fact that genuine attempts to account expressively for farmer's risk-avoidance in actual irrigation planning are sparse and a substantial shift in emphasis in this respect appears to be essential

5.3.2 Security of land tenure

The considerations in paragraph 4.3.5 were meant to illustrate the potential influences , irrigation may have upon the farmer's safety position in terms of tenurial status. Designing for risk avoidance in the context of open systems design for smallholder irrigation will hence have to attribute prime importance to related questions.

If "success-stories" of smallholder irrigation are being discussed, reference will inevitably be made to the cases of Japan, Taiwan and China.
Irrigation developments in these countries have been favoured by the existence of natural irrigation areas, by the command over large contingents of labour and by extensive land-and-water improvement works that enhanced water-control and thus could take full advantage of the new seed-fertilizer technology of the "Green Revolution".
However a major factor amongst others contributing to this course of events in these countries with different development paths and social systems were reforms of agrarian structures in the aftermath of political events that prevented the marginalisation and the "de-landing" of small cultivators and that ensured their access to land.[2)]

---

1) BERRY, FORD and HOSIER (1980) p. 34
2) PEARSE (1980) pp 224 and 238-243

Open systems considerations as stressed throughout this dissertation suggest that attempts to "draw lessons" from location specific experiences in order to transfer such experiences to other systems-frameworks are likely to encounter substantial difficulties, a point that will be further illustrated in chapter 6. However, the premise that the smallholder is a rational decisionmaker that underlies the arguments in the foregoing chapters, is likely to result in decision-making-behaviour that will avoid to trade ecological uncertainties for even greater institutional uncertainties possibly brought about through irrigation. And there are few aspects of risk-avoidance more stringent in the small farmer's decision making process than those related to his access to land. Such considerations underline the importance of land reform measures if designing for security is to become a genuine planning criterion in smallholder irrigation. However, it is again the overall systems context, that determines the impact that such measures can have in project-reality, as the case of the irrigation component of the Sao Fransico Polders Project in Brazil demonstrates:

AYRES[1] reports that land tenure problems were impeding the implementation of this project, which was unique in Brazil as it provided for the expropriation of private lands. It was evident that without land reform the profits from irrigation would have accrued to the large landholders in the area. But when land reform measures were undertaken, "the project fell considerably behind schedule, in large measure because the expropriation of private lands went at a snail's pace, and the decree providing for such expropriation expired. Less than half of the expropriable land was in fact expropriated."[2]

Hence if the systems context, i.e. in this case the whole of the agrarian structure and the legal and political framework are not conducive to such approaches, land reforms may encounter serious problems.

Whether other methods to ensure land-tenure-security can be more promising such as tenancy security laws, water reforms with differential water-rights and/or ceilings on access rights to water-use that aim at disincentives to induce large farms to refrain from

---

[1] AYRES (1983)

[2] ibid., p. 117

"de-landing" poor smallholders, will depend on local systems circumstances. However, irrigation-projects that are not accompanied by interventions to secure the land-tenure-status of smallholders may run the risk to bring about "silent land reforms" in disfavour of the intended beneficiaries and hence incur social opportunity costs that ought to be considered in decision making about project selection.

5.3.3 Formalist approaches

Attempts to design for the farmer's risk-avoidance in smallholder irrigation seem to imply the necessity for projections of potential opportunity costs a farmer is likely to incur with irrigation. This however must prove to be an impossible task since opportunity costs are even difficult to quantify where farmer observation is possible. Some authors argue that they cannot be clearly apparent since they depend upon the farmers subjective judgement of the benefits foregone in a specific use of resources.
These problems of an "ill-structured" reality which confronts the planner when attempting to select risk avoiding design-alternatives are however further complicated. This is because the potential sources of increasing uncertainty for the smallholder in the advent of irrigation may seem to be countless. A low degree of social cohesion or a lack in irrigation know-how coupled with the farmer's" ignorance, not only about technology but also about legal rights and opportunities[1]" as an irrigator may reveal to be just as seriuos constraints as a lack in water-reliability. And weakness of the legal system, a high degree of socio-economic heterogeneity, strong political positions of rural élites etc. etc. are all factors that compound potential uncertainties brought about by physical interdependencies or by potentially low financial rates of return on the farmers resources.
On the other hand side extremly different means of diminishing farmer-related risks may be proposed as "appropriate".

---

1) THORNTON (1983) p. 3

The economist may argue that a sound financial rate of return to the farmers own resources coupled with a "safe" cash-surplus projection may be the best way to provide for risk-avoidance. Or he may propose social cost-benefit weightings in the context of overall project selection to counteract impending inequality issues or other he may consider credit programs to help.
The agronomist may intervene in favour of farming systems approaches, may propose new resistant but still high yielding varieties or may be in favour of on-farm research trials. The engineer may opt for dam construction and water-storage since this is the "best" way to prevent seasonal river-water fluctuations and the related uncertainty-problems or may even propose automated water control in the water distribution system to minimize operational deficiencies and resulting risks with respect to water allocation. And the manager may prefer a higher degree of organizational centralization or may be in favour of management improvements to water control and may even dream to bring about a "water revolution" by introduction of such "low cost"-measures 1).
But some of those measures or all of them may ignore the real constraints the farmer faces or some of them or only a certain combination may prove to be feasible or effective in the given environment.

In such a highly complex project-situation the planner may basically choose among four general types of planning approaches to find the "appropriate" way of minimizing the smallholder's risk:

1. <u>Formalist approaches</u>, that are characterized by the explicit or implicit use of mathematical and other models.
2. <u>Heuristic approaches</u> that use principles as guides for action.
3. <u>Operating unit approaches</u> that begin with carefully selected people or machines specially tooled with regard to certain performance characteristics.
4. <u>Ad hoc approaches</u> which "present reality as the only given" 2)

Formalist approaches to account for farmer's risk in planning are numerous and have experienced a boom with the advent of mathematical programming methods. JOY e.g. who emphasizes the complexity of small farmer environments, refers to this very complexity to advocate

---

1) compare BOTTRALL (1981) pp. 23. 24 and DAVIES (1983)
2) BOGUSLAW (1965) as quoted by DE GREENE (1973) p. 81

Linear Programming (LP) as a method which can 'in principle cope with a good deal of it'1). On the basis of such attitudes numerous applications of LP to small farm planning have been undertaken and various studies, e.g. those of LOW have sought to incorporate risk into their analyses 2). JOHNSON on the other hand argues, that the reduction of the original problem to a small subset of attributes permitted by the formal LP-routine and the assumptions about the data needed to fill the gaps between our imperfect knowledge and the perfect knowledge demanded by the model lead to a LP-form of the problem which to him 'appears almost absurd in its simplicity'.3)

Such considerations have lead to a substantial shift in the application of formalist approaches from optimizing problems and prescriptive studies to their use in more exploratory investigations and as planning aids by way of simulation models4). However, if the cost-effectiveness of such approaches is taken into account, their application in smallholder irrigation is likely to remain largely restricted.

5.3.4 Farmer-related risk-profiles of irrigation projects

Refering back to the above mentioned types of planning approaches evidence suggests that in the practice of smallholder irrigation "ad hoc approaches" or at the most "operating unit approaches" are predominant - if the farmer's risk situation is considered at all. It is in view of this situation that a number of authors suggest that the sensible application of heuristic planning procedures as planning aids - e.g. check-lists, decision-matrices, problem-hierarchies etc.- may in many cases be more useful than formalist approaches.5)

As such a heuristic aid to planning for risk-avoidance "farmer-related risk-profiles of irrigation-projects" may be a useful and

---

1) JOY (1969)
2) LOW (1974)
3) JOHNSON (1980) in BARLETT (1980) p. 38
4) compare e.g. ZUCKERMAN (1977)
5) see e.g. CHAMBERS (1977) + CARRUTHERS and CLAYTON (1976) quoted in BIGGS (1978); BIGGS (1978) and KORTENHORST (1980).

cost-effective means. It is suggested, that such profiles, in a similar way to the simplified model in FIG. 5.1 may attempt to represent the existing, location-specific state of knowledge about potential sources of uncertainty for the smallholder in a simple ordinal scale. Applied in an on-going process of systems adaptations such a profile would have to become continuously more comprehensive and include multidisciplinary viewpoints. It is not suggested that decisions ought to be based on such profiles but that they help to guide judgements. And it is not suggested that potential sources of farmer's risk may be represented by such profiles in a comprehensive and satisfactory way.

Moreover, it may well be that indications about risk levels related to a certain variable necessitate prior assumptions about other variables. E.g. high levels of organizational centralization may only reduce farmer's risks if management capacities are high, if there is strong political support and if it does not bring about excessive social opportunity costs. Such deficiencies are inherent in heuristic approaches that do not aim at comprehensive formalization.

However, it is suggested that such profiles may help to identify farmers-related constraints across disciplines, and they may help that decision makers take a more balanced view of constraints priorities and the possibilities to intervene - or become aware at all that such constraints exist.

Moreover such profiles might indicate in a sufficiently comprehensible multidisciplinary manner where potential complementarities or tradeoffs arise from particular interventions and they may be combined with compatibility matrices to help in this direction. Thus they may be useful guides in improving design-approaches according to the beneficiary constraint-situation.

It may indeed be possible in certain environments to substitute improved management discipline for more substantial infrastructure[1] without increasing the farmers risk. Or it may be possible in specific circumstances to 'rearrange physical facilities to meet socio economic realities'[2], e.g. by identifying regions of socio economic homogeneity within the project area and by arranging distribution networks, water pricing and user-groups accordingly.

---

1) LAZARO et al (1979) p. 7
2) BROMLEY (1982) p. 18

In yet another environment farming systems approaches may prove to be adequate as long as "resources" of skilled management are too scarce to ensure water-allocation reliability.

By means of risk profiles various resource constraints may become more obvious and agronomists and engineers may focus more attention on economic instead of technical efficiency. On the other hand, economists may realize that they 'should be less concerned with the full rigour of modern cost-benefit analysis and other management techniques and more involved with study of the salient facts and testing of options, using criteria derived from insights obtained from basis socio economic concepts' 1).
Moreover, such planning aids may help to focus attention on needs for institutional designs in an early planning stage and they may point to very location-specific interdisciplinary solutions were cross country experiences may not be relevant.
Most important of all, such heuristic approaches to planning may help to ensure, that attention is drawn to the least advantaged members in irrigation schemes, the smallholders.

---

1) CARRUTHERS and CLARK (1981) p. 243

5.4 Conclusion

It has been premised in the context of this dissertation that socio-technical systems of irrigation are open to multiple interactions with their environment. Since part of this environment cannot be fully controlled by the irrigation organization while on the other hand it may considerably impinge on project-performance, open systems approaches to planning appear to be adequate.

A systematic and iterative systems adaption between project goals, design-characteristics and environment implies increasing attempts to synchronize the project's intentions with the small farmer's goals. Heuristic planning aids like farmer-related risk-profiles of irrigation projects may support such efforts.

Given the priority-order of subsistence and safety goals in the farmer's decision making and given the impact of social structures on such decisions, smallholder irrigation planning will have to focus attention on issues of institutional uncertainty that may be inconsistent with such goals.

The neglect of such issues may not only bring about "failure" of smallholder-irrigation-efforts, it may do so on the expense of those intended to be the beneficiaries.

It is here were 'irrigation aspects of agriculture cannot be seperated from the larger social/political climate which exists' (1) and where irrigation planning and contribution to the formation of political will may have to coincide.

---

1) BROMLEY (1982) p. 17

		SYSTEMS-VARIABLE / FARMER RELATED RISK-LEVEL OF IRRIGATION-PROJECT		LOW →		HIGH
GICAL		VARIABILITY OF RAINFALL	1	LOW		HIG
		DEPTH OF RAINFALL	2	HIGH		LC
		VARIABILITY OF WATER-SOURCE	3	LOW		HIG
	LOCAL RURAL LEVEL	LAND-TENURE STATUS OF SMALLHOLDER	4	OWNER-OPERATOR	SHARE CROPPER	WAGE LABOURE
		DEGREE OF SOCIAL COHESION	5	HIGH		LC
		DEGREE OF SOCIO-ECON.HETEROGENEITY	6	LOW		HIG
		POLITICAL POWER OF RURAL ELITES	7	LOW		HIG
		LAND TITLING	8	CLEAR LEGAL TITLES		NON-EXISTEN
		SIZE OF FARMER'S HOLDING	9	LARGE		SMAL
		IRRIGATION KNOW HOW OF FARMER	10	HIGH		LC
	NAT. LEVEL	ADMINISTRATIVE CAPACITY	11	HIGH WITH LOW TURNOVER		LOW WIT HIGH TURNOVE
		POLIT.PRIOR.OF SMALLHOLDER PROGR.	12	HIGH		LO
		LEGAL SYSTEM	13	STRONG		WEA
GOALS		FINAL PROJECT GOALS	14	SECURITY ORIENTED		OUTPUT ORIENTE
		DEGREE OF GOAL-INCONSISTENCIES BETWEEN MULTIPLE GOALS		LOW		HIG
ZATIONAL		DEGREE OF CENTRALIZ.OF MANAGEMENT	15	HIGHLY CENTRALIZED		LO
		FARMER PARTICIP.IN GOAL-FORMULATION	16	HIGH		LO
		CAPACITY OF INFORMATION + COMMUNICATION SYSTEM	17	HIGH		LO
		DEGREE OF WATER MANAGEMENT CONTROL	18	HIGH		LO
	PRO-JECT	FIN.,ECON.+SOCIAL RATE OF RETURN(RR)	19	HIGH		LO
		VARIANCE OF PROB.DISTRIB.OF RR	20	LOW		HIG
	FARM	FINANC.RR TO FARMERS OWN RESOURCES	21	HIGH		LO
		CASH SURPLUS (CS)	22	HIGH		LO
		VARIANCE OF PROB.DISTR.OF FRR + CS	23	LOW		HIG
		ZONING OF FARM BUDGETS	24	EXISTENT		NON-EXISTEN
		WATER PRICING	25	ABILITY TO PAY		COST APPROAC
		KIND OF WATER SUPPLY	26	STORAGE/TUBEWELLS WITH SECURE O + M		RIVER-DIVERSIO WITH LOW O +
		RATIO FARM WATER SUPPLY TO WATER REQUIREMENTS	27	HIGH		LO
		DEGREE OF ENGINEERING WATER CONTROL	28	HIGH		LO
		NO.OF USERS ALONG SUPPLY-CHANNEL	29	LOW		HIG
		PROJECTED FARMING PRACTICES	30	FARMING SYSTEM ORIENTED		COMMODIT ORIENTE

5.1 - Heuristic determination of farmer related risk profiles of irrigation projects.

ANNEX

CASE - EXAMPLE

6.0 AN OPEN SYSTEMS APPROACH TO THE EVALUATION OF RWS-irrigation-schemes in India

6.1 General

The character of irrigation schemes as open socio-technical systems implies, that there is a dynamic interrelationship between location-specific situation-variables including the goal-systems of interest-groups, the operationalization of feasible and acceptable project-objectives and the organizational as well as physical design-characteristics of an irrigation-scheme.
The following evaluation of Indian irrigation projects is ment to illustrate the interdependence of these variables and demonstrate the usefullness of an open systems-approach in analyzing such complex interrelationships.
The data used are based on a project-visit to India which I undertook in 1981 1). However, as the purpose of this visit was neither related to a detailed evaluation of these projects, nor to conceptual considerations as put forward in the context of this dissertation, the data at hand - especially concerning economic and socio-economic parameters - are far from beeing comprehensive.

However, it is hoped that the general reasoning of the here suggested systems-approach to smallholder-irrigation can be demonstrated notwithstanding such deficiencies.

6.2 The background : Warabandi and RWS

By the end of the 1970's India's increase in irrigation development reached impressive dimensions: the capacity of the irrigation-infrastructure constructed covered a total of approx. 50 million hectares 2). However the gap between created potential and actually irrigated area was striking. SECKLER notes 3):

---

1) HUPPERT (1983)
2) 52.25 ha by 1978 according to SECKLER (1981) p. 4
3) ibid., p. 5

> 'If 'capacity utilization' is defined as the amount of effectively irrigated land which can be obtained from existing supplies of water at the headgates of irrigation systems... then the 30 million ha of potential surface irrigation in India is reduced to an effectively irrigated area of 10.9 million hectares...'

This stupendous discrepancy was found to be partly due to the absence of field channels in the outlet command areas and partly due to the absence of a formal water-distribution-system.1) At the same time, it was recognised, that there was a strong bi-model pattern of capacity utilization in India: about 25% of the systems, predominantly in Northwest-India were estimated to operate at water-utilization-effeciencies of about 70% while the remaining 75% operated only at about 25% efficiency2). The high-effeciency systems corresponded largely to the irrigation schemes where "Warabandi"3), a traditional system of water-management was practiced. This fact induced the Indian Government in the mid 70's, supported by World-Bank and FAO to promote the introduction of new water-management-concepts - meanwhile called "Rotational Water Supply" (RWS) - in a number of projects throughout the country. In accordance with traditional Warabandi-principles, the RWS-concept presumes that the requirements of "classical" rotational water-distribution-systems are not applicable in smallholder conditions: allocation of varying water-dosages to different crops in accordance with differing crop-water-requirements throughout the season, taking into account soil-moisture-conditions of locally varying soil-types and hence differing irrigation intervals were operational tasks not practicable under conditions of "patchworks" of small, fragmented holdings. Highly complicated irrigation-schedules would result, that would be difficult to be followed or controlled. This is why "Warabandi" simplified water-distribution categorically in order to bring about organizational feasibility on one hand side and ensure a reliable, timely, predictable and equitable water-allocation on the other hand.

The main principles of traditional Warabandi are as follows:

i) Individual holdings are put together to form irrigation-

---

1) MALHOTRA (1982) p. iii
2) SECKLER (1981) p. 10
3) the literal meaning of "Warabandi" corresponds to "fixation of turns"

units ("chaks") of about the same size. This chak then receives a constant, uniform flow of water at the chak-outlet according to its area (usually about 1 cusec per 400 acres), but regardless of intended cropping-patterns, and -intensities and regardless of soil-types. The flow at the outlet varies only if the supply to the main-canal-system is subject to fluctuations.
This principle of constant flow at the outlet ensures reliability of supply and makes it possible for the users to control the adequacy of the pointedly scarce allocation. Flow-reductions in case of main-canal-supply-fluctuations distribute shortcomings equally to all chaks.

ii) Within the chaks, water is distributed on a rotational basis to the users. The individual dosage received (i.e. the time allowed for useage of the constant flow) is proportional to the area of the holding.
This principle ensures an equitable water-distribution[1] which again is easy to be controlled by the users.

iii) Irrigation-intervals are scheduled such, that each user can easily predict and remember the time of his irrigation-turn: normally weekly turns are in use, i.e. a certain farmer has the right to use the water always at the same day of the week, during the same time for the same length of time (provided the supply-channel is served).

Predictability and reliability of allocation together with an equitable distribution of scarce water - as mentioned in chapter 4 - are essential design-characteristics that adapt the system to the farmers objectives of risk-avoidance and food-security.

Since Warabandi and the above stated principles of waterdistribution-management were highly efficient in Nordwest-India, the RWS-projects attempted to transfer these organizational and technical design-characteristics into projects elsewhere. One of the goals of RWS-projects was thus to achieve a substantial increase in water-

---

1) MALHOTRA stresses that "equitable" water-allocation in India means invariably an allocation proportional to land area. And BOTTRALL confirms that with rare exeptions, this is the general pattern in developing countries. MALHOTRA (1982) p. 40; BOTTRALL (1981) p. 26

utilization-efficiencies and hence profitability through "soft" organizational inputs of low capital-intensity.

6.3 Traditional Warabandi - a systems view

Warabandi as practised traditionally in Northwest-India is by far not an ideal system and it has drawn substantial criticism: THORNTON quotes RAJ[1] who notes disadvantages such as

i) heavy water-losses entailed by the system

ii) lack of adjustment of water supply to crop-water-requirements (a criticism repeated by REIDINGER[2])

iii) impending problems of waterlogging and salinization due to overirrigation in certain periods of the cropping cyrcle.

These and further disadvantages of this method of water-distribution can be deducted from TAB 6.1 . This table indicates the compatibility of environmental parameters (institutional aspects, resources and farmers goals) as well as project goals, listed on the left hand side with the organizational and physical design-characteristics of the system, listed on the top side of the table. The row/column-intersections indicate compatibility (+), neutrality (•) or non-compatibility (-).

Table 6.1 presents the predominant design features of traditional Warabandi as practiced in parts of the Bhakra-canalsystem in Haryana.

Due to lack of data, the goal-systems are incomplete and the farmers goals indicated are based on assumptions only. RAJ's objections appear in the following row/column-intersections of TAB :

ad i: 5-m, 5-n; 15-m, 15-n
ad ii: column n
ad iii: 10-m

However, such criticisms fail to take into account the multi objective nature of the Warabandi-method and the systems-interactions between environment, goals and design-characteristics.

---

[1] RAJ, K.N. in THORNTON (1966) p. 12

[2] REIDINGER, R.B. quoted in MALHOTRA (1982)

DESIGN-CHARACTERISTICS ENVIRONMENTAL PARAMETERS + GOAL SYSTEMS			DESIGN CHARACT. OF TRADIT. WARABANDI														
			ORGANIZATIONAL							TECHNICAL							
			CONTROL-ENTITY AT OUTLET: FARMERS	CONTROL-ENTITY BELOW OUTLET: INDIV. FARMER	COORDINATION-ENTITIES AT OUTLET: FARMERS-DEPUTY COLLECTOR	COORDINATION ENTITY BELOW OUTLET: FARMERS	COMMUNICATION-LINE FOR REGUL. OF DISPUTES: FARMER-DEPUTY COLLECTOR	PARTICIPATION-STATUS OF FARMER: INDEPENDENT	BASIS FOR WATER-PRICING: AREA OF SPECIFIED CROP GROWN	TYPE OF CROPS: INDEPENDENT	1 CUSEC PER 400 ACRES	CROPPING CALENDAR: INDEPENDENT	FLEXIBILITY OF IRRIG. INTERVAL: STAGGERED PLANTING	FIXED FLOW AT OUTLET: ~ 1 CUSEC	NO ADJUSTMENT TO VARYING CROP WATER REQUIREMENTS	WATER ALLOC. ONCE A WEEK AT FIXED TIME	NO TIME ADJUSTMENT FOR DELIVERY
BHAKRA-CAN. / HARYANA			a	b	c	d	e	f	g	h	i	k	l	m	n	o	p
ENVIRONMENTAL PARAMETERS INSTITUTIONAL ASPECTS	1	• STRONG + TRADIT. IRRIGATION-LEGISL.	·	·	+	·	·	·	+	·	·	·	·	·	·	+	·
	2	• MEDIUM ADMIN. CAPACITY	+	+	−	+	−	·	−	·	·	·	·	+	+	+	+
	3	• POOR SOCIAL COHESION (STRONG COMPETITION FOR WATER	+	+	·	+	+	+	·	·	−	·	·	+	·	+	−
RESOURCES	4	• HOLDING SIZE MEDIUM (~ 4 ha)	·	+	+	+	+	+	·	·	·	·	+	·	·	·	·
	5	• HIGH WATER SCARCITY	+	+	·	+	+	+	−	·	+	+	·	−	−	+	+
	6	• SCARCE FINANCIAL RESOURCES FOR O+M	+	+	·	+	·	·	·	·	·	·	·	+	+	·	·
FARMERS GOALS	7	• RISK AVOIDANCE	·	+	·	+	+	+	·	+	·	+	+	+	·	+	·
	8	• FOOD SECURITY	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·
	9	• SECURE WATER-RIGHTS	+	+	+	+	+	·	·	·	·	·	·	·	·	·	·
	10	• MAXI. OF NET RETURNS	·	·	·	·	·	·	·	·	−	·	+	−	−	·	−
	11	• EQUITABLE WATER RIGHTS	+	+	+	+	+	·	·	·	·	·	·	+	·	·	−
PROJECT GOALS	12	FINAL: - POVERTY/REDUCT./DISASTER COM.															
	13	1.ORDER: • DROUGHT-PROTECTION • HIGH PRODUCTIV. OF WATER															
	14	2.ORDER: • CROPPING-INTENSITY ≈ 40 %	·	·	·	·	·	·	·	·	+	·	·	+	·	·	−
	15	• IRRIG. OF LARGEST FEAS. AREA	·	·	·	·	·	·	·	·	+	·	·	−	−	·	·
	16	3.ORDER: • TIMELY + PREDICT. DISTRIB. OF 1 CUSEC PER 400 ACRES	·	·	·	·	·	·	·	·	·	·	·	+	+	+	−
	17	• EQUITABLE + PREDICTABLE DISTIBUT. OF 1 CUSEC PER 400 ACRES	+	+	+	+	+	·	·	·	·	·	·	−	·	·	−

⊞ - DESIGN CHARACTERISTIC TAKES ENVIRONMENTAL PARAMETER INTO ACCOUNT OR SUPPORTS SPECIFIC GOAL IN QUESTION

⊟ - DESIGN CHARACTERISTIC IN CONFLICT WITH ENVIRONMENTAL PARAMETER OR WITH GOAL

⊡ - NO PARTICULAR RELATIONSHIP BETWEEN DESIGN CHARACTERISTIC AND ENVIRONMENTAL FACTOR OR GOALS

TAB. 6.1

The project goals to provide disaster-prevention and drought protection imply the provision of little irrigation-water for many people instead of intensive irrigation for a few. This goal necessarily remains in conflict with the individual farmers objective of profit-maximization, whose viewpoint RAJ and REIDINGER take in statement (ii). However the project-goal of drought protection is in line with the farmers aims of risk avoidance and food security. to bridge the gap between these conflicting goals, organizational and physical design-characteristics had to be selected taking into account the prevalent environmental parameters:

- to provide little water to many people entails corresponding extension of the canal-system and hence -unavoidingly- increases water losses (see RAJ: point (i)).
- objectives to enlarge the canal network tend to be in conflict with the situation variable "medium administrative capacity". Hence to be able to achieve this objective design features were selected that account for the mentioned constraint: fixed flows at chak-outlets do not require regulation operations, and hence save man-power otherwise required for operation and administrative purposes. However, such fixed flows, again unavoidingly, entail increased water losses and cannot match varying crop water requirements. (RAJ points (ii) and (iii)).
- to cope operationally with differing water requirements of a large number of users and to prevent stronger farmers from taking more than their due share - trying to satisfy their profit maximization goal - a simple system of reliable, timely and easily predictable rotation had to be introduced: the fixed turns once a week. By necessity this mode of distribution remains in conflict with individual farmers goal to satisfy optimum crop water requirements (RAJ point (ii)).

Hence RAJ and REIDINGER, failing to take into account the systems interactions mentioned above, were unaware of the fact that a remedy of the - undoubtedly existing - conflicts they mentioned, would necessitate adjustments of design-characteristics which then would induce themselves other conflicts with existing goals and given environmental conditions. "Improvements" in such a multiple objective systems context can thus only be judged in view of the <u>overall</u>

changes in the system which they bring about.

6.4 The transfer of Warabandi - systems interactions

As mentioned in para 6.2, the intention of World Bank supported RWS-projects in India is to transfer the "sucessful" principles of Warabandi into irrigation-schemes elsewhere in the country. One of the most frequently mentioned projects of this kind is the Sree-Rama-Sagar (or "Potchampad"-) project in Andhra Pradesh, where 600 000 hectares of potential irrigation-area are supplied with water from the Ghodavari-river-system by means of three storage- and diversion -dams. Looking at the situation-variables and the projects-goals however, reveals substantial differences to conditions under which Warabandi is used in Haryana: TAB 6.2 represents environmental conditions and goal-systems of the Sree-Rama-Sagar-Project related however to the design-characteristics of traditional Warabandi, equal to those given in TAB 6.1 . The ensuing incompatibilities mean that design-characteristics of traditional Warabandi, if used in this system-context induce substantial conflicts and problems, as indicated by minus-signs in TAB.6.2 . TAB. 6.3 then shows modifications in design-characteristics, environmental parameters and goals systems that have proved to be necessary due to incompatibilities in systems-interactions. Some of the major problem areas in the system balance that emerged in this "transfer of technology" are the following:

a) The project-goals are substantially different from drought protection and maximization of water-productivity as persued in Haryana: the operationalized objective is a cropping intensity of 100%, i.e. the aim is to achieve one optimal crop per holding per year (non-rice crops in the dry-season or paddy in the monsoon-season) and thus contribute to increases in per-capita-incomes and agricultural surplus production. This change in goals induced unforseen interactions in the "environment/goals/design - characteristic"-relationships.
The constant flow at the chak-outlet had to be fixed according to the estimated peak water requirements of the average cropp-

DESIGN-CHARACTERISTICS ENVIRONMENTAL PARAMETERS + GOAL SYSTEMS				DESIGN CHARACT. OF TRADIT. WARABANDI														
				ORGANIZATIONAL							TECHNICAL							
				CONTROL-ENTITY AT OUTLET: FARMERS	CONTROL-ENTITY BELOW OUTLET: INDIV. FARMER	COORDINATION-ENTITIES AT OUTLET: FARMERS-DEPUTY COLLECTOR	COORDINATION ENTITY BELOW OUTLET: FARMERS	COMMUNICATION-LINE FOR REGUL. OF DISPUTES: FARMER-DEPUTY COLLECTOR	PARTICIPATION-STATUS OF FARMER: INDEPENDENT	BASIS FOR WATER-PRICING: AREA OF SPECIFIED CROP GROWN	TYPE OF CROPS: INDEPENDENT	1 CUSEC PER 400 ACRES	CROPPING CALENDAR: INDEPENDENT	FLEXIBILITY OF IRRIG. INTERVAL: STAGGERED PLANTING	FIXED FLOW AT OUTLET: ~ 1 CUSEC	NO ADJUSTMENT TO VARYING CROP WATER REQUIREMENTS	WATER ALLOC. ONCE A WEEK AT FIXED TIME	NO TIME ADJUSTMENT FOR DELIVERY
SREE-RAMA-SAGAR - PROJECT				a	b	c	d	e	f	g	h	i	k	l	m	n	o	p
ENVIRONMENTAL PARAMETERS	INSTITUTION. ASPECTS	1	• NEW + WEAK IRRIGATION-LEGISL.	·	·	—	·	—	·	—	·	·	·	·	·	·	·	·
		2	• WEAK ADMINISTR. CAPACITY	+	+	—	+	—	—	—	·	·	·	·	+	+	+	+
		3	• POOR SOCIAL COHESION	+	—	—	—	·	+	·	·	·	·	·	+	·	·	—
	RESOURCES	4	• SMALL SIZE OF HOLDINS (av. ~ 0.4 ha)	·	—	—	—	—	—	—	·	·	—	—	·	·	·	·
		5	• WATER SUFFICIENT IN EARLY IMPLEM. STAGES	·	·	·	·	·	·	·	·	—	·	·	·	—	·	—
		6	• SCARCE FINANCIAL RESOURCES FOR O+M	+	+	·	+	·	·	·	·	·	·	·	·	·	·	·
	FARMERS GOALS	7	• RISK AVOIDANCE	·	—	·	—	—	—	·	+	·	+	·	+	+	+	·
		8	• FOOD SECURITY	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·
		9	• SECURE WATER-RIGHTS	—	—	—	—	—	—	·	·	·	·	·	·	·	·	·
		10	• MAXIM. OF NET-RETURNS	·	·	·	·	·	·	·	+	—	·	·	—	—	·	—
		11	• EQUITABLE WATER-RIGHTS	—	—	—	—	—	—	·	·	·	·	·	+	·	·	—
PROJECT GOALS		12	FINAL: • IMPROV. OF LIVING STANDARDS															
		13	1. ORDER: • INCREASES IN PER CAP. INCOMES • INCREASE OF AGR. PROD. + EQUIT. W-DISTR.															
		14	2. ORDER: • CROPPING INTENSITY OF ~ 100 %.	·	·	·	·	·	·	·	·	—	·	·	—	—	—	—
		15	3. ORDER: • PROVISION OF CROP-WATER REQU. FOR SPECIFIED CROP (1 SEASON)	·	·	·	·	·	·	+	+	—	+	·	—	—	—	—
		16	• TIMELY + PREDICTABLE DISTRIBUTION OF 1 CUSEC PER 100 ACRES	·	·	·	·	·	·	·	·	·	·	·	+	+	+	—
		17	• EQUITABLE DISTRIBUTION OF 1 CUSEC PER 100 ACRES	—	—	—	—	—	—	·	·	·	·	·	+	·	·	—

⊞ = DESIGN CHARACTERISTIC TAKES ENVIRONMENTAL PARAMETER INTO ACCOUNT OR SUPPORTS SPECIFIC GOAL IN QUESTION

⊟ = DESIGN CHARACTERISTIC IN CONFLICT WITH ENVIRONMENTAL PARAMETER OR WITH GOAL

⊡ = NO PARTICULAR RELATIONSHIP BETWEEN DESIGN CHARACTERISTIC AND ENVIRONMENTAL FACTOR OR GOALS

TAB. 6.2

		DESIGN-CHARACTERISTICS ENVIRONMENTAL PARAMETERS + GOAL SYSTEMS	MODIFIED DESIGN-CHARACTERISTICS OF WARABANDI: RWS														
			ORGANIZATIONAL							TECHNICAL							
			CONTROL-ENTITY AT OUTLET: CHAK-COMMITTEE (PRESID.)	CONTROL-ENTITY BELOW OUTLET: GROUPS OF ZONES	COORDINATION-ENTITIES AT OUTLET: CHAK-COMMITTEE - DEPUTY COLLECTOR	COORDINATION ENTITY BELOW OUTLET: CHAK-COMMITTEE	COMMUNICATION-LINE FOR REGUL. OF DISPUTES: FARMER - GROUPS-COMMITTEES-COLL.	PARTICIPATION-STATUS OF FARMER: GROUP-MEMBER	BASIS FOR WATER-PRICING: AREA	TYPE OF CROPS: INDEPENDANT BUT NO RICE OR ONLY RICE (KHARIF)	1 CUSEC PER 100 ACRES (NON RICE) 1 CUSEC PER 40 ACRES	CROPPIN CALENDAR: INDEPENDANT	FLEXIBILITY OF IRRIG. INTERVAL: STAGGERED PLANTING	FLOW REGULATION ACCORDING TO CROP WATER-REQUIREMENTS	ADJUSTMENT TO VARYING CROP WATER REQUIREMENTS	WATER ALLOCATION ONCE A WEEK AT FIXED TIME	TIME ADJUSTMENTS FOR DELIVERY
SREE-RAMA-SAGAR-PROJECT			a′	b′	c′	d′	e′	f′	g′	h′	i′	k	l	m′	n′	o	p′
ENVIRONMENTAL PARAMETERS a) INSTITUTIONAL ASPECTS	1	• NEW+WEAK IRRIGATION-LEGISL.	·	·	−	·	+	·	+	·	·	·	·	·	·	·	·
	2	• WEAK ADMINISTR. CAPACITY	+	+	+	+	+	+	+	·	·	·	·	−	−	+	−
	3	• POOR SOCIAL COHESION	−	−	−	−	−	−	·	·	·	·	·	−	·	·	+
	3′	• NEW WATERUSER GROUPS+ COMMITTEES	+	+	+	+	+	+	·	·	·	·	+	+	·	·	·
b) RESOURCES	4	• SMALL SIZE OF HOLDINGS (av.~ 0.4 ha)	+	+	+	+	+	·	+	·	·	−	−	·	·	·	·
	5	• WATER SUFFIC. IN EARLY IMPLEM. STAGES	·	·	·	·	·	·	·	·	+	·	·	·	+	·	+
	6	• SCARCE GOVERNMENT-INVESTMENT-FUNDS	·	·	·	·	·	·	·	·	·	·	·	−	−	·	·
c) FARMERS GOALS	7	• RISK AVOIDANCE	+	+	·	+	+	+	·	+	·	+	·	−	−	+	·
	8	• FOOD SECURITY	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·
	9	• SECURE WATER-RIGHTS	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·
	10	• MAX. OF NET RETURNS	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·
	11	• EQUITABLE WATER RIGHTS	+	+	+	+	+	+	·	·	·	·	·	+	·	·	+
	11′	• SOCIAL STATUS IN USER ASSOC.	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·
PROJECT GOALS	12	FINAL: IMPROVEMENT OF LIVING STAND.															
	13	1. ORDER: • GROWTH IN INCOMES • INCREASE IN AGRIC.PROD. • REDISTR. OF BENEFITS															
	14	2. ORDER: • CROPPING INTENSITY ~ 100 %	·	·	·	·	·	·	·	·	+	·	·	+	+	−	+
	15	3. ORDER: • PROVISION OF CROP WATER REQU. FOR SPECIFIED CROP (ONE SEAS.)	·	·	·	·	·	·	·	+	+	+	·	+	+	−	+
	15′	• STRENGTHENING OF ADMIN. CAPACITY	·	·	+	·	+	·	·	·	·	·	·	+	+	·	·
	15″	• FUNCTIONING WATER USERS ASSOCIAT.	+	+	+	+	+	+	·	·	·	·	+	·	·	+	+
	16	• TIMELY+PREDICTABLE DISTRIBUTION OF 1 CUSEC PER 100 ACRES	·	·	·	·	·	·	·	·	·	·	·	−	−	+	+
	17	• EQUITABLE DISTRIBUTION OF 1 CUSEC PER 100 ACRES	+	+	+	·	·	·	·	·	·	·	·	+	·	·	+
	17′	• ESTABLISHED USER GROUPS+ COMMITTES	+	+	+	+	+	+	·	·	·	·	+	·	·	+	+
	17″	• FUNCTIONING EXT. SERVICE	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·

⊞ = DESIGN CHARACTERISTIC TAKES ENVIRONMENTAL PARAMETER INTO ACCOUNT OR SUPPORTS SPECIFIC GOAL IN QUESTION

⊟ = DESIGN CHARACTERISTIC IN CONFLICT WITH ENVIRONMENTAL PARAMETER OR WITH GOAL

⊡ = NO PARTICULAR RELATIONSHIP BETWEEN DESIGN CHARACTERISTIC AND ENVIRONMENTAL FACTOR OR GOALS

TAB. 6.4

ing pattern in the chak, and was estimated to 1 cusec per 100 acres in dry-season for non-rice and 1 cusec per 40 acres in monsoon-season for paddy (as compared to 1 cusec per 400 (!) acres in traditional Warabandi). Such a substantial increase in irrigation-duties however seriously aggravated the problem of overirrigation in time-periods outside peak requirements due to fixed flows at the chak-outlet already mentioned above: serious problems of waterlogging and subsequent yield-depressions forced the management recently to abandon this Warabandi-principle of constant flow, and flow regulating structures are now being installed. (see TAB. 6.2 , 14-m, 15-m; TAB. 6.3 , 14-m' and 15-m').

However, in the same way as the change in goals (from drought protection to 100% cropping intensity) and the subsequent change in design-characteristics (from 1 cusec per 400 acres to 1 cusec per 100 (4) acres) induced changes in situation parameters (water logging problems + farmers goals with emphasis on profit maximization), the attemps to remedy this problem by introduction of flow regulation brings about new conflicts with environmental factors as well as with the existing goal system:

Flow regulation in correspondance with crop water requirements asks for evapotranspiration measurements and estimates of water requirements, entails needs for regular gate adjustments and induces increased maintenance and repair works. This however conflicts with environmental factors like poor administrative capacity and scarce government financial resources for operation and maintenance (O + M) (TAB. 6.3 , 2-m'+n'; 6-m'+n'). Moreover, new conflicts with prevailing objectives emerge: flow regulation - especially under conditions of low administrative capacity - will counteract intentions for reliable, timely and predictable water allocation and will hence be in conflict with farmers objective of risk avoidance. (TAB. 6.3 , 7-m+n, 16-m+n)

This leaves basically two options: 1) new goals are added, i.e. strengthening of administrative capacity and improving of O+M, and are operationalized by clear definition and quantification (TAB. 6.3 , row 15') and additional government funds are provided. 2) Or: goal chievement levels are reduced, e.g. to lower percentage values of intended cropping intensity.

In case none of these options is taken, the system may equilibrate itself: the inconsistency in the goal/environment/ design constellation may result in "project-failure"; the achievement levels envisaged may not be reached.

b) Not only the project goals but also environmental conditions are substantially different in Sree-Rama-Sagar from traditional Warabandi schemes: while the average size of holdings in the Haryana-section of the Bhakra-Canal-System is approx. 4 ha, the average holding in Sree-Rama-Sagar comprises only 0.4 ha.

Again, this change in systems parameters entails the need for substancial readjustments:

A regular weekly water-turn - the core of Warabandi design characteristics - poses no major problems in Haryana if crops and soil conditions require a two- or three-weekly rotation instead. The farmer can subdivide his holding into several parts and "stagger" his cropping and his water allocations accordingly.

In Sree-Rama-Sagar however, such strategies encounter problems. To divide a small holding of a fraction of a hectare into several subsections and then stagger planting and irrigating will be impossible: to provide all the different labour inputs - from land-preparation till to harvest - at different times for different small land-segments will be uneconomic for the farmer especially if he lives some distance from his irrigation plot. He will hence try to cooperate with his neighbours and take his turn only every second or third week, but then the double or triple volume of his usual water allowance. This adjustment however curtails the objective to make water allocation reliable and easily predictable, and hence - in times of water shortages - may conflict with the farmers risk avoidance objectives. (TAB. 6.2 , 7-o, TAB. 6.3 , 7-o)

c) Warabandi as practiced in Northwest-India satisfies the farmers goal of access to secure water rights by means of coordination of operational activities and by communication in case of conflicts directly between water users and the administration (deputy collector). However, again, differing environmental conditions in Sree-Rama-Sagar induced changes in these organizational characteristics:

Direct farmer/administration contacts are feasible in Haryana due to relatively large holdings - and hence a limited number of farmers to be dealt with per unit area - and due to age-old Warabandi traditions which restrict the number of conflict cases. Rights and obligations of the users are known since generations and are well established in the irrigation-legislation which dates back to the "Northern-India-canal-and-drainage-act" of 1873. Penalties for violations of rules are known to be "draconian"1).

In Sree-Rama-Sagar however, small holding sizes - and hence large numbers of users per unit area - combined with poor administrative capacity and a relatively new and still largely unknown irrigation legislation render the above mentioned Warabandi practices unpracticable. (see TAB.6.2 , row 9 a-f and row 1-3).

To overcome this problem, water users associations have been created in order to transfer partial conflict regulation as well as control- and coordination tasks to user groups. This changed substancially the institutional environment faced by the farmers and meant that corresponding operational project goals for the creation and maintenance of such associations had to be added to the goal system of the project, including establishment of corresponding extension provisions (see TAB. 6.3 , rows 3', 11', 15'', 17' and 17'').

The introduction of such water users associations and the corresponding change in organizational design characteristics (see TAB.6.3 columns a' to f') may solve the above mentioned problems if such assiciations are functioning properly. However it may be difficult to bring about such a functioning in a context of relatively poor social cohesion (see TAB. 6.3

---

1) SECKLER (1981) p. 26

row 3) - and thus ensure secure water rights even to a socially weak smallholder. Nevertheless, the fact, that SECKLER[1] argues categorically against water user associations as being "counter-productive" in the context of RWS-projects appears to neglect the nature of the above mentioned systems interelationships.

The foregoing observations show, that the transfer of Warabandi from given "environment/goal/design"-circumstances as prevalent in Haryana to "foreign" systems preconditions in Sree-Rama-Sagar, necessarily effected goals, design-features and environment and changed the Warabandi character of the water management system nearly beyond recognition.

6.5 Conclusion

The case exemple outlined in this chapter was meant to illustrate the dynamics of systems interrelationships between environmental parameters, goal systems and organizational/physical design parameters of irrigation schemes.

It shows that the systems nature of multiple objective smallholder irrigation schemes and the only partially influencable character of the physical and institutional environment in which they are set up requires a carefully balanced approach between these very environmental factors, the goals to be achieved and the design features of the irrigation organization to be established.

The admirable achievements of Warabandi to bring about an equitable water distribution to smallholders hardly matched in government initiated projects in the Third World are certainly worth efforts to be replicated elsewhere - if local systems interrelationships allow.

---

1) SECKLER (1981) p. 30/31

REFERENCES

ADAMS, W.M. (1983) "Irrigation as hazard : farmers' responses to the introduction of irrigation in Sokoto, Nigeria". Paper presented at ODI-workshop on irrigation in Tropical Africa, March (mimeo)

AYRES, Robert L. (1983) "Banking on the "poor" - the World Bank and world poverty" MIT-Press, xiv + 282 pp.

BARLETT, Peggy F. (Ed.) (1980) "Agricultural Decision Making" Academic Press London, xv + 378 pp.

BAUM, Gerhard, A. and Shem Migot-Adholla (1982) "South Kano Irrigation Scheme - Socio Economic Adjustments in Rural Development Planning". Quarterly Journal of International Agriculture, 21, (1): 37-51

BAXTER, R.E. and Ray Rees "The Penguin dictionary of economics" Penguin Books, 466 pp.

BELSHAW, D.G.R. (1976) "Improving management procedures for agricultural development" in HUNTER, G.; A.H. Bunting and A. Bottrall (Editors) (1976) p. 414-428

BERGMANN, Hellmuth (1973) "Guide to the economic evaluation of irrigation projects" , OECD, Paris, 133 pp.

BERRY, Sara S. (1980) "Decision making and policymaking in rural development" in Peggy F. Barlett "Agricultural Decision Making" Academic Press

BERRY, R. Albert and William R. Cline (1979) "Agrarian Structure and productivity in developing countries" John Hopkins

BERRY, Leonhard; Richard Ford and Richard Hosier (1980) "The impact of irrigation on development : issues for a comprehensive evaluation study", A.I.D. Program Evaluation Discussion Paper No. 9

BHARADWAJ, Krishna and P.K. Das (1975) "Tenurial conditions and mode of exploitation - a study of some villages in Orissa". Economic and Political Weekly, Annual Number, Feb. and Review of Agriculture, June

BIGGS, Stephen D. (1978) "Planning rural technologies in the context of social structures and reward-systems". Journal of Agricultural Economics, Sept.

BOS, M.G. and J. Nugteren (1974) "On irrigation efficiencies" ILRI, Wageningen, The Netherlands, Publication No. 19, vi + 89 pp

BOTTOMLEY, Anthony (1979) "Designing irrigation schemes for risk avoidance" in ICID Bulletin, July, pp 69-75 .

BOTTRALL, Anthony F. (1981) "Comparative study of the management and organization of irrigation projects" World Bank Staff Working Paper No. 458, Washington D.C. ii + 274 pp.

BROMLEY, Daniel W. (1982) "Improving irrigated agriculture - institutional reform and the small farmer" World Bank Staff Working Paper No. 531 Washington D.C.

BROMLEY, D.W., D.C. Taylor and D.E. Parker (1980) "Water reform and economic development : institutional aspects of water management in the developing countries." Economic Development and Cultural Change 28 (2) pp. 365-387

CARRUTHERS (1976) "Planning and management linkages - electic observations of a dilettante irrigation planner". Paper presented at ODI. Workshop on choices in irrigation management. 27. Sept. - 1. Oct.

CARRUTHERS, Jan (1979) "Too late to change. The reality of multidisciplinary planning in irrigation". Paper presented at a conference at the Institute of Development Studies 4-7 Dec. (mimeo)

CARRUTHERS, Jan (1982) "Irrigation development : implications of recent experience for aid policy" . Issue paper for Workshop on Irrigation Development Assistence, OECD, Paris

CARRUTHERS, Jan and Colin Clark (1981) "The economics of irrigation" Liverpool University Press xviii + 300 pp.

CARRUTHERS, Jan,D. and N. Mountstephens (1978) "Integration of Socio Economic and Engineering Perspectives in Irrigation Design" in Development Research Digest, 2, IDS, Sussex

CARRUTHERS, Jan and M. Upton (1982) "Guidelines for small scale irrigation development in Africa - economic issues", Paper presented to the Working Party on Small Scale Irrigation in Africa, FAO, Rome (mimeo)

CHAMBERS, Robert (1977) " Men and water : the organization and operation of irrigation" in B.H. Farmer (Ed.) "Green Revolution?" Mac Millan Press, xvi + 429 pp.

CHAMBERS, Robert and Jon Moris (Eds) (1973) "Mwea - an irrigated rice settlement in Kenya" Weltforum Verlag, München, 539 pp.

COWARD, E. Walter (Ed.) (1980) "Irrigation and agricultural devevelopment in Asia", Cornell Univ. Press, 369 pp.

DAVEY, C.J.N and J.R. Rydzewski (1976) "Relation between irrigation project technology and management", Paper presented at ODI Workshop on choices in irrigation management (mimeo)

DAVIES, Jonathan (1983) "Water revolution? - Irrigation and agricultural development", Department of Agricultural Economics and Management, Univ. of Reading, Dissertation

DE GREENE, Kenyon B. (1973) "Sociotechnical systems - factors of analysis, design and management", Prentice Hall Inc. Eaglewood Cliffs, New Jersey xvi + 416 pp.

DE LOS REYES, R.P. (1979) "Stereotypes and facts in irrigation management : preliminary findings from a case study of a Philippine communal gravity system", in Donald C. Taylor and Thomas H. Wickham "Irrigation policy and the management of irrigation systems in Southeast Asia", ADC, Bangkok.

DOPPLER, Werner (1977) "Towards a general guideline of irrigation water charging policy", Agricultural Administration (4) p. 121-129

GIBBONS, David S.; Rodolphe de Koninck and Ibrahim Hasan (1980) Agricultural modernization, poverty and inequality" Gower, ix + 225 pp.

GITTINGER, J.P. (1982) "Economic analysis of agricultural projects", John Hopkins xxi + 505

GRIFFIN, Keith (1979) "The political economy of agrarian change", Second ed., Mac Millan Press, London, xxiii + 268 pp.

GRIFFITH, W.J. (1983) "Madness of fowl, marriage with cat", Paper presented at ODI-workshop on irrigation in tropical Africa, March (mimeo)

HARRISS, John (1976) "Problems in water management policy and objectives : the role of local institutions and their relationship with bureaucracy", ODI workshop on choices in irrigation management 27. Sept. - 1.Oct. 1976 (mimeo) 8pp.

HAZLEWOOD, Arthur and Ian Livingstone (1982) "Irrigation economics in poor countries", Pergamon Press, viii + 144 pp.

HOBEN, Allan (1980)"Agricultural decision making in foreign assistance : an anthropological analysis", in BARLETT (Ed.) (1980) pp 337-369

HOLY, M. (1982) : "Irrigation systems and their role in the food crisis", in ICID Bulletin, 31 (2) pp. 4-24

HOSSAIN, Mahabub (1977) "Farm Size, tenancy and land productivity - An analysis of farm level data in Bangladesh Agriculture", Bangladesh Development Studies, V (3), July

HUNTER, Guy; A.H. Bunting and A. Bottrall (1976) "Policy and practice in rural development", Eroom Helm, London, 520 pp.

HUPPERT, Walter (1983) "Aspekte kleinbäuerlicher Bewässerung in Indien" in Entwicklung und ländlicher Raum 3, pp. 17-22

ISLAM, Tarafder R. (1977) "Socio economic and institutional factors determining efficiency of low-lift pump-irrigation in Bangladesh" in STAUB, W.J. (Ed.) Proceedings of a workshop on implementing public irrigation programs, Honululu, Hawaii : East-West Food-Institute (1977)

JAHNKE, H. and R. von Oven (1980): "Planungskontrolle und Monitoring bei landwirtschaftlichen Projekten in Entwicklungsländern" in Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus 17, pp. 705-728

JOHL, S.S. (1980) "Irrigation and agricultural development" Pergamon Press, x + 370 pp.

JURRIENS, M. and M.G. Bos (1980) "Developments in planning of irrigation projects", in ILRI, Publication, Wageningen, The Netherlands, P.No. 21

KORTENHORST, L.F. (1980) "Factors affecting the viability of smallholder irrigation", in ILRI, Publication No. 21, Wageningen, The Netherlands, pp. 125-138

LAZARO, R.C.; D.C. Taylor and T.H. Wickham (1979) "Irrigation policy and management issues :an interpretive seminar summary" in Irrigation policy and the management of irrigation systems in Southeast Asia", ADC, Bangkok

LIPTON, Michael (1977) "The technology, the system and the poor" : the case of the new cereal varieties", Paper for the Institute of Social Science Studies 25th Anniversary Conference, The Hague

MALHOTRA, S.P. (1982) "The Warabandi and its infrastructure", Central Board of Irrigation and Power, New Delhi, Publication No. 157

MC INERNEY, John P. (1978) "The Technology of Rural Development", World Bank, Staff Working Paper No. 295, Washington D.C.

MÜLLER, Julius (1977) "Gedanken zur soziologischen Problematik von Bewässerungssystemen im Rahmen der staatlichen Entwicklungspolitik in Zeitschrift für Bewässerungswirtschaft, Vol. 2, pp 187-222

NIX, J.S. (1979) "Farm Management : the state of the art (or science)" Journal of Agriculture Economics" 30 (3), pp 277-292

NORMAN, D.W. (1976) "The organizational consequences of social and economic constraints and policies in dry-land areas" in Guy Hunter, A.H. Bunting and A. Bottrall "Policy and Practice in Rural Development, Croom Helm London

ORAM, Peter (1980) "Development of appropriate crop technology for irrigated agriculture in semi-arid regions" in JOHL (1980) pp 51-83

ORTIZ, Sutti (1980) "Forecasts, decisions and the farmer's response to uncertain environments", in P. BARLETT (1980) pp. 177-202

PARKER, Barnett R. and A.D. Kaluzny (1982) "Design planning to meet goals in human service organisations", Human Systems Management 3, pp. 77-90

PATZAK, G. (1982) "Systemtechnik - Planung komplexer innovativer Systeme", Springer Berlin, Heidelberg, New York, xiv + 445 pp

PEARCE, Richard (1983) "Sharecropping : towards a Marxist view", Journal of Peasant Studies 10 (2/3) pp 42-70

PEARSE, Andrew (1980) "Seeds of plenty, seeds of want - social and economic implications of the Green Revolution", Clarendon Press, Oxford, xi + 262 pp

REIDINGER, R.B. (1980) "Water management by administrative procedures in an indian irrigation system" in COWARD (1980) pp. 263-288

ROUMASSET, James A. (1976) "Rice and Risk" North Holland Publishing Co., xxi + 251

RUSTEMEYER, Friedrich C. (1964) "Die Productivität der Landwirtschaft - Begriff, Messung und Anwendung" Alfred Strothe, Hannover, 117 pp.

RUTHENBERG, Hans (1980) "Farming systems in the tropics", Claredon Press, Oxford, xxii + 424 pp

SAGARDOY, J.A. (1982) "Organization, operation and maintenance of irrigation schemes", FAO Irrigation and Drainage Paper No. 40, Rome, viii + 166 pp.

SAGE, A.P. (1981) "Systems-engineering; Fundamental limits and future prospects", Proceedings of IEEE, 69, No. 2, 158-66, Feb.

SANDERS, John H. (1979) "New Agricultural Technology in the Brazilian Sertao" in Proceedings to International Workshop on socio-economic constraints to development of semi-arid tropical agriculture", ICRISAT, Hyderabad, India

SECKLER, David (1981) "The new era of irrigation management in India" (mimeo)

SMITH, William E., Francis J. Lethem and Ben A. Thoolen (1980) "The design of organizations for rural development projects - a progress report", World Bank Staff Working Paper No.375, Washington D.C.

SPREDDING, C.R.W. (1979) "An introduction to agricultural systems", Applied Science Publ. London, ix + 169 pp.

STAUB, William J. and Donald G. Green (1977) "A performance management unit for agricultural agencies" in STAUB, W.J. (Ed.) Proceedings of a workshop on implementing public irrigation programs, Honululu, Hawaii : East-West Food-Institute (1977).

THORNTON, D.S. (1966) "Contrasting policies in irrigation development", University of Reading, Development Study No. 1

THORNTON, D.S. (1969) "Human and social aspects of irrigation development" in "The economics of irrigation development" Development Study No. 6, Univ. of Reading, pp 50-63

THORNTON, D.S. (1975) "Some aspects of the organisation of irrigated areas" in Agricultural Administration Vol. 2 (3), pp. 179-194

THORNTON, D.S. (1976) "The organisation of irrigated areas" in HUNTER et al. (1976) pp. 147-157

THORNTON, D.S. (1983) "Technology and institutions for increased food consumption and production among the rural poor in Southern India" Univ. of Reading, Department if Agric. Econ. and Management, Discussion Paper 1/83

UPTON, Martin (1973) "Farm management in Africa - the principles of production and planning", Oxford University Press, reprint 1979, xiv + 341 pp.

UPTON, Martin (1979) "The unproductive production function" Journal of Agric. Economics, 30(2) pp 179-195

WALKER, Hans H. (1981) "Die Organisation von Bewässerungssystemen", Doctoral Thesis, Univ. Hohenheim, Germany, 385 pp

WALKER, Hans H. (1982) "Determinants in the organization of irrigation projects" Univ. of Hohenheim, Germany (mimeo)

WALKER, Hans H. and W. Graf zu Castell (1979) "The contribution of organisation analysis to the appraisal of development projects - the example of the Ahloo Pilot Irrigation Scheme in Kenya" in Zeitschrift für Ausländische Landwirtschaft 18(1) pp 49-68

WORLD BANK (1981) "Accelerated development in sub-saharan Africa - an agenda for action", Washington, D.C.

ZAPATA, Juan A. (1980) "Policy Framework for investment in irrigation projects" in Johl (1980), pp. 41-50

ZUCKERMAN, P.S. (1977) "Different smallholder types and their development needs", Journal of Agricultural Economics 28, 119-128