Irrigation Management: Ends, Means and Opportunities

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Robert Chambers

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Abstract

Views differ about objectives and criteria for irrigation and irrigation management - between individuals, groups, disciplines, professionals and departments; according to whether one or several objectives and criteria are considered; according to who is meant to benefit; and according to where objectives and criteria are located on long causal chains. As a practical framework, five focal objectives and criteria are proposed: productivity, especially of water; equity, especially in its distribution; long-term stability, both environmental and through maintenance of works; carrying capacity (livelihood-intensity), reflecting the size of population supported at a decent and secure level; and well-being, including health, amenity, nutrition and psychic factors. Measures to optimise achievement of these objectives include decisions about the size and location of area to be irrigated; changes in farm size; the scheduling and delivery of water; choice of cropping system and crop zoning; the frequency with which different zones receive irrigation; the staggering of cultivation; and the spatial and temporal spread of cultivation rights. Bringing this repertoire to bear, there appear to be rather few serious conflicts between the objectives. Perhaps the main one is between productivity and equity where high transmission losses reduce the productivity of system water distributed to tailends, but this is often offset by the highly productive use of groundwater supplied by seepage losses. In contrast, complementarities are very strong, especially with redistribution of water from head to tail which can at once be more productive, more equitable, reduce waterlogging, support more livelihoods, and enhance well-being. Many constraints on optimising are linked with who gains and who loses from current practices, and who would gain and who would lose from changes. Facing these questions, the approach of practical political economy seeks realistic opportunities by asking how all can gain, or how losers can be reconciled to their losses. Three major problems and opportunities are presented by first, the professional training and incentives of irrigation managers, second, the search for ways in which headreach farmers can gain while receiving less water, and third, the purchase and distribution of land to landless and very small farmers at the time when irrigation comes. To proceed further, four next steps are proposed.

This paper is an attempt to explore objectives and criteria for irrigation and irrigation management, to state some of the principal means for achieving them, and to identify practicable approaches for optimising performance. The main attention is to South Asia, especially India, and to canal irrigation; but much of the discussion could apply also outside South Asia, and some of it applies to lift irrigation. 'Irrigation management' refers usually to the operation of irrigation, but planning and design are sometimes also embraced. An 'objective' is an 'end' or purpose, especially of irrigation generally, an effect or impact which it is intended to have, while a 'criterion' is a standard or measure of good performance, especially in irrigation management. In common usage, the two often overlap, as with 'productivity' and 'equity'.

The Quest for Criteria

The first task is to identify and agree objectives for irrigation and criteria of performance which can be used for planning, design and operation. This task is complicated by different views about objectives and criteria. For example, asked to write down their first criterion for good irrigation management, or their first objective, different people would give different answers. Five points can help to explain why this is to be expected, and also lay out some of the issues and analysis.

i. different views

Each group, discipline, profession and department has its own immediate concerns. While there would be exceptions, something like the following first immediate thoughts, reflecting the personal and professional interests of the respondents, might be expected on a first criterion for irrigation management:

Type of person	possible first criterion of irrigation management
landless labourer	increased labour demand, days of working and wages
farmer	delivery to his farm at low cost of adequate, convenient, predictable and timely water for his preferred farming practices
irrigation engineer	efficient delivery of water from headworks to outlet

type of person	possible first criterion of irrigation management
gricultural engineer	efficient field application of irrigation water from the outlet to the root zone of the crop
agronomist	'The purpose of irrigation is to create and maintain the optimum moisture regime for plant growth and in particular to maximise production of that part of the plant which is the harvestable product' (Willens 1975:1)
gricultural economist	high and stable farm production and incomes
general economist	a high internal rate of return
political economist	equitable distribution of benefits from a project especially to disadvantaged groups
sociologist	participation of irrigators in management

i. the single criterion trap

The question asked requires only one criterion or objective but many criteria, and many objectives are possible. It is then scarcely surprising that eople would differ in what they put first. After careful reflection, lists of criteria or of objectives might be agreed, with much commonality between respondents from different disciplines. But long lists are difficult to hold in the mind. One struggles to simplify. Moreover, for operational purposes, not many criteria can be handled. The trap of the single criterion is tempting: Thus in the words of a distinguished and successful irrigation manager, 'High productivity is the key...to paraphrase Matthew, 'Seek ye first production and all these things shall be added on to you' '(Giglioli 1968:9). This does not assume that production is necessarily an end in itself, but that through it other ends or objectives ('all these things') will be achieved. The two criteria that are most commonly stated singly are, first, high production or productivity, s in this example; and second, efficiency of water supply.

ii. how many gain or lose and who they are

Objectives and criteria are often expressed in terms of direct benefits to 'farmers' or 'irrigators'. But objectives may include all those who are affected, or who might be, or might have been, by a project and its management. Besides the (usually assumed to be male) farmers, this includes women, children, tenants, sharecroppers, landless labourers, and migrants attracted seasonally or permanently. Beneficiaries are also in

›me sense staff of departments working on irrigation, and even those ho attend conferences to discuss irrigation. Those who are harmed by a ·oject or its management (for example those displaced by a dam) are so part of the calculus. Objectives and criteria may thus be narrow, mited to those directly affected or broad, including various groups of others directly affected.

. objectives, criteria and causal chains

A further reason why different criteria and objectives would be ven is the length and complexity of the causal chains involved and the any points at which they can in principle be measured or assessed.

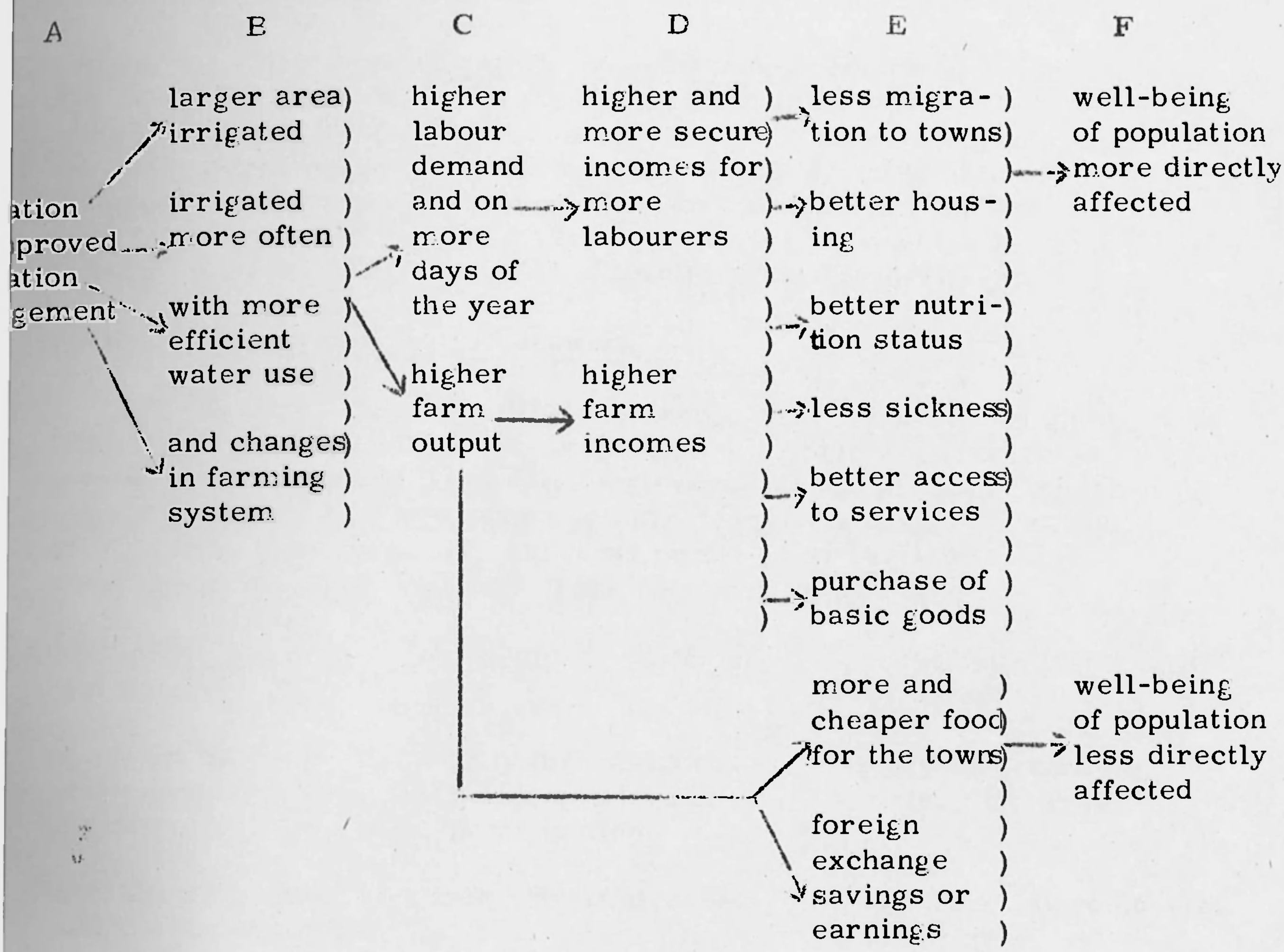
At the extreme of the general level of 'objective', there is the rerarching question of the purpose of life and the purpose of development. Perhaps all would agree that irrigation and good irrigation management should contribute to development, even though not agreeing what evelopment is. At an abstract level, expressions like 'enhancing the iality of experience' may embrace a dimension of supreme importance, it much of what that refers to is difficult to relate to the more material orld. Perhaps, becoming slightly more concrete, most people might gree, in some sense, on an objective of well-being especially for those ho are less well off, and that those who are deprived should have more what they want and less of what they do not want. Becoming more oncrete still, there is the World Bank's definition of rural development.

> 'Rural development is a strategy designed to improve the economic and social life of a specific group of people - the rural poor. It involves extending the benefits of development to the poorest among those who seek a livelihood in the rural areas. The group includes small-scale farmers, tenants and the landless.'
>
> (World Bank 1975:1)

The World Bank definition of rural development, does not, owever, include wider national objectives for the economy and the ociety which may include producing cheap food for urban areas, arning or saving foreign exchange, settling surplus population, and o on.

Here it may help to think of causal sequences and how objectives and criteria intersect with them. Some hypothetical elationships can be presented in causal sequence from left to right.

ria of irrigation management Objectives of Irrigation



Several observations and qualifications arise from this diagram:

, it only picks up some sequences of effects of irrigation. There are others, as direct health effects.

nd, each arrow postulates a cause-effect or input-output relationship. Thus irrigation or irrigation management is only an input, but the items under B both outputs from A and inputs to C, and so on, until the chain of input-output tionships ends in wellbeing for the population affected, whether directly or ectly.

d, the outputs result from much more than just the input in the diagram. higher farm output may result from technological change, weather, credit, host of other factors and their combinations). This may especially be so in links between income and well-being, with an indeterminancy which is not ial to irrigation.

fourth, the diagram assumes benefits, but effects can also be disbenefits (worse nutrition, more migration to towns, lower incomes etc.).

finally, the criteria of *irrigation management* per se are on the lefthand side of the diagram, while the objectives or impacts intended from *irrigation* are on the righthand side. Since the arrows are hypotheses, and may or may not be valid, case by case, it is possible to have irrigation management which is good by its own criteria, without achievement of a desired impact or objective, or even with a negative effect (e.g. if productivity rises but nutritional status declines).

v. the need for a practical framework

A final reason why different people can be expected to state different objectives and criteria is the lack of a universally accepted normative and practical framework for evaluating the planning, design and management of an irrigation system. Many sets of objectives and criteria have been proposed, and some people (*mea culpa*) keep on changing the ones they suggest. Thus we have, for example

productivity (of water)

equity (in its distribution to users)

stability (in maintaining the water supply)

continuity (in water use throughout the year)

carrying capacity (in sustaining population at acceptable levels of living)

(Chambers 1977:361, on what a list of objectives of irrigation in conditions of South Asia might include)

economy (production)

equity (benefit distribution and farmer participation)

efficiency (water use)

(Early 1981:1 describing potential benefits of irrigation system performance in most cases not fulfilled)

productivity (especially of water)

equity (especially of water distribution)

long-term environmental stability

at least cost

(Bottrall 1981:26, stating the assumption that the main concern of an irrigation manager of a large irrigation system should be to achieve an optimum balance between these goals. He also mentions cost recovery and employment as possible criteria (*Ibid* 26 and 43)).

Other lists have included convenience to irrigators, utility to irrigators, and quality of life.

Whatever the objectives or criteria, there will be a cost side, and a benefit/disbenefit side. The cost side is relatively well understood, whether in terms of irrigation water at the point of diversion or storage or elsewhere, of financial, staff or management costs, or of opportunity costs of not using resources elsewhere or in other ways. I shall therefore concentrate on benefit/ disbenefit side.

On this benefit/disbenefit side, there seem to be three needs: first, objectives which capture the major benefits/disbenefits which can be attributed to irrigation and irrigation management; second, operational criteria which can be assessed or measured and used to improve, monitor and evaluate irrigation planning, design and operation; and third, parsimony, in seeking objectives and criteria which are few but focal enough to capture the major dimensions and to act as proxies for others. The resulting short list should be useful for thinking about irrigation planning, design and operation, and the criteria included should be usable for the management of irrigation systems.

The list proposed here has five objectives which slice the reality at different points and in different ways, and which to varying degrees can be made operational as criteria. No doubt this list can be improved upon; for the time being it may at least provoke discussion, dissent, and progress towards something better. The five objectives are:

productivity
equity
stability
carrying capacity
well-being.

It is arguable that it would be useful to add convenience or utility of water supply to farmers, but these are partly subsumed by productivity and equity.

Five Focal Objectives and Criteria

i. productivity

Productivity means output divided by input[1]. In common parlance, it is sometimes used to mean, quite simply, production. Thus if someone were to say of an irrigation system, 'productivity has gone up', they may mean that production has gone up. Strictly, however, productivity will have gone up only if production has gone up per unit input.

In practice there are many possible meanings and measures for productivity. At the operational level, for purposes of monitoring, management and evaluation, the best measure of productivity will vary from system to system, and according to immediate purpose. A common and often useful interpretation of 'productivity' on an irrigation system is a measure of production per unit of water. Lenton (1981) has described various operational measures. He points out that productivity performance can be measured by water delivered, area irrigated, yield, or income, and the measures can be at the level of farm, of an outlet, or at higher levels of aggregation. Which of these is best will depend on circumstances. The denominator for the productivity of water can also be taken as water in the root zone, at the farm gate, at the outlet, or at higher points in the system, including the point of storage or diversion. Thus productivity can be defined:

a. <u>if water is a limiting resource</u>

oductivity =

water delivered (to outlet, farm gate, or root zone)	or	area irri- gated	or	production, or yield per unit area	or	gross income	or	net income

divided by (the line below the fraction bar):

quantity of water available or issued — at the point of diversion or in the storage, or issued from the headworks, or at points lower in the system (in each case with or without rainfall in the command area)

b. <u>if water is not a limiting resource</u>

oductivity = production or gross income or net income / land or labour or capital or management or other scarce resource

In this case, good irrigation management will still lead to high productivity, but the measure of productivity will be different.

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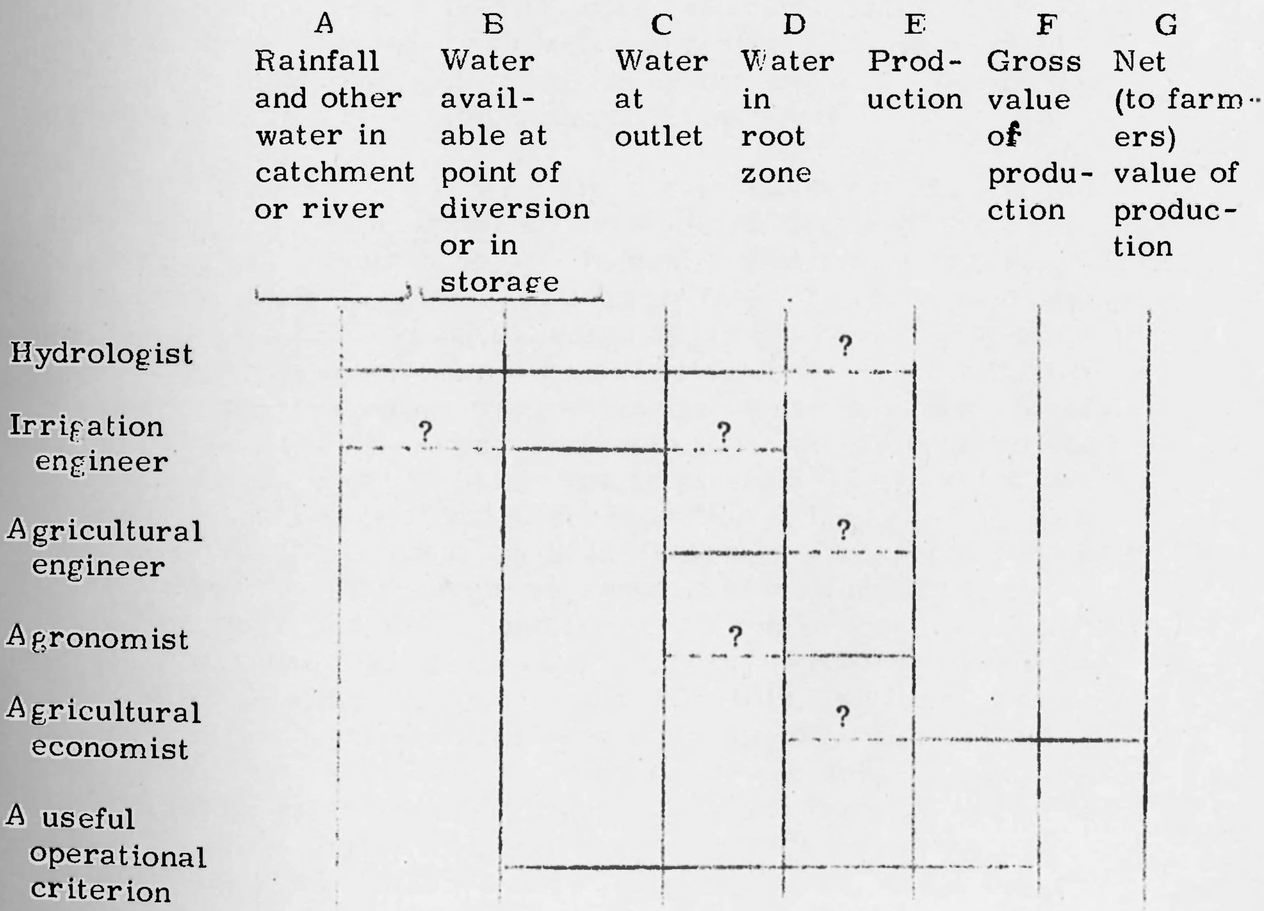
1. Productivity is defined in Bannock, Baxter and Rees' A Dictionary of Economics (Penguin 1972) as 'The 'productiveness' of a factor of production measured by expressing output as a ratio to the amount of input required to produce it; or by expressing the change in output as a ratio to the change in amount of input required to bring it about'. I am using productivity in the first of these two senses.

All of these versions of productivity are in principle measurable. Which is best operationally depends on the relative scarcities of resources, the cost and accuracy of data collection, the timeliness with which it can be analysed, its utility for management purposes once analysed, and the relationships between it and other criteria and benefits.

Taking water as the scarce resource, some of the possible measures of productivity, earlier along the causal sequence, are thus, in technical terms, efficiencies (see e.g. Bos and Nutgeren 1974), that is ratios of water at a point of delivery to water at a point of issue. These correspond interestingly with the objectives or criteria which it was supposed above that different persons and specialists might give for good irrigation or good irrigation management. Diagrammatically, these can be shown as follows:

<u>Points of Input and Cutput Measurement for Different Professions and Disciplines</u>



At both general and operational levels, the most widely useful meaning and measure of productivity, where water is limiting, may be the gross value of production (which can be measured through crop-cutting exercises and surveys of prices) divided by the water available at the point of storage or diversion. This sounds straightforward, but hardly anything to do with water is simple, except perhaps drowning. The techniques and problems of measurement of productivity of water and of the operational use of such measurements deserve separate analysis and discussion. The most serious complication is probably the conjunctive or independent use of groundwater within a command area, making it difficult to know what irrigated production to attribute to canal water, what to groundwater deriving from seepage of canal water, and what to groundwater deriving from other sources.

ii. equity

Equity is a more difficult concept. The Shorter Oxford English Dictionary calls it 'The quality of being equal or fair; impartiality; even-handed dealing.. That which is fair or right..' Applied to the practices of irrigation system planning, design and management, this raises the question: how equal?

This question has received many answers. As with the doctrine of prior appropriation (that whoever first exploits a resource has a right to continue to do so), inequality comes through usage to be regarded as a right, even if not entirely fair. Topenders, or early comers to an irrigation settlement project, gain customary usage to water which they then come to regard as their right, even though it usually means less water or no water to tailenders or late comers. Offsetting this and often conflicting with it, is the widespread doctrine of proportionate equality (Anderson and Maas 1978:41) which identifies equity with the supply of water in proportion to land surface area. In this doctrine, the inequality of landholdings is accepted and water is allocated, as in the warabandi systems of Northwest India (Malhotra 1982a and b), to each farmer in proportion to landholding size. Thus those who are already better off, with more land, get more water: and those who are worse off, with less land, get proportionately less; and those who are worst off, with no land, get none at all. In South Asia, as elsewhere, both doctrines can be found applying on the same system: headreach farmers have sometimes (as in the Cumbu Valley of the Periyar Vaigai Project in Tamil Nadu) established privileged rights to water, while lower down the project area, the theory of water distribution is that it should be proportional to land.

In India, the inequity of both doctrines is increasingly questioned. The doctrine of prior appropriation is challenged by attempts to redistribute water from headreaches to tailends (see below). About the doctrine of proportionate equality, doubts were raised at the workshop on water distribution practices held at the University of Roorkee in July 1982 (IWRS 1982) by three senior engineers, one of them asking why, if hospitals were for all, irrigation water, similarly provided from public funds, should not be for all also. Nor is proportionate equality always enshrined in traditional practice: in the village of Duli in North Arcot District, Tamil Nadu, it is said that when tank water is short it is allocated for an equal small area for each landholder regardless of landholding size. Further, two projects have recently been pioneered which apply the more equitable principle of equal personal rights to water: one under small tanks; and one with lift irrigation.

The small tanks example is the Sukhomajri project (Seckler and Joshi 1981; Malhotra 1982:61-66) near Chandigarh where each household (defined as a chula or hearth) has an equal water right, including landless households. In the words of S. P. Malhotra (1982:66):

> 'A new method was designed to allocate water first to the 'people' and only secondarily to 'land'. Some were found to be unable to utilize a part or whole of their share. For their benefit, a suitable mechanism, for marketing the surplus, has been evolved. The method ensures a water right for every family, even if it is landless, and has been named as haqbandi'.

The second example, with lift irrigation, is the Gram Gourav Pratisthan, started by Vilas and Kalpana Salunke at Naigaon in Purandar Taluka near Pune (Chambers 1981; Morehouse 1981; Parulkar 1982). Here the allocation of water is based on the number of members in a household, subject to a basic financial contribution per household member and to the household having adequate land under command of lift irrigation. Since in practice most households have land and most have been able to raise subscriptions, the resulting allocation of water may achieve quite a high degree of equality per person.

On canal irrigation, however, such equality, however desirable, is usually a long way off. In part of Maharashtra, full water is allocated to the first 2 hectares, with diminishing allocations per hectare as hectarage rises above 2 hectares (personal communications, D R. Arora and E. Stains). But elsewhere, water distribution is far from meeting even the criterion of proportionate equality; the disadvantages of tailenders are notorious. Research in Sri Lanka has shown concentrations of wealth, influence, tractors, and services at the tops, and conversely poverty, lack of influence, lack of farm power, lack of services, and disadvantages such as higher pupil:teacher ratios in schools, at the tails (Moore et al. 1982). In India, research by WAPCOS[1] (reported in Lenton 1982) on the Mahanadi Reservoir Project in Orissa has found a gradation in paddy yields on outlets from 1.54 tons at the very head down to only 0.22 tons at the very tail. Even on the Upper Ganga Canal, where warabandi is practised, recent research on one distributary reported by Padhi and Suryavanshi (1982:26) has shown a contrast between an irrigation intensity of 119 at the head, and only 72 in the middle and 68 at the tail, accompanied moreover by a much higher concentration of sugarcane at the head. On other systems, tailends which are meant to receive water never do, or have only recently received it as a result of the redistribution of water, such as those of the reforms of Integrated Water Management in Andhra Pradesh (Ali 1981). In these circumstances, of gross inequalities in the supply of water to different parts of irrigation systems, it is not surprising that attempts to improve management limit themselves at most to the target of the principle of proportionate equality, to the supply of water proportional to land, since the application of even that unequal principle would be far more equitable than current practice.

For operational measures of equity, Lenton (1981) has made proposals parallel to those for productivity, following the principle of proportionate equality. These would measure the equity of water delivery, of area irrigated, of yields, or of income at different points in the system, expressed as performance at a tail reach location (on a watercourse, or minor canal, or distributary, or branch canal, or main canal) divided by performance at a head reach location. Performance on different parts of a system would be indicated by taking heads and tails, as desired, of watercourses, minors, distributaries, branch canals, or main canals.

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1. Water and Power Consultancy Services (I)Ltd., "Kailash", 26 Kasturba Gandhi Marg, New Delhi 110 001.

For both general and operational purposes, equity can, then, be taken to mean more rather than less equal benefits from irrigation management, to more rather than fewer irrigator families, with priority to the disadvantaged.

iii. stability

Productivity and equity taken on their own do not encompass changes over time. Yet the sustainability of productivity, equity, and other benefits, is important.The term 'environmental stability'(Bottrall 1981)is clear, and refers to the prevention or minimising of physical changes with adverse effects, such as water-logging, leaching of nutrients from soils, salinity, erosion, silting, the 'mining' of groundwater, infestations of weeds, and pests and diseases. Maintenance of physical works is another vital aspect of stability.

The objective of stability can, then, be defined as the sustained achievement of other objectives. As an operational criterion, it can be assessed through the monitoring of appropriate physical measures such as groundwater levels, through the inspection of works, and through trends in performance indicated by other criteria.

iv. carrying capacity

Carrying capacity refers to the performance of an irrigation system in making possible adequate, secure and decent livelihoods. One way of describing it is as livelihood-intensity, the ratio of acceptable livelihoods generated or supported, to water or other scarce resources. Whereas equity, as defined, refers to fairness and relative equality in the distribution of water and benefits, carrying capacity refers to the population enabled by an irrigation project to live above a minimum level. The preoccupation of irrigation management with production has tended to obscure the benefits to the poorer people for whom irrigation may create livelihoods through more employment, higher wages, and income spread through more of the year. Carrying capacity should capture some of the wider effects of irrigation and irrigation management on the disadvantaged, including women (Agarwal 1981), tenants, sharecroppers, the landless, migrant labourers, and people who have migrated from rural areas to urban slums and who may return if there are good opportunities for a livelihood.

Since carrying capacity in this sense is not yet an accepted objective or criterion, three points of elaboration are in order. First, carrying capacity is affected by planning and design. Where unoccupied land is settled under irrigation,this is through the size of holding and cropping pattern; and where land is already settled, through the size of geographical area it is decided to irrigate (affecting more or fewer farmers). The planned water duty is a central decision here. Second, where food and income flows to households are more stable under irrigation than with rainfed agriculture, the acceptable level of livelihood (expressed as mean income) may be lower because there is less need for larger surpluses to carry through bad years. Third, higher intensities of irrigation may provide more continuous employment for those without land, and more frequent flows of income to those with land; thus the more intensive irrigation of a smaller area may be more livelihood intensive than the less frequent irrigation of a larger area.

The measurement of carrying capacity is not easy. The simplest measure is to count the population directly supported by a project, but this is complicated by the concept of an adequate, secure and decent livelihood: some may be supported by a project at an unacceptable level, while others may be migrants who achieve an acceptable level by virtue of combining seasonal employment on the project with work elsewhere. At this stage it may be less important to try to measure levels of carrying capacity operationally, than to use it and livelihood-intensity as general objectives or criteria in analysis and decisions to influence directions of change - towards greater livelihood-intensity and higher carrying capacities.

v. <u>well-being</u>

These four objectives and criteria pick up many of the benefits and disbenefits of irrigation and irrigation management, but not all. There remains the human well-being of the people affected. Productivity, equity, stability and carrying capacity, may all contribute to this, but do not encompass it all.

Much depends on what people themselves value, but perhaps four aspects of well-being, might command their agreement and that of outsiders:

i. <u>health.</u> The adverse health effects of irrigation through malaria, schistosomiasis (though not in India), and sometimes drinking water, are well known.

ii. <u>amenity</u>. Irrigation can improve amenity through water for washing, and bathing, through raising groundwater levels so that water for drinking and other domestic purposes does not have to be lifted so far, and so on.

iii. nutritional status, which can be affected positively or negatively by changes associated with irrigation.

iv. psychic factors, such as a sense of control of the environment, freedom from domination, participation, and other non-material aspects of the quality of experience, depending upon what people themselves value.

Some, but not all, of these are suseptible to measurement.

Repertoires for Optimising

Many measures are or could be used to improve the planning, design and operation of irrigation systems to optimise productivity, equity, stability, carrying capacity, and well-being. They include many which will not be considered here, including engineering works, on-farm development, methods of field water application, and farmer participation. This is not to suggest that these are unimportant. They are, however, relatively well understood and well documented. The focus here will be on the resources or dimensions of land, water, crop, location and time, which taken together open up a range of options which are, I think, quite often thought about by experienced planners, designers and managers, but which do not seem to be written down and considered together.[1]

These dimensions or resources present options as follows:

dimension or resource	options presented by
i. land	size and location of area to receive irrigation
ii. farm size	planning new settlement, or redistributing land.
iii. water	the scheduling and delivery of water
iv. crop	choice of cropping system, including crop zoning
v. location and intensity	frequency with which different zones receive irrigation
vi. timing	the staggering of cultivation
vii. spread of cultivation rights	rights in different places and/or at different times

1. I would like to be proved wrong and would welcome references to sources apart from those cited in this paper, where these aspects of irrigation management are considered together.

i. size of area to be irrigated

In analysing the size of area to be irrigated, it is useful to start with Keller's (1981) membrane concept. He writes that he likes to think of

> 'the physical objective of an irrigation project as being to stretch the water like a membrane uniformly over the intended command area. The irrigation project canals, farm watercourses, and field ditches form the rigid framework needed to push the membrane out.....an adequate irrigation system and effective management of it are essential to stretch and hold the membrane in place. A uniform membrane over the entire command area represents an efficient and equitable system..'

Planners, he says, design projects with different concepts of 'membrane tension', reflecting degree of designed water scarcity. The designed water scarcity which is optimal for crop growth per unit area is not the same as the designed water scarcity which is optimal for crop growth per unit water. For one thing, as Keller points out, most field crops will produce about 90 per cent of potential yield when only supplied with about 75 per cent of peak water requirements. The size of area to be irrigated thus has major implications for the productivity of water. Size of area is also closely linked with the other options - of farm size, water scheduling, cropping system, location and intensity of irrigation, staggering, and on some small systems, spatial and temporal variations in cultivation rights.

ii. farm size

Farm size is a variable that can be controlled only where new land is being settled, or where land is redistributed (see pages xx - xx below). Farm size most strongly affects:

productivity: the well documented inverse relationship of Indian (and much other) smallholder farming, that productivity per unit of land declines with holding size, suggests that (at least over some ranges of size) productivity will be higher the smaller the farm units (Saini 1979:112-116, 122-3, 152-3).

equity: more, smaller landholdings will within limits be more equitable

carrying capacity: more, smaller landholdings may provide more livelihoods per unit water.

iii. scheduling and delivery of water available

The scheduling and delivery of water is perhaps the most powerful tool for optimising benefits from irrigation, and is receiving increasing attention. The classification of types of scheduling in South Asian conditions is still, however, at an early stage. In India, the normal form of comparative analysis is not limited to or even determined by, types of scheduling, but is rather based on regional variations of total irrigation and cropping system (e.g. Saksena 1982). Of these, the best known and best documented is the warabandi system of Northwest India (Reidinger 1980; Malhotra 1982a and b), with its (in Keller's terms) high tension membrane and rotations between minors and between farmers, who receive less water than they need for the land they have. Second, there are the systems in areas of Western India where water is meant to be supplied only to those who indent for it. Third, there are the systems of South India where land is localised, that is, zoned, for either irrigated wet (usually paddy) or irrigated dry crops. This is nothing like a full review of typology, but its significance is that with the partial exception of northwest Indian warabandi, it is not a classification in terms of water scheduling. It is no substitute for analysis and classification of different types of water delivery schedule.

For scheduling proper, the usual broad discrimination in India as wlsewhere is into three types of delivery:

continuous flow)
)
rotations) American Society of Civil Engineers 1980
) Mathur 1982
demand systems)

Kathpalia (1980) distinguishes systems of upstream control which distribute the available supply of water, and downstream control which is based on demand. There is some correspondence here with the categories used by Replogle and Merriam (1980) for conditions in the United States. They consider the frequency, rate and duration of water supplied and distinguish between schedules which are rigid and supplier-controlled, and those which are flexible and user-controlled, as follows:

a. rigid, predetermined, supplier-controlled:

i. constant amount - constant frequency (rotation schedule)

ii. constant amount - variable frequency (modified frequency rotation schedule)

iii. varied amount - varied frequency (varied amount rotation schedule)

b. flexible, user-controlled:

i. demand

ii. limited rate demand

iii. arranged (as to date)

iv. limited rate arranged

v. restricted arranged

vi. fixed duration - restricted arranged

These may not be useful categories for India, but the point of listing them is to raise the question whether comparative analysis of actual and potential scheduling practices on Indian canal irrigation might not lead to a similarly extensive and useful, though different, classification. The Roorkee Workshop on water distribution practices (IWRS 1982) provided some material for this, and reinforced the case for such an analysis and for developing methods for deciding what scheduling is best in what conditions.

In terms of options, it is common for the scheduling procedure to be changed as a season passes and as water becomes scarcer. This is routinised in the Northwest Indian warabandi (Malhotra 1982a and b) and also in an elaborate way in Valencia in Spain (Maas and Anderson 1978:25-42), where distribution starts according to the principle of proportionate equality (emphasising the equity objective) but later with increasing scarcity shifts more to priority for the more valuable crops (emphasising minimising losses, which is the productivity objective). Thus, subject to the physical capacity of the system and the established rights of irrigators, it is not necessary to opt for only one form of scheduling.

Many of the implications of the scheduling of irrigation water for productivity, equity, stability, carrying capacity and well-being are too obvious to deserve elaboration at this point.

iv. <u>location and intensity of irrigation</u>

The 'membrane' can be stretched over different areas, and with different frequencies to allow different intensities of irrigation. Patterns of application vary between high intensities for the whole of a command, where water is adequate for that, to stretching the membrane over different areas in rotation, which can be described as the sequencing of zones.

The sequencing of zones can be overlooked as an option, but it is quite common in South India. One example is Lower Bhavani in Tamil Nadu (Sivanappan et al 1982). On this project, many short distributaries take off from a long canal. They are numbered even and odd, and water deliveries alternate by seasons between all the odd numbers and all the even numbers. Another example is the yaya (ayacut) under Tissawewa tank in Hambantota District in Sri Lanka. There, in the second, yala, season, the water diverted and stored in the tank proved inadequate to irrigate the whole area. This led to a decision to adopt a system of irrigating only two thirds of the area each yala, so that each cultivator had two yalas in succession and then missed one.

Location and intensity of irrigation have implications for all five objectives and criteria. In particular, high intensities tend to generate year round livelihoods for labourers, while sequencing of zones may be more equitable than leaving some potential irrigators out altogether.

v. crop choice and zoning

The crops to be grown is a major choice. In high tension systems where the water supplied to a farmer is inadequate to irrigate all his land, the choice of what crop to grow with limited water can be left to the farmer, as it is with warabandi in Northwest India. Elsewhere, deliberate crop zoning is found in the localisation of South India into irrigated wet and irrigated dry areas; in the block system of Maharashtra (Gandhi 1981:10-11) where blocks of land are sanctioned for particular crops; and in the phad system of Maharashtra (Patil 1981) where originally at least each farmer held land in a number of blocks. Each block has its own crop (which can be suited to its soil characteristics) and receives its own appropriate water supply.

Crop choice and zoning have implications especially for productivity, equity, stability and carrying capacity. The well-known and familiar condition is where ample supplies of water are (unproductively, inequitably) appropriated in the head reaches to provide heavy irrigation to grow thirsty crops (paddy, sugarcane), leading to waterlogging and salinity, while tailends receive inadequate water, have lower intensities, grow drought-tolerant crops like bajra, and support a smaller population over less of the year than they might.

vi. timing: the staggering of cultivation

In this option, the timing of cultivation is staggered between different parts of a command The costs and benefits of staggering can be complicated. Climatic conditions, photoperiod sensitivity of crops, and relationships of yield to temperature, sunlight, and rainfall at or near the time of harvest are all often relevant. There may be either wide or narrow latitude for planting dates for high yields In the Dry zone of Sri Lanka, where involuntary staggering is almost universal in the growing of paddy in both the maha (main) and yala (subsidiary) seasons, there are also other advantages and disadvantages (for some of which see e.g. Chambers 1975:35-46).[1] To some extent, staggering, where it occurs, is involuntary in that headreach farmers initially take quantities of water which leave little or nothing for the tails. This involuntary characteristic has tended to obscure its potential especially for productivity and equity. Two aspects may be mentioned.

First, staggering spreads peak water demands over different parts of the system. Especially in diversion systems where the river source limits peak flow, or where canal capacities constrain, this can mean that a larger area can be irrigated. Even with the warabandi of northwest India, it may be asked whether a larger area might not be irrigated by farmers through staggering the frequency of water deliveries (through the frequency with which minors receive water) in a phased manner throughout a command. Farmers might then stagger their planting dates, fitting their peak water requirements to those times when they would get water at closer intervals. As a result each farmer could then plant a larger area.

Second, staggering spreads peak power and labour demands. Labour shortages may well be a major constraint on medium and large farms in much of India's canal irrigation outside the Northwest: for example, Elumalai (1982:77) writes of the Parambikulam-Aliyar Project in Tamil Nadu that shortage of labour effects the full development of the command area even after a considerable gestation period. Labour is also probably a major constraint on large systems such as Malaprabaha and Tawa where there are many large farmers. With staggering, this constraint is eased, as labour moves physically

1 There is a substantial subsequent literature derived from research by the Agrarian Research and Training Institute, Colombo, and Reading University.

down the command as cultivation activities succeed each other, with benefits not only to productivity, but also to the livelihoods of the labourers who gain longer periods of continuous employment.

vii. <u>spatial and temporal cultivation rights</u>

The final option is the spatial and/or temporal spread of cultivation rights. These are found in some traditional and other small or medium-scale systems. They involve equity either through the scattering of one family's holdings through several zones, one or more of which may receive water; or through a sequence of rights to cultivate the same piece of land. The former is found in the bethma system of Sri Lanka (Farmer 1957; Leach 1961), and in the phad system of Maharashtra (Patil 1981), and the latter in the kattimaru and thattumaru tenure of Sri Lanka under which the rights to cultivate a number of paddy plots are rotated annually among several people. While these systems are not very common, they are both productive and equitable: productive through the growing of the same crop in the whole of a block of land making it easier to supply appropriate water, and through matching the area to be irrigated to the amount of water available in each season; and equitable because where water is inadequate, all cultivators lose the chance to cultivate in those blocks which it is decided cannot receive water, and all share in those blocks which are irrigated.

While this option may not be open on many large-scale systems, it deserves to be on the check-list for any lateral-thinking approach to irrigation planning and management.

Conflicts Between Objectives

This repertoire is far from a complete list but it does include some of the more obvious measures available for optimising the achievement of productivity, equity, stability, carrying capacity and well-being. These objectives, with any one set of measures, in any one context, may be complementary or may conflict. The greatest interest is attracted by conflicts and the choices which they present, but the greatest opportunities may be presented by complementarities. Let us, however, start with conflicts. For any five objectives, ten conflicts on a one-to-one basis are theoretically possible. With ingenuity or wide knowledge, examples of all ten might perhaps be mustered. But only four seem obvious to the writer:

i. productivity versus equity

Three common conflicts between productivity and equity can be suggested:

First, transmission losses. Between headworks and tailend fields transmission losses are often high, with figures of over 50 per cent. Other things being equal (which, however, they never are) this means that water available at the reservoir or diversion will be more productive at the head than at the tail; distributing water to the tail may then be more equitable, but distributing it to the head more productive. (This is simplistic, and some of the complicating and compensating factors are discussed below pp. xx - xx).

Second, water scarcity. When water available is less than that required for the crops that are growing, the equitable distribution of water over an entire system might mean low production or no production at all, whereas the inequitable concentration of the water in one area will be more productive, enabling a crop to be harvested at least there even if not elsewhere.

Third, groundwater 'mining'. If, as in parts of Tamil Nadu, there is a decline of the groundwater table in normal years through 'overextraction', this may be offset by intermittent total recharge in years of very heavy rainfall. Productivity, in the sense of total production over a long period, may be higher with 'mining' in normal years, since this provides space underground for the storage of more water in years of very heavy rainfall. But equity will not be served to the extent that smaller and poorer farmers lose out. Some will be unable to deepen their wells as the water level drops and others unable to afford lift technologies which can raise water from greater depths.[1]

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1. There is an interesting analogy with strategies in pastoralism on common land. An earlier theory had it that a constant level of stocking should be aimed at, the objective being sustained production at a safe and rather low level. This has now been challenged with a theory that range will be more productive if stocks are allowed to increase in good years beyond what was previously considered a safe level, recognising that heavy destocking would be necessary when bad years come. The conflict with equity arises because those with few stock are less well able to build up herds in good years, and are more vulnerable to losing stock or being unable to sell them, in bad years.

ii. productivity versus stability

This conflict occurs where short-term productivity of land is at the cost of long-term. The most common example is wh[illegible] water applications in the headreaches are liberal, and used f[illegible] thirsty crops like paddy, which are highly productive in the short term, but which lead to declining yields and even no yields at all through consequent rising water tables, waterlogging and salinity. Another example is groundwater mining where extraction exceeds recharge (even taking account of years of heavy rainfall), with the result that production eventually ceases.

iii. well-being versus productivity

A community may require canal water for domestic purpose during a dry season when there is no irrigation. This dry season flow depletes a storage reservoir so that less water is available for irrigation the next season, and less is produced.

iv. well-being versus equity

Continuing the example above, because less water is available in the next season, tailend supplies suffer.

Where there are conflicts, such as these, and where management interventions can affect them, then hard choices have to be made about the trade-offs. A useful technique for optimising is a transformation curve which plots the performance of different measures against the two objectives which are represented by the x and y axes (see e.g. Major and Lenton 1979:190). But it can easily escape attention that the repertoire of measures for optimising is so extensive that it may always be worthwhile to search for complementarities, and only to accept choices involving straight conflicts (where more of one means less of another) when an inventive search for complementarities has failed.

The shortness of this list of conflicts may be the result of my ignorance and lack of imagination. Provisionally, it suggests that conflicts between these objectives are not all that serious or common (except perhaps with productivity versus equity) and that the complementarities between them are usually strong.

Complementarities

Setting the five objectives against the seven sets of measures in the repertoire (and bearing in mind that there are also many other measures, especially through improved structures, and on-farm development), there can be striking potential complementarities at system level between productivity of water, equity in its distribution, long-term stability, high carrying capacity, and well-being. For the sake of brevity, let us consider only one type of situation which is familiar in India outside the northwest.

Early in the life of a project, water is abudant because the headworks are complete but the canals and other works lower down are not yet ready. So the headreaches receive much water and grow paddy or sugarcane, the paddy often under more of less continuous flow and with field to field irrigation, even though high infiltration rates make some of the soils unsuitable for these crops. As construction is completed towards the tailends, not enough water is available for them because the head reaches continue to appropriate more than their designed requirement. Receiving less water, less reliably, and in a less timely fashion, farmers at the tails grow less profitable, drought-tolerant drops, with lower intensities. And in consequence of heavy water applications at the head and the high infiltration rates, the water table rises and waterlogging, salinity and declining productivity ensue.

In such conditions, redistribution of water from head to tail can achieve all five objectives simultaneously. If less water is issued at the top, farmers there can grow crops which are more suitable for the soil, and if water is redistributed to the tails, then total production should rise, and equity will be served. Stability will be enhanced through reduced waterlogging. Carrying capacity will be increased through higher labour demand both in the head reaches (to the extent that dry crops are more labour-demand than wet, and that intensities are higher), and in the tail where irrigated area and intensities increase. Well-being should gain through these effects, through reduced health hazards from standing water in the head reaches, and through more canal water for domestic purposes in the tails.

The main qualification is the possible conflict of productivity and equity if transmission losses are high between the head and the tail. The problem is not the equity, since tailenders are receiving more water, but the total productivity of the water available to the system. Adverse effects of the transmission losses can, however, be exceeded by production gains of two sorts:

i. groundwater recharge from seepage in transmission. Though a problem in the headreaches, elsewhere this can be a benefit, providing groundwater closer to the surface both for conjunctive use in irrigation and for domestic purposes. A problem in the headreaches thus becomes an opportunity lower down. Groundwater reduces risks, raises cropping intensities, Moreover, farmers who have to lift irrigation water tend to use it more sparingly and productively than those who receive it through surface channels.

ii. higher productivity of water, after allowing for transmission losses, at the tail, resulting from larger areas irrigated, water-sparing crops, and the adoption of higher-yielding practices in response to a more adequate, convenient, predictable and timely water supply.

Given these major advantages of redistribution, the question is what prevents their realisation.

Practical Political Economy

There are many physical and technical impediments, but many constraints also appear to lie in the political economy of canal irrigation. Those who gain from current management practices may lose from changes. The approach of practical political economy is then to ask who would gain and who would lose and to see a. whether there are ways in which the repertoire could be used to enable all to gain from the changes, and b. if that is not possible, whether there are ways in which inevitable losers could be reconciled to their losses.

Three sets of problems and opportunities may especially deserve analysis. They are: the professional training and incentives of irrigation managers: the search for the non-zero sum, for ways in which topenders can gain from receiving less water; and the purchase and distribution of land.

i. the professional training and incentives of irrigation managers

Perhaps the greatest problem in improving canal irrigation management lies in the professional training and incentives of irrigation managers. The emphasis of training on design and construction is well known, and there are moves in the direction of developing training for operation. But one difficulty is that the very methods -

of diagnostic analysis, of monitoring and control, of water scheduling, of managing staff and farmers, and of training itself - are in early stages of development for South Asian conditions. The International Programme for Irrigation Management[1] when it is finally launched and if it holds to the objectives set for it, should contribute to these methodologies and to training which can spread knowledge and use of them; initiatives like the course for irrigation managers at the Indian Institute of Management, Bangalore, should break new ground in developing materials and methods; and the Indian Government has major proposals for training.

But even if the professional training in canal irrigation operation were already available, there remain the problems of personal incentives for irrigation managers to manage systems so as to optimise the five objectives. Caution is needed in generalising, and the warabandi systems of Northwest India may be exceptions to what follows. But careful, scholarly studies have documented aspects the working environment of irrigation managers which suggest that they are subject to incentives to manage their systems badly. Pant (1981:102) records some of the grievances of farmers on the Kosi canal as follows:

> 'Unlimited amount of water was given to certain farmers, irrespective of the location of their fields, who obliged officials in terms of money or grain. In case of others, they would charge money but would never bother to know whether water was made available to them or not. With regard to canal maintenance, the feeling was that overseers and engineers were not interested in the upkeep of canals. Every year vast amount was spent on the repair of canals but they remained as before. The main reason was, that the officials were interested only in getting their 'shares' from the contractors and never bothered whether the work was properly done or not by the contractors.'

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1. The International Programme for Irrigation Management has emerged from discussions and explorations within the Consultative Group for International Agricultural Research, the Technical Advisory Committee of which set up a Study Team which reported (CGIAR 1982) in March 1982. The Study Team recommended priority to developing methodologies, together with training, selective information dissemination, and action research. The CGIAR endorsed the proposals as the highest next priority but budget cuts prevented its undertaking direct financial responsibility. A group of interested donors has asked the Ford Foundation to be the lead agency in taking the next steps in establishing the Programme.

For another part of India, Wade (1982) confirms this impression and elaborates on a system of control of transfers, sale of posts by politicians to engineers, channelling of funds through contractors, and earning by engineers of many times their annual salaries from maintenance works and from farmers.

To the extent that such systems prevail, incentives are perverse and low standards of management and maintenance of canals, otherwise so puzzling with able managers, are less difficult to understand. They have a need to raise money to buy their postings, which can cost as much as ten times the annual salary of the officer (Bhargava 1982), and to be able to stay in them, and they have the opportunity to raise money for themselves; but this is at the cost of stability - of maintenance that is not carried out or which is sub-standard, and at the cost of productivity and equity in the distribution of water since managers have an interest in not communicating with farmers, in 'rumour-mongering' about water shortages, in engendering uncertainty, and in delaying deliveries.

In the context of this paper, the issue is not a moral one. It is the straight practical question of how, where such conditions occur, it can be made rational for managers to change their practices. Apart from changes in the wider political system, several suggestions have been made (Wade 1982:320-1), of which the three strongest may be professional training, to include not only engineering and agronomy but also management science, and which should aim to foster the development of an ethos of professional service around operation and maintenance; the provision of storage intermediate between dam and fields so that irrigators would have more control over their water supply; and strengthening the user side both by councils of irrigators and through an independent monitoring organisation, the reports of which would be made public.

ii. the search for ways all can gain

With redistribution of water from headreaches towards the tails, it may appear that farmers in the headreaches must lose, and therefore oppose the change, but this is not necessarily so. In the classic and much cited case of the Lateral C on the Peñarauda River Irrigation System in the Philippines, tighter management and redistribution of water led to higher yields for all locations (Wickham and Valera 1978).

Quite often, headreach farmers appear to be locked in to their variety of the tragedy of the commons. This is especially marked with field to field irrigation of paddy. The abundant issue of water and consequent flooding, combined with the cultivation of paddy by his neighbours, remove any option from a farmer to grow anything but paddy; and then because all farmers follow this practice, water-logging, salinity and flooding ensue, reducing or eliminating yields.

But with a change of water issues to a smaller but more controlled, convenient, predictable and timely supply, together where necessary with on-farm development (field channels, bunding, etc.), top-end farmers may be able to gain from less water in the following ways:

- less waterlogging and salinity
- less damage from flooding
- less leaching of nutrients
- better returns to fertiliser and other input applications
- more varied and flexible cropping patterns, responding to demand and prices
- timely water for crop requirements
- higher cropping intensity, especially if some of the water saved (by switching from paddy and by restraining water issues at times of heavy rainfall) can be stored to support an additional crop (for example in South India by changing from one Irrigated Wet crop to two Irrigated Dry crops, as preferred by some farmers (Wade 1978))
- more convenient scheduling of farm operations through knowing when water will come (and release of time in between waterings for other activities)

In short, the possibility is of enhancing the productivity of water and other factors such as land and labour through trading off less water with other characteristics of water supply such as fit in time and quantity with crop water requirements, manageability, and predictability.

Not enough is known about the opportunities here, but an example from Sri Lanka is encouraging. After a field trip to the Kaudulla Project in the Dry Zone of Sri Lanka, M. P. Moore (1980) wrote:

> '..the I. E. [Irrigation Engineer] wanted to give water for paddy to stage I [presumably in the head reach]. The farmers responded with the request for water for highland crops for the whole scheme. Even stage I farmers supported this - strong evidence that the higher prices of non-paddy food crops are weaning farmers away from their devotion to rice'.

In this instance, at the insistence of farmers against the irrigation management, both productivity and equity were, it seems, likely to be served by redistribution to other parts of the project of water that would otherwise have all gone to the top.

Perhaps there is, over much headreach land in India, what might be described as a latent ratchet: a possibility of a collective change to a more productive, more profitable and more water-sparing farming system which is prevented because seepage, flooding and field-to-field irrigation lock farmers in to paddy. On large canals, the collective decision-making of smaller systems in Sri Lanka may be difficult. But a priority would seem to be to develop and use methods of farming system analysis which can identify potentially preferable cropping patterns, to try these on limited areas, and then to promote collective decisions to change.

If analysis shows that topenders must lose, the issue is then political, and the most effective solution will be political, through providing means for tailenders to apply pressures and to negotiate redistribution.

iii. <u>purchase and distribution of land, or 'redistribution when growth'</u>

A massive opportunity for all to be better off than before is presented by the redistribution of land at the time when new irrigation is introduced. At that time, the land of farmers who will receive irrigation water is 'stretched': it is likely to have potential to produce more, to have a higher cropping intensity and decreased risk, and to double or treble or more in value. These are windfall gains. If, at the time these gains were occurring, land were bought from larger farmers and made available to very small farmers and to the landless, larger landowners could still end up much better off than they were before irrigation came. In some other versions of land reform, larger farmers are bound to end worse off. In this version, they might or might not be better off than they would have been without the reform, depending on the prices paid for the land, but they would be better off than they were before. Opposition to the programme, and subversion of it, might then be less marked.

Redistribution 'when' growth is far from a novel suggestion. The land ceiling legislation in most Indian States differentiates between a higher ceiling for rainfed and a lower ceiling for irrigated land, implying that redistribution should take place when irrigation arrives. The opportunities presented have also been pointed out for lift irrigation by B.G. Verghese, for tank irrigation by A. Sundar and P.S. Rao, and for canal irrigation by Anthony Bottrall.

In an article on lift irrigation introduced by the Deen Dayal Research Institute in Gonda District, in eastern Uttar Pradesh, Verghese (1981) speculates as follows:

> 'It might also be feasible to appeal to those whose farm sizes have been irrigationally 'stretched' twofold or threefold to donate a small fraction of the 'land gain' to a common pool which, if consolidated could result in the creation of a land bank of five, 10 or more acres in a village in a new variant of bhoodan in which benefited individuals gift land to the community of which they are a part and on which crops or kitchen gardens could be cultivated by young farmers' clubs or hired labour for village school-feeding programmes, or fodder raised for landless dairy farmers, or fuel trees, or whatever...'

In a paper on land acquisition for minor irrigation tanks, Sundar and Rao (1981) observe that those whose land is acquired for new minor irrigation tanks lose out: either they are allocated land which is often not as good as that which they lost, or they are compensated inadequately and late in cash. In contrast, those within the command of the tank gain from the higher productivity and enhanced value of their land so that the effective holding after the completion of the project is twice or more that of the pre-project stage. If a small portion of the land of farmers in the command were purchased from them with the money that would otherwise have gone on compensation to those who lose their land to the tank, and if that purchased land were allocated to the evacuees, everyone would be better off than before.

For canal irrigation, Bottrall (1981:28) considers that there are "very good opportunities for land redistribution of the initial planning stage, before project completion." Indeed, if we examine the figures for India, the potential equity benefits for very small farmers and the landless of any effective programme of purchase and distribution of land when irrigation is introduced appear quite staggering. Table 1 gives the existing and ultimate irrigation potential in India:

Table 1: Existing and Ultimate Irrigation Potential, India
(million hectares)

	Surface Irrigation			
	Major and Medium	Minor	Groundwater	Total
Ultimate	58.5	15.0	40.0	113.5
1981/82 (estimate)	28.6	8.4	24.5	61.5
Potential still to be realised	29.9	6.6	15.5	52.0

Sources: 1. Report of the Irrigation Commission, 1972.
2. Report of the National Commission on Agriculture.
3. Ministry of Agriculture and Irrigation, Central Water Commission and Central Groundwater Board.

See also GOI 1982:59.

The Sixth Five-Year Plan envisages creating the remaining potential by the year 2000. To get a sense of orders of magnitude, let us suppose that with shortfalls in target achievement, some 40 million hectares are added by the end of the century. If only one quarter of that land was purchased, 10 million hectares would become available. If landless families were settled on one irrigated hectare each, this could mean that some 10 million households, drawn from the poorest, would become irrigation farmers, directly supporting perhaps 50 million people, and indirectly supporting many more in secondary employment.

Gains in productivity could also be expected through the inverse relationship: the areas retained by larger farmers would be more productive per unit area by virtue of becoming somewhat smaller; and the new small farms should, partly because of their manageable size, be highly productive per unit area.

The difficulties of redistributive land reform are well known.[1] With redistribution when growth takes place through new irrigation, and with prompt compensation, there would be three points which suggest that the process might be politically more feasible:

i. the farmers who sold land should find cash useful at the time when irrigation came. The exploitation of irrigation water usually requires further investment - in land shaping and levelling, in the construction of channels and drains, in the purchase of inputs, and in the employment of labour.

1. I have written this without reviewing the experience with the operation of the land ceiling differential between irrigated and rainfed land. The reader is asked to bear in mind that for that reason some of the comments and suggestions may be misplaced, or may even be current practice.

ii. the farmers who sold land would be left with a more manageable unit.[1] With irrigation, the management of a farm becomes much more demanding. Farmers who sold land might often find the new smaller farm easier to manage, and might even achieve a higher net income off that smaller farm, well capitalised, than off a larger area of land which was more difficult to manage and under capitalised, and which might otherwise be left fallow or cropped at a low intensity.

iii. in planning new projects with smaller rather than larger areas under command to allow higher intensities of irrigation. This would require careful appraisal, scheme by scheme. Especially where water can be carried over from season to season in storage, a smaller area covered by the 'membrane', but which was covered by it (i. e. cropped) more often during the year, could, when combined with land redistribution, be more productive and more equitable. In this case, the larger farmers some of whose land was taken, would additionally gain through the higher intensities and the size of landholing that was viable for the newly settled farmers might be reduced, thus enabling more to be settled.

('when' The crucial question is whether a programme of 'redistribution ~~with~~ growth' could be administered. The key aspects are the values set on land, and prompt payment.

First, high enough prices. If purchase prices were set too low, it might look good in the accounts, but it would aggravate the dangers of the process being subverted. An emphasis on 'purchase' rather than 'compensation' would require prices higher than the pre-irrigation land values, but in terms of families subsequently settled this might be cheap at the price.

Second, prompt payment. Many schemes have fallen down because of long delays in payment.[2] Acceptance of a programme of land purchase would be much easier with cash on the nail.

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1. This is, I think, a valid argument, but it must be qualified by recognising the frequency with which farmers tackle the problem of too much land to manage by leasing it out either for rent or with sharecropping arrangements.
2. In Sri Lanka, in the H area on the Mahaweli Project, compensation was meant to be paid to farmers who lost land above a certain acreage; but when it was not assessed and seemed unlikely to be paid, unofficial compensation took place in the issuance of additional plots to the larger farmers, thus reducing the numbers of landless households that could be settled.

For both these reasons, purchase of land would be best undertaken in advance of the arrival of irrigation- because land prices would be lower, and because cash payments would be in time to allow larger farmers to invest in land improvement.

A practical difficulty is that these activities would coincide with other urgent and demanding work on the official side. With canal irrigation, these include dam and canal construction, the distribution of the first water, extension activities for changed agriculture, and on-farm development below the outlets. Staff for land acquisition are liable to be engaged in obtaining land for canals and other works. A programme of 'redistribution when growth' would require a greater concentration of staff effort at an early stage, and perhaps a special section or department.

Conclusion

To proceed further with some of the practical questions in this paper, would seem to entail, among others, the following next steps:

i. field testing and development of operational criteria such as productivity and equity

ii. analysis of alternatives in water scheduling, and how to determine optimal schedules. A textbook on this would appear a high priority, but the methods of analysis and scheduling have to be developed and systematised first.

iii. the development, dissemination and use of methods of cost-effective farming systems analysis to identify how headreach farmers can benefit from less water

iv. assessment of the potential for land redistribution through purchase from larger farmers at the time when irrigation comes, including a reassessment of current land ceiling practices. This would again include farming systems work to determine appropriate farm sizes for those who were settled on the purchased land.

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