DIAGNOSTIC ANALYSIS TO IMPROVE CANAL IRRIGATION PERFORMANCE!

PROBLEMS AND APPROACHES

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A. Diagnostic Analysis : Importance and Meaning

The priority given by many governments and aid agencies to improving performance on existing canal irrigation systems needs no emphasis. Many programmes are planned or are being implemented, on the hardware side, these include physical rehabilitation, canal lining and realignment, additional control structures and communication equipment, drainage, watercourse reconstruction and equipment for on-farm water distribution and land levelling. On the software side there are reviews of management information systems, operational procedures such as rotational distribution of water, staff training programmes, and increased attention to farmer participation in operational management as well as maintenance.

In practice the choice of components and the detail and priority of these programmes are based more on the general professional opinions of national and international experts than on analysis of particular existing irrigation systems. Ideas about what best to do vary and have been changing. Surprisingly, little attention has been paid, though, to the methods of analysis for identifying good mixes and sequences of action for individual canal irrigation systems. This paper seeks to open up this subject of analytical methods and to contribute to their development and use. At this stage in our knowledge it is in order to present and consider a variety of approaches. It will help to be clear about the meanings of words. Various terms - appraisal, diagnostic analysis, evaluation, investigation, observation, analysis, diagnosis, prescription, among others - have been used. Much debate is possible about what these words should mean. There is probably no ideal usage. The one to be followed here is shown in table 1.

Table 1 Overlaps in the Meanings of words (see next page)

Investigation		Diagnostic Analysis	Action
Diagnosis		Prescription	

A comparison of methods of diagnostic analysis used by doctors and irrigation management practitioners can be instructive (Lowdermilk 1984). Diagnosis, in its medical sense, is more than just investigation. It has been defined as 'determination of the nature of a diseased condition: identification of a disease by investigation of its symptoms and history' (SOED 1955 edn.)[1] and so entails an element of analysis.

[illegible]

Table 1 : <u>Appraisal: Overlaps of Meanings of Words</u>

(sequence)			
Project identification →	Detailed design →	Project appraisal	ACTION
Investigation	Analysis		
Diagnosis	Prescription		
D i a g n o s t i c A n a l y i s			
A p p r a i s a l			

Thus appraisal means the same as diagnostic analysis, or diagnosis and prescription, or investigation and analysis, or, more approximately, project identification, design and appraisal

Prescription - determining treatment - is a separable and subsequent activity. The term 'diagnostic analysis' used in the title of this paper refers to the analytical activities in diagnosis and prescription. Although closely linked, it can be separated from activities of investigation, of finding out about things, which are the subject of a separate paper (Chambers and Carruthers 1985).

All professionals can benefit from a study of diagnostic analysis techniques because they are in essence a form of applied systems analysis. Ideally it is an approach, a way of thinking, that attempts to use scarce resources in the most efficient manner (in the economic jargon to obtain equi-marginal returns to all resources). It is a modelling approach, abstracting, because of resource scarcity, from the ideas, theories, data, analytical techniques, hardware such as computers, and operational plans only those elements that are judged to be essential to the issue being addressed.

We argue that diagnostic analysis should in practice be critical, questioning approach, in effect a form of sensitivity of marginal analysis. This exploration of the implications of the selected elements to be studied or evidence to be assessed is in part a verification procedure for the abstraction or model of the system.

B. Problems

Some main elements of the problem presented for diagnostic analysis to improve performance on existing canal irrigation systems can be described by five propositions, referring respectively to complexity, uniqueness, repertoire, professional dispositions, and gaps. Let us consider these in turn.

1. Complexity: canal irrigation systems and complex

It has become conventional wisdom that canal irrigation systems should be analysed as 'wholes'. They have many connected parts, and leaving any of these out is liable to lead to only partial understanding and misleading diagnosis and description. But if all parts of the system are to be considered, then it is a necessary preliminary to define what those parts are. We must start by asking what a 'whole system' is, its anatomy, parts, boundaries and nature. As a start in defining and illustrating complexity, canal irrigation systems can be examined in three ways : in terms of domains, dimensions and linkages.

a. domains

Three domains can be separated out.

A commonsense reply to the question 'What is canal irrigation system?' points to a <u>physical</u> domain - an infrastructure of weirs, dams, and reservoirs, sluices, canals and control structures for capturing, storing and distributing water for irrigated farming, together with the water itself. The physical domain includes not just the main system down to the outlet, but also field channels, fields, field drains and larger drains. This is how many people, particularly irrigation engineers, think of canal irrigation systems much of the time.

The complexity of the physical domain is not just the scale and details of the fixed elements, which may cover thousands or hundreds of thousands of hectares, with an intricately branching network of channels and controls; it is also to be found in the nature of water, and the difficulties of its capture, distribution, measurement, application to plants, and disposal. For the engineer, scientist or general analyst, it could scarcely be a more maddening and elusive compound. It flows, seeps, percolates, evaporates, condenses, combines with other compounds, forms parts of plants and other living things, and is brought in and out of environments unpredictably by the weather. Much of the intellectual and practical challenge of canal irrigation comes from the characteristics of this fascinating but infurating substance which moves about, changes its form, and mocks measurement.

A second domain is <u>bio-economic</u>. It would be more usual to divide this into two - a biological domain concerned with growing crops, and an economic domain concerned with costs of inputs and production, and then with consumption and sale. These activities are, however, sequences without marked natural breaks. The sequences are normally linked with the outcome of one period dependent in part on the preceding set of outcomes. The outputs of one stage are inputs of the next. The bio-economic domain includes the supply or purchase of inputs or credit before crop growth, all biological organisms including not only crops but also livestock, grass, trees, weeds and sometimes fish and birds, and the processes of husbandry, harvesting, storage, consumption and sale. It includes irrigated farming systems but is not limited to them. It also encompasses human, animal, and plant health and disease.

A third domain is <u>human</u>, the people directly controlling, using or affected by the physical and bio-economic domains. The human domain separates into two main groups - farm households and laboureres on the one hand, and irrigation and other departmental staff on the other. The irrigation staff are usually organised as a hierarchy and spread out over the physical system while farm households lack a comparable hierarchy and are organised, if at all, as village communities or hydrological groups. Both staff and households have their social and operational structures, and their interests, conventions and conflicts.

Any appraisal of the whole of a canal irrigation system should, it would seem, take accout of all three domains. To omit the physical domain is unthinkable. To omit the bio-economic is conceivable in a strict and narrow engineering view, but unlikely to be seriously advocated. But omitting the human domain, or considering only parts of it, is much more common (see World Bank 1983, 92-6). Yet it is as much as heroic simplification to omit people - staff, farm families and labourers from analysis or canal irrigation systems, as it is to omit farm families from farming systems analysis. Once people are included, however, many and more complex variables are introduced into the whole - legal, administrative, social and psychological, and concerning rights, conventions, incentives, information, organisation, management and so on.

Further problems are presented by boundary definitions. The limits of the physical domain at first look clear. Maps mark the edges of a project. The area inside a line is the 'project' or 'scheme'; and that outside is 'non-project'or 'non-scheme'. In practice, though it is not so neat. There may be works higher up in a catchment; there may be controls or rules to protect a water supply which operate outside the project area proper; seepage in one area may be the groundwater resource of another; and lower down in a system it is quite common to find irrigators and others outside who use or are harmed by the excess and drainage water which comes out of the project area. Water leaks in and out of any boundaries one cares to draw. The bioeconomic boundaries, too, are unclear. Input supply, credit, processing and marketing may be located physically outside a project area, or physically inside it; and animals (or pests) come in and out, daily or seasonally. The human boundaries of the system are also not exact. People move in and out, both staff and members of farm households, and seasonal migration may bring laboureres into a project or out of it.

b. <u>dimensions</u>

Canal irrigation systems are also complex in the dimensions of space and time.

The spatial dimension is the better recognised. The network of canals, branch canals, distributaries, minors and field channels is often described in terms of top and tail, or head, middle and tail, with the common experience and belief that headreaches are well supplied with water, middle reaches moderately supplied, and tails short of water, though in practice there are many variations, subtleties and exceptions.

The time dimension is less well recognised. First, there is an historical perspective. Despite the popular conception irrigation systems are not physical entities constructed to blueprints; as Levine has pointed out, they are more like organisms which grow, spreading out over time, fitting the physical terrain, pulled here and there by human activity, and decaying and being restored. Second there is a seasonal perspective. Each irrigation season has its own climatic, hydrological, biological and human conditions, and its own internal rhythm in the domains. Then third, there are irrigation cycles wherever there are rotations of water supply. Each irrigation will have a different value to a farmer. The value of any irrigation will be determined in part by those preceeding it and will be confirmed by the efficiency of subsequent irrigations until the crop is harvested, and finally, there are daily changes, especially between night and day.

One way of simultaneously presenting some of the spatial and temporal interactions is linear, as one proceeds down an irrigation system. Viewed this way, performance is a function of a long process proceeding through of space and time, from the capture of the water to the satisfaction of human needs.

Catchment--->storage--->canals--->distributaries--->minors--->outlets
diversion

↓

processing<---harvest<---crop<---soil<---fields<---field channels

↓

storage → consumption / sale--->cash → satisfaction of needs -----> well-being

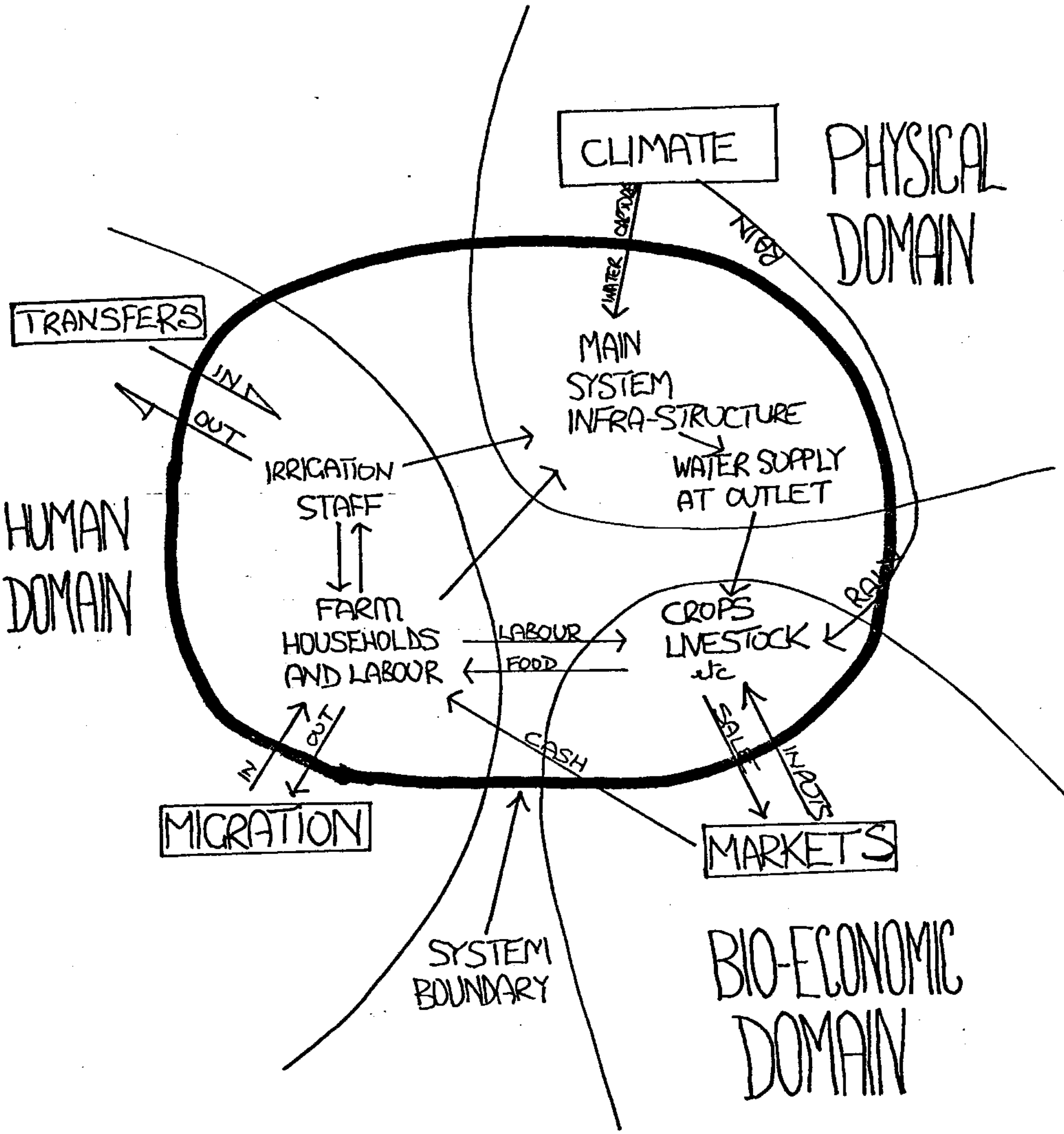
Each component in this sequence will have a different weight in determining final outcomes. Similarly the timing of activities associated with each component will be of varying degrees of importance. Explicit recognition of these components and their timing should help analysis. However, this unilinear approach directs attention to a central process, but neglects other flows in or out, such as labour for cultivation or water out in drainage.

c. <u>linkages</u>

Another perspective in looking at a canal irrigation system is to focus upon the series of linkages between the domains and elements within them. Some of the main linkages are shown in Figure 1. Some of these linkages are well researched and well understood. The capture of water through dams and diversions is a matter of high refinement, well developed, and well practised by irrigation engineers as high status activities of their profession. Similarly, crop water requirements and responses to water have been endlessly researched by agronomists, and hold few mysteries still to be revealed. But linkages and interactions have been neglected. Sociologists, political scientists and students of public administration were at first slow to look at the management and incentives of irrigation staff, the organisation and behaviour of farmers and the interactions between farmers and staff. No discipline has effectively claimed main system management as its province although it is practised to varying degrees by civil engineers. The appropriation of that valuable resource, water, has not been a central focus of analysis. The farming system and labour availability have rarely been studied, nor have the distribution of benefits through food, cash and other effects. In consequence, the true complexity of canal irrigation systems has been under-recognised.

Figure 1

Domains and Linkages



Note: For the sake of clarity, the domains have been "pulled apart" from each other.

2. <u>Uniqueness: each canal irrigation system is unique</u>

A corollary of complexity is uniqueness. It is common to be surprised at how dissimilar irrigation systems are on closer examination when at first they appear much alike

Uniqueness may be masked by simple classifications by system characteristics, such as size (major, medium, minor), water source (run-of-the river, reservoir, or lift), administrative system (warabandi in Northwest India, indenting in the old Bombay Presidency in India, localisation in South India), crop (paddy, sugarcane, wheat, 'irrigated dry' or upland crops, and so on), soil type (black clay, red sandy and so on), physical topography and layout (delta, alluvial plain, undulating etc), or climate (arid, semi-arid, subtropical, tropical).

These classifications cross-cut each other. They also omit much else of significance, for example, water adequacy and reliability; canal capacity in relation to peak demand; physical capacity to control flows; rights to water; financial responsibilities; political organisation and environment; farm sizes; farmers' relations and communications with staff; and labour availability.

Each canal irrigation system has grown and evolved, fitting the physical and social landscape to take its own idiosyncratic shape. There may be types of canal irrigation systems, but the principles of classification are not well developed. At this pre-Linnean stage in classification, we may be lumping together birds, bats and insects because they fly, or whales, fish and jellyfish because they live in the sea. Each individual deserves to be treated as genus or species in its own right; in default of a diagnostic typology, each system deserves to be treated as essentially unique.

3. <u>Repertoire: a choice of many measures</u>

As if complexity and uniqueness did not make the task of seeing how to improve performance difficult enough, the repertoire of potential actions is formidably long. Expanding on an illustrative list presented elsewhere, (Chambers 1984) they may include:

- action research;
- administrative practice and law;
- administrative structure;
- biological problems and potentials;
- farmers' organisations;
- farming systems;
- main system water distribution;
- main system works and maintenance;
- management science and monitoring;

- physical problems (waterlogging, salinity etc);
- pricing systems (inputs and outputs);
- resource exploitation (groundwater, foreshore cultivation etc);
- services (extension, training, credit, marketing);
- works at or below the outlet.

Any of these can present a focus for appraisal and a point of intervention. Moreover, the choice, mix and sequence can vary for different parts of a system.

Nor does this list do more than begin to encompass the range of approaches. Starting with the water supply, its allocation, distribution and appropriation, and crosscutting the actions listed above, a repertoire for optimising performance can also include:

- varying the size of area to be irrigated;
- reallocating stored water between or within seasons;
- changing the scheduling and delivery of water;
- controlling which crops are grown and their marketing;
- staggering the sequence of cultivation activities;
- alternating irrigation between zones.

Moreover, within each of the items in each of these lists, there are many variations.

4. Predispositions: the chooser affects the choice

Each discipline and profession has its own concerns and agenda. Visiting the same project at the same time, a systems engineer, an agricultural engineer, a soils scientist, a crop agronomist, an agricultural economist, and a sociologist, will all see and ask about certain different things and may neither see nor know to ask about others. Each also has areas of ignorance. As Will Rogers said: "everyone is ignorant, only on different subjects." A sociologist may not know about cross regulators: an engineer may not know about soil-plant-water relationships; an agronomist may not know about labour availability and relations: and a soils scientist may not know about market prices and crop profitability. Professionals feel most confident and secure their own terrain, and are reluctant to trespass on that of others. For reasons or prudence and preference, they therefore tend to identify problems and propose actions which fall within their own interests and competence.

Taking the earlier list of potential actions, a tendency toward the following preferences can be anticipated:

Type of action preferred	Who by
action research	researchers and research-funding organisations
administrative practice and law	administrators and lawyers
administrative structure	administrators
biological problems and potentials	agronomists
farmers' organisation	sociologists and social anthropologists
farming systems	agricultural economists
main system water distribution	political economists
main system works and maintenance	irrigation engineers
management science and monitoring	management scientists
physical problems and potentials	soils scientists, hydrologists, agricultural engineers, drainage engineers
pricing water for revenue or efficiency	economists
resource opportunities	geographers and lateral thinkers
services	agricultural extensionists
works at or below the outlet	agricultural engineers

The disciplinary bias is complicated by political stance. The literature of a discipline will inevitably vary to greater or lesser degree depending upon the political or ideological stance of the authors. In economics Marxian and neo-classical authors will study different aspects of problems, measure different variables and often interpret statistical series in different manner. This is less the case of engineering and agricultural science but even there, political biases or 'blinkers' are to be found. For example, in a socialist state technology will be directed primarily to group, regional or national control rather than to individual ownership with obvious implications for the design of pumps, wells and other elements of hardware.

The implication of professional predispositions for diagnostic analysis is both obvious and startling. If any one of the fourteen types of action may be the best point of entry, and if the actions identified by a team depend on the disciplines and to a lesser extent the politics of its members, then the appropriateness of those recommendations will depend on the composition of the team.

5. Gaps: disciplines miss links

The final part of the problem is posed by the gaps between disciplines. Part of the arrogance of bad science is the assumption that if all relevant disciplines are applied to a problem it will be fully covered, rather as searchlights might illuminate all sides of a target. The reality is different. In practice, disciplines tend to narrow their beams to shine more intensely on smaller areas. Where measurement is difficult, as with water flows or crop water requirement, much ingenuity, time and money can be devoted to the search for precision, to the neglect of extensive areas left in darkness. With canal irrigation, much is known by engineers about structures, and by agronomists about crop water requirements, as the textbooks testify. By their silence, too, the same textbooks reflect astonishing blindness to linkages cruicial for good performance.

Some of these are:

- main system water scheduling and distribution;
- communications within the irrigation bureaucracy;
- communications between bureaucracy and farmers;
- communications between bureaucratic agencies (e.g. agriculture, irrigation and groundwater);
- how farmers appropriate and share water among themselves;
- farmers' activities above the outlet;
- what happens to water at night;
- labour availability and constraints;
- irrigation staff transfers, incentives and motivation.

Since these, and other gaps like them, are not central concerns of any disciplines, good methods for relevant diagnostic analysis are not available off the shelf. They have to be invented.

Peter Medawar (1985) asserts that it was Linnaeus and Darwin who 'rescued zoology from the odium of being no more than a heap of ostensibly unrelated facts'. The irrigation literature verges on such disarray and it is enormous and often specialist and fragmented. It might appear that specialised blindness is inevitable and that no synthesis is possible. We do not share that view. In the Second World War operations research showed that the scientific mind could, if properly directed, very successfully understand and effectively tackle complex problems normally regarded as outside its normal competence. The Management Menus outlined later are an entry point to a necessary synthesis and provide a focus for those forced to practice outside their specialism.

Given the combination of complexity, uniqueness, repertoire of many measures, professional predispositions, and gaps left by disciplines, developing cost-effective methods of diagnostic analysis presents fine intellectual and practical challenge. There cannot be many fields where the potential for enhanced human well-being are so high, yet the methods for achieving it so little developed.

C. Diagnostic analysis requires creative thinking

Diagnostic analysis requires more than the simple application of techniques and application of checklists. New ideas and ways of looking at empirical evidence are also needed in irrigation. We see three major roles for diagnostic analysis in generating and testing new ideas.

First, in the absence or dearth of organised knowledge, diagnostic analysis can help to provide the empirical stimulus for creation ofnew ideas, concepts and hypotheses about an irrigation system and its management.

Second, once there is a body of organised knowledge, diagnostic analysis can help reinforce, confirm or reject a particular inference or interpretation about an aspect of the irrigation system.

Third, diagnostic analysis, by being multidisciplinary and system-oriented can help explore gaps and force specialists to consider and assess important linking ideas and concepts from various disciplines. In this latter role, the analysts will be compelled to perform both of the first two roles above; that is to generate new ideas and to draw upon, review and critically assess conventional views.

We have argued that irrigation systems are complex social systems with some unique characteristics and great variation between them. The systems themselves and the supporting technical, economic and political systems are undergoing rapid change. Variability and change create a need in diagnostic analysis for regular reappraisal of conventional views and the testing of new ideas. For these reasons, we argue that practitioners of diagnostic analysis require a creative approach. Beveridge (1980) argues that creative thinking about problems can be cultivated by a four stage but iterative process: collection of information; contemplation; conception and criticism. He reviews this and three alternative procedures (see Table 2) all of which may have a role enabling analysts to make creative assessments and to move rather rapdily to action.

Table 2. Some ways of creating new ideas and problem solving

1. Beveridge (1980):	2. de Bono (1970)	3. Zwicky(1969)
Creative thinking	Lateral thinking	Morphological thinking
4 Stages:		
- Collection - Contemplation - Conception - Criticism	- Consider alternative approaches - Challenge assumptions - Suspend judgement - Use visual images - Break problem into components - Seek random stimulation - Brainstorm	- Define problem - List Components/ elements - List attributes of elements - Tabulate matrix of elements and attributes - Appraise options (see later discussion)

4. Various authors:
Group thinking

First session:

Pool information
without appraisal or criticism
Stress positive helpful responses

Second session:

Evaluate using critical thinking
List applicable, testable
plausible ideas

Source: Beveridge (1980)

It is unhelpful to polarise argument about methods to the relative merits of long-term scholarly research and rapid diagnostic analysis. Seldom are these sensible or even feasible alternatives. Improved diagnostic analysis at the beginning of any study can test relevance of existing (explicit) theory. The pilot phase of studies are all too often disregarded or skimped. Rapid diagnostic analysis can assist in the early phase to relate and integrate subject matter in a cost-effective way. Furthermore, we would note that, at the boundaries, even scholarly research has to adopt short-cut methods to establish the relevant context of the defined problem being studied.

Critics of diagnostic analysis often worry about the high inductive content. In the literature on scientific method, there is often what is somewhat puzzling discussion to laymen about the paradox of induction (how do you know what you know, how can you see what you don't know and so forth). We would wish to avoid academic debate on the pros and cons of positivist approaches to social science. We accept that surveys using preconceived and often implicit theory may discourage analysts from adopting a critical view of the validity and relevance of their theory. The papers of Wood (1981) and Richards (1981) are helpful in this context. However, one precept of diagostic analysis as described here is that practitioners should be aware of their biases and adopt a critical, questioning, open-minded approach. We can do no more than urge a sound training in the accepted general principles (theory) with a degree of scepticism and a deal of curiosity.

D. Orientations and Approaches

Before considering analytical tools, it will be useful to stand back and examine some of the more basic orientations and approaches which influence analysis.

Those to be considered below are : factors affecting analysts' prescriptions, linear blueprints or iterative learning process, single or multiple objectives, problem or opportunity and ideal or feasible.

1. Factors affecting analysts' prescriptions

Many factors affect analysts' prescriptions, and the development professions generally have rarely undertaken anything like adequate introspection to understand why they recommend what they do.

No analysis can ever be completely open. What is prescribed is influenced by fashion and by on-going programmes and resources known to be available when it comes to implementation. As we have noted; each profession, and each team, has its biases.

An analogy with psychotherapy may help here. The same distrubed patient would be examined, diagnosed and treated quite differently by a psychiatrist, a behaviourist, and a family therapist. Apart from a few basic personal data, they would ask the patient different questions, generating data to fit their preferred diagnosis and treatments. The psychiatrist would try to find out which drugs would be best; the behaviourist would try to find out what programme of conditioning would relieve or remove the symptoms; and the family therapist would try to find out what family relationships could be manipulated to improve the patient's condition. There are parallels between psychiatrists and engineers, both preferring physical treatment, between behaviourists and advocates of operational plans, both preferring a programmed approach, and between family therapists and administrators who seek to change structures and the external environment. The really good psychotherapist understands and commands a wide repertoire of treatments without doctrinaire adherence to anyone. The eclectic and versatile pluralism of the good psychotherapist who adapts the treatment continuously to the evolving needs and condition of the patient might usefully be emulated by those who seek to understand and treat sick irrigation systems.

This is not to say that specialised schools of diagnosis and treatment are in themselves bad. The thoughtful reader will have noted already that this paper is at home in the 'main-system-management-first' school, as implied by the attention, derived from the examples, given to examining the physical system and its capacity, and then to an operational plan. But good diagnostic analysis will be open to many possibilities, ready to explore key gaps, and able, like the good psychotherapist, to draw on many ideas and treatments and fit their mix and sequence to the needs and opportunities of the individual system.

2. <u>Linear blueprint or iterative learning process</u>

In architecture, engineering, cost benefit analysis, and rural development planning, professionals need and use linear sequences of procedures. They come to feel secure with manuals and rules which tell them what to do, and blueprints to be implemented in predetermined ways. Many also have a psychological need for certainity, for closure, for things to be 'cut-and-dried'. Systematic linear procedures to find out about complex realities can, however, easily become bottomless pits. The long checklist may be useful as an aide-memoire; it can be disastrous as a required agenda for detailed investigation which generate and indigestible mass of data.

As with psychotherapy again, there is a minimum of data useful for basic reference. Beyond that, the process of finding out more, and seeing what to do, is a continuous and iterative one. Most effectively, it will not follow any preset sequence, but will involve participants in opportunistic probes and explorations, some of which turn out to be blind alleys, others of which open up new areas. Ideas of what to do change, and with implementation, the reality itself also changes and reqqires new investigation and analysis. Cost-effectiveness is more likely with intuitive leaps to examine a wide range of possibilities, than with solid plods through the dull steps of a manual.

Much of the best learning is by doing. What is called the 'blueprint' approach to development has been contrasted with the more creative and more successful 'learning process' approach (Korten 1984). The learning process approach entails undertaking action at an early stage and learning from its results, making adjustments and changes, and moving from learning to be effective to learning to be efficient to learning to expand. In this approach, analysis is a continuous or frequently repeated process.

Without wishing to over-polarise the options, there is a contrast or tension here between two schools of thought and action: those who start changes quickly after less investigation and analysis, and those who start them later after more. As pathological extremes these take the form, respectively, of action without diagnostic analysis and diagnostic analysis without action (because it never ends so that action can start). In between these poles there are many reasonable positions, and serious questions about which is best.

To illustrate, a diagnostic analysis to draw up an operational plan for a canal irrigation system may reach preliminary conclusions entailing rotations. The feasibility of these rotations may depend on the capacities of a large number of distributaries and minors. Analysts might argue for extensive checking and measurement to establish whether the capacities are there, and then to make modifications. But others might argue that although risks are involved, if preliminary indications from a rapid appraisal suggest that most channels will be big enough, the best course is to go ahead and learn from what happens. No one knows in advance exactly what will happen, but trying to operate the rotations will quickly show where they are feasible, and where not. Analysis will reveal that some water may be lost, and some banks may overtop, but the learning will be faster, and the benefits to cultivators will come quicker. Prudent professional reflexes favour getting it right first; much practical experience favours learning by doing.

3. Single or multiple objectives

Another common preference is the single objective, usually production. Maximising production is a comforting technical objective, and makes thinking about irrigation less complicated and difficult than when other objectives are admitted. Maximising returns to scarce factors of production is similar. But on reflection most would agree that the objectives of irrigation are, at an overarching level, to maximise human well-being. This requires a complex of goals, not just production but also equity, (including benefits to the disadvantaged - landless, women and others), sustainability and stability of production, health, and non-agricultural benefits (water for domestic purposes etc). In this sense, objectives are multiple and appraisal becomes more complex but more realistic. Complexity has to be faced and we assert that elements of diagnostic analysis are an essential adjunct to weighing the sets of objectives that policies and projects aim to satisfy.

4. Problem or opportunity

Problem-solving can be useful activity, but it is not necessarily the most cost-effective use of scarce resources. Not all problems are worth solving. It may simply not be worth trying to get water to a distant tailend, or get design discharges flowing in a main canal, or to reduce seepage losses by lining distributaries. It depends on costs, benefits and alternatives. The alternatives may often include some which involve not solving problems but exploiting opportunities. The two orientations may be characterised as:

	Problem-orientation	Opportunity-orientation
task	-diagnosis of deficiency	-identification of potential
evaluative style	-'closed' evaluation against original design specification	-'open' evaluation against what might now be achieved
action recommended	-ease a constraint	-exploit a resource
target set	-minimise loss, or restore to a previous or intended condition	-develop a new level performance

An opportunity orientation starts with resources. On an irrigation system this leads logically to examining the distribution of those resources, notably water. This in turn leads to main system management and distribution below the outlet. An opportunity-orientation raises positive questions of:

- irrigating a larger area
- increasing intensities
- growing more profitable crops
- staggering cultivation to spread peak water demand
- seeking ways in which topenders can accept receiving less water
- exploiting waterlogging (for growing trees, establishing fish farms, irrigating a summer crop with lift irrigation, etc.)
- water-saving responses to maximise use of rainfall
- use of groundwater replenished by canal seepage
- saving and using water wasted at night

There is a sense in which some problems are opportunities. But not all are. And not all opportunites begin as problems. It is not a question of either a problem-orientation or an opportunity-orientation, but of a balanced mix. The recurrent danger is that preoccupation with problems will prevent the recognition and exploitation of opportunities. Good diagnostic analysis can assist in sorting options, keeping clear of details and premature selection of the obvious (normally a problem) for detailed study or action.

5. Ideal or feasible: practical political economy

Some analysts are tempted to present 'ideal' solutions which are not feasible. This is most likely if the human domain is neglected and technical efficiency or professional norms are stressed. It is true that for many reforms, someone must lose. But this is not always so. The approach of practical political economy searches first for ways in which performance can be improved without anyone losing. This appears to have occurred in the example of the Morna Project. An operational plan was devised where headenders gained from less flooding and waterlogging, and tailenders gained from more water (Joshi: 1983). A major practical difficulty with this type of reform is that though all irrigators may gain, irrigation staff may not if they have to work harder or accept lower levels of unofficial remuneration.

In the other reform situations where some must lose (who may or may not be compensated for their losses) feasibility is an obvious key criterion. While there may be no simple solutions here, the main point stands. It is not just that proposals should be screened mentally for practical feasibility, but also that such feasibility should be actively sought, determining to some extent from the start what sort of questions are asked.

Bottrall was thinking on these lines when he recommended that actions should be ranked for administrative and political feasibility and implemented in sequence starting with the easiest. He suggests (1981b:76) that a list of desirable reforms in roughly ascending order of 'difficulty' might read:

- procedural reforms - redefinitions of responsibilities, improved work programming, improved information and monitoring systems, etc.;
- reforms in training curricula (in-service and basic education);
- development of representative and effective farmers' institutions;
- changes in staff's terms of employment (rules governing recruitment, salaries, promotions, transfers);

- changes in methods of project financing; and
- fundamental changes in organisational structure'.

These all refer to 'management', as this was the aspect on which he was concentrating.

In his major report (1981:148-163) Bottrall produced a large framework for diagnosis on irrigation systems. Running as it does to 16 large pages, it is impressively comprehensive. It is divided into three sections: The Resource Base; Indicators of Project Performance; and Identification of Causes. These have been found a useful aide-memoire for anyone conducting a diagnostic analysis. The sequential steps involved are (1983: 104).[4]

(1) A descriptive inventory of the local environment (physical, technical, social, economic) and of the administrative and other resources for use within the scheme.

(2) An evaluation of the scheme's actual performance in relation to potential, in which the leading criteria are productivity (especially of water distribution), equity, environmental stability, cost and cost recovery.

(3) A review of the main factors likely to explain the level of performance achieved, including the technical design of the irrigation system; the organisational and administrative framework within which scheme management is expected to operate; the quality of performance of key support services activities within the limitations of that framework; and the quality of farmers' management at the watercourse and field levels.

(4) An assessment of the relative importance of these factors as explanations of scheme performance.

(5) Recommendations for remedial action.'

E. Analytical Approaches

A wide range of analytical techniques can be brought to bear to assist diagnosis. What follows illustrates some methods for ordering and analysing information and procedures. It does not include rapid methods for finding out about systems, which are covered separately by Potten (1985).

Six analytical approaches will be examined. Each could be further developed as an approach if diagnostic analysis methods were more extensively used by practitioners.

1. Resource-based, top-down

This is the normal method of river basin planning or irrigation project analysis and planning. It usually starts with an assessment of the water resource, its capture, storage, distribution, use and disposal. Parallel to this a market analysis of crop opportunity is carried out and this in turn is integrated with various measures of other resource availability before the final infrastructure design is made and the various technical, economic, financial and other tests are carried out (see Carruthers and Clark 1981, Bergmann and Boussard 1976 and for a case study Lieftinck et al. 1968).

2. Performance-based, bottom-up

This approach (personal communication, David Seckler) would start with low yields, whether at tailends or where there was waterlogging or some other problem, systematically investigate why, and what was needed to be done to improve yields working 'backwards' up the system searching for explanations and remedies.

This could be variant of the approach of performance monitoring and gaps (Lenton 1983) in which performance is monitored, or monitoring information analysed, to identify and act on performance gaps, as in the diagram (Figure 2). As management monitoring and evaluation systems (M & E) and general management information systems improve, the scope for 'analysis by exception' expands. In this approach the performance norms would be specified and, when not achieved (the exception), action taken to investigate causes and remedy defects. At present such responsive M & E systems are rare.

3. Flow charts, algorithms and other diagrams

Flow charts and algorithms express the logic which lead analysts through decision processes. They require careful thought to construct. If well done, they ensure that unlikely options or often neglected factors are borne in mind.

A flow diagram (Figure 3) for the decision 'to save or use reservoir water in kharif' illustrates both the strengths and the weaknesses of the method. It raises questions which are sometimes overlooked, such as costs of storage, and whether spill water will be used elsewhere. But it does not, as it stands, deal with, among other things, the definition and estimation of 'value', or the probabilities involved in the answers to the question. (Both are, however, susceptible to systematic treatment).

A team investigating rehabilitation could set itself the task of elaborating various flow charts as part of its RRA working method. In principle, algorithms could be prepared for all the key probes (see below). Irrigation water at night would appear as especially promising candidate (Chambers 1985a).

Other analytical techniques that help managers conceptualise, probe, rank, group and scan information include oval diagramming (see Delp et al.), bar charts for seasonal analysis, modelling (see Lenton 1983), brainstorming, morphological analysis discussed previously (see Delp et al.), and plotting maps and aerial photographs.

Figure 2

Monitoring and Feedback (from Lenton 1983)

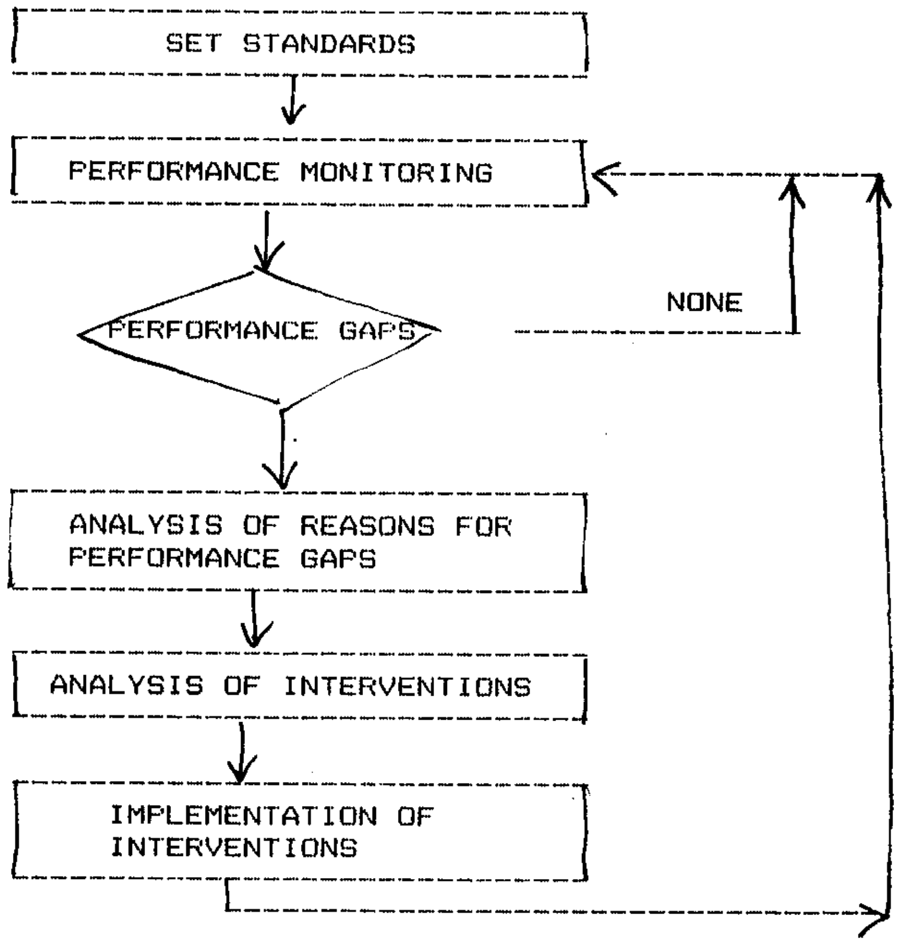
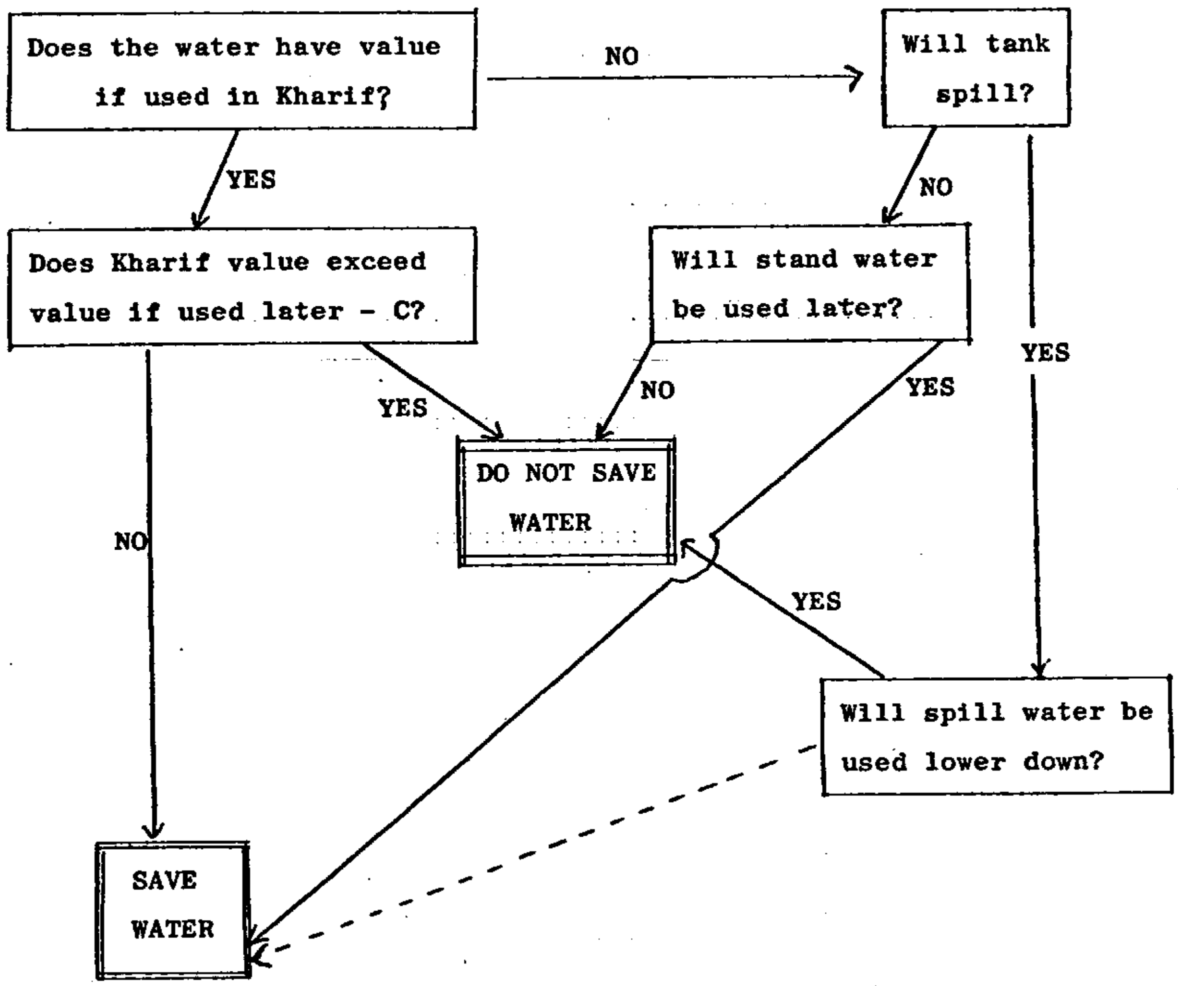


Figure 43

Algorithm for Decision: To Save or Use Reservoir Water in Kharif



C = net cost of saving and storage

= cost of saving and storage - cost of spilling.

4. Modelling

In irrigation management, as in other areas of management science, there is increasing emphasis upon quantitative analysis. Engineers, in particular, like to deal with numbers. It would be good to report that quantitative analysis in irrigation management had shifted from merely recording data to a study of relationships and actions based on these insights. However, data collection is all too often seem as an end in itself, and perhaps because it is little used in analysis, the quality of data is unreliable.

However, this situation should change. Mathematical modelling approaches to exploring management problems, particularly at the level of the river basin, reservoir operation and main system management are low-cost options to action research (Lenton 1973, p25-9). Increasing availability of powerful low-cost computers and software have removed some barriers experienced by pioneers (eg. Smith 1973).

Model building and their operation, forces the analyst to specify the objectives of the exercise clearly, to enunciate the assumptions and data used and to conduct sensitivity analysis to expose the system characteristics. Lenton (1983) proposes using such models in various combinations with action research to help diagnose and plan appropriate interventions.

SOGREAH (1985) demonstrate, by use of a case study, the practical benefits of a modelling approach to diagnostic analysis that resulted in a new operating system and a 20 per cent water saving without any modification to the existing structures.

We conclude that the discipline of specifying and making operational a valid model is a powerful method of attempting to understand an irrigation system, diagnosing constraining features and spotting windows of opportunity.

5. Menu maps

In the computer programming field a device known as a 'Menu Map' is commonly used to show, on one page, the overall set of ideas and issues covered by the programme. The Menu Map is a chart that displays how the programme is constructed, how to move from one area to another, and what options the programme offers. The Menu Map enables the analyst to select options, whilst seeing the overall 'big picture', but it does not require all the information to be memorised.

Irrigation systems as we have shown, are complex with several domains (physical, bio-economic and human - see Figure 1), with time and space dimensions, and with numerous linkages. Analysis requires a model to capture and present key elements and Menu Maps are potentially valuable aids to teams using diagnostic methods. Analysts of irrigation management can devise and draw Menu Maps of key issues and show their relationships to each other. A skeletal master framework with some details infilled is shown in Figure 4. The scope for detailed breakdown using the same Menu Map concept is immense. Figure 5 shows the way in which the accounts might be broken down. In turn a systems analyst might produce a complete and detailed map for just one element of this map say the timekeeping and payroll activities.

The general Menu Map could set out the purposes of irrigation management investigations by identifying; (i) the facts, or what activities irrigation management presently encompasses. The Map could be made a more analytical device and the information augmented if parallel maps were prepared, to show; (ii) the means of how this could be achieved; (iii) the sequence or when the activities are undertaken; (iv) the place or where they are carried out; and (v) the person or who achieves the activity.

Thus the first stage of diagnostic analysis management review using this approach might have four steps. The first would produce a Menu Map with the above five sets of information on each activity. The second stage would attempt to establish the reasons for what management presently undertakes, for the means selected, for the sequence, for the location chosen, and for the person responsible, by asking why of each initial first stage response. In the third stage alternatives could be explored by using trigger words such as 'more', 'less', 'alternative' or 'eliminate' to question the conventional way of getting activities completed. In the fourth stage a synthesis and plan are produced for each component under review.

IRRIGATION MANAGEMENT

General Menú Map

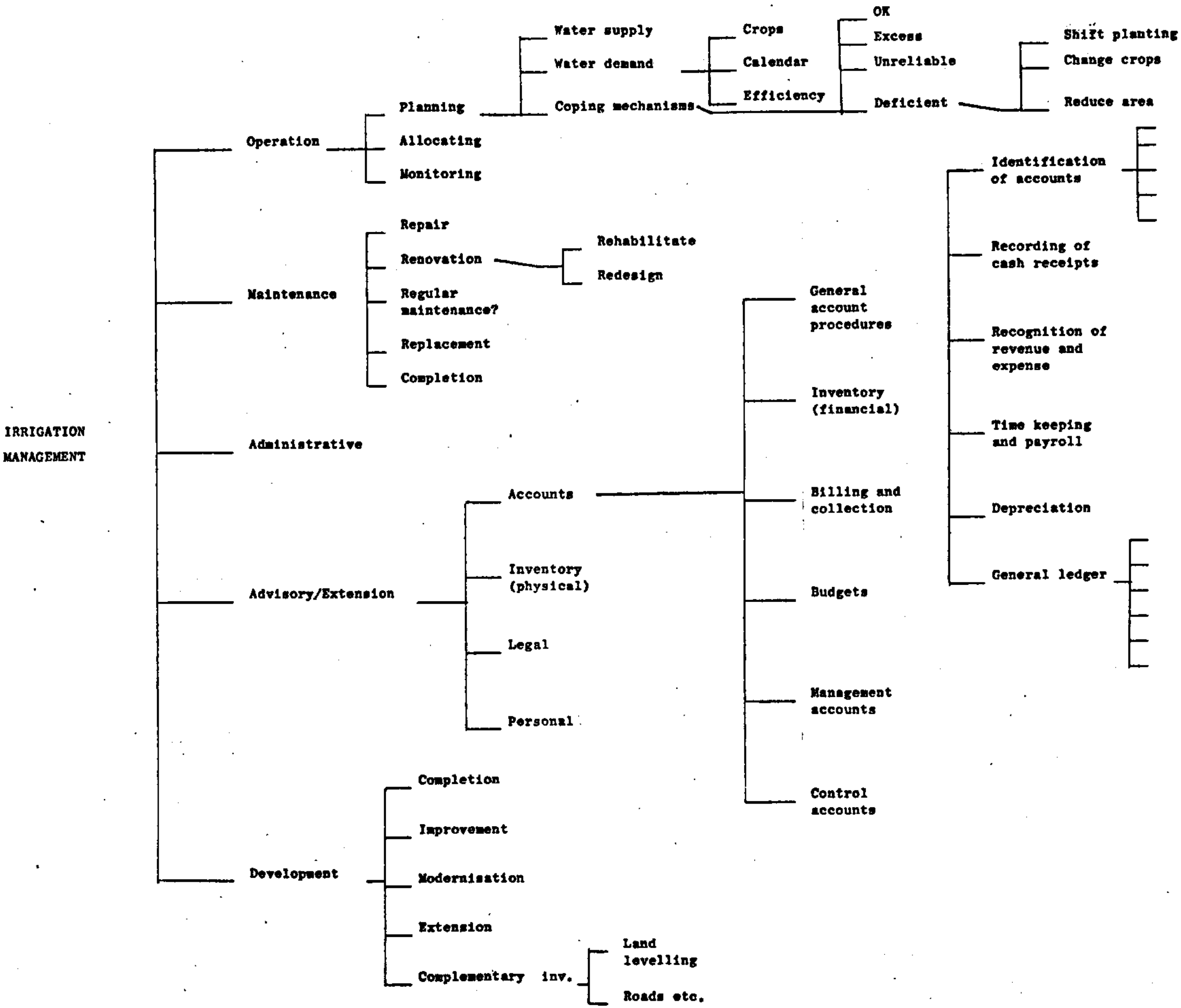
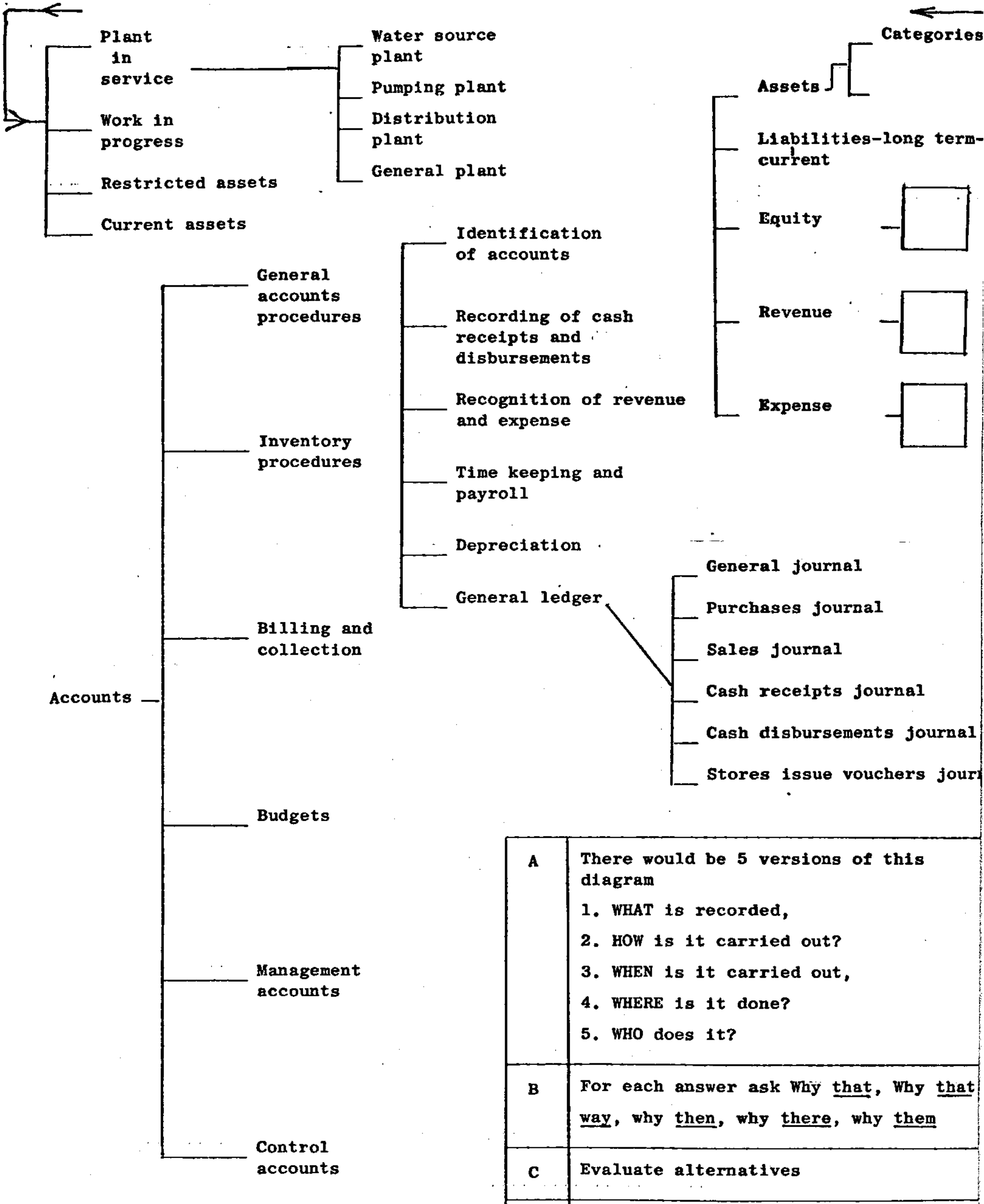


Figure #4

Figure 4.5 MENU MAPS OF ACCOUNTS



A	There would be 5 versions of this diagram 1. WHAT is recorded, 2. HOW is it carried out? 3. WHEN is it carried out, 4. WHERE is it done? 5. WHO does it?
B	For each answer ask Why <u>that</u>, Why <u>that way</u>, why <u>then</u>, why <u>there</u>, why <u>them</u>
C	Evaluate alternatives
D	Synthesis

An example might help make the proposed procedure clear. In any Irrigation Department stores of items for use in operation and maintenance must be maintained. A master framework Menu Map would contain the activity 'stores inventory'. In the first stage of review what is stored is established, how they are stored, when they are stored, where and who is responsible. Then for the second stage the question 'why store that' is asked of each important stored item and the answer recorded. Similarly the questions why that way, why then, why there, are addressed. In the third stage alternatives or not storing, storing more or less or coping with the need in other ways are examined, together with the question of alternatives. Finally a synthesis and storage plan is produced detailing what is stored, how, for what duration and in what location under whose responsibility (for a farm study example see Carruthers 1981).

6. Key questions and probes

Another approach using diagnostic analysis thinking is to identify and then work on key questions. Methods for exploring the questions would be developed, where they do not already exist. Use of the key question approach would aim to establish the potential for improved performance within certain limits defined by the question and its sequel. The methods would be used as and when appraisers judged the question worth exploring. They would have a dual purpose: to understand parts of the system, opened up through the question as a point of entry which would raise and illuminate other issues; and to generate an agenda for action.

Some useful probes concern the linkages and aspects of canal irrigation which are relatively neglected. Here is a preliminary list (in alphabetical order) to which readers will wish to add and from which they may also wish to subtract. Each question would have its own subroutine for investigation and analysis:

- are surplus, spill and drainage water used and by whom and with what benefits?
- could crop changes, staggering, zoning and/or rotations improve performance?
- could headreach farmers do as well or better with less water?
- how do cropping patterns and irrigation intensities vary between parts of the system?
- how do farmers influence their water supply?
- how is the reservoir managed?
- how, on what basis, subject to what pressures, and by whom, are distribution decisions made?
- is there a labour constraint?
- what do managers know about what is happening on their systems?
- what do tailend farmers get?

- what do tailend farmers know about what they will get and when it will come?
- what happens to groundwater?
- what happens to water at night?
- what happens when water is scarce?
- what happens when it rains?
- what is the control capacity of the system and how much of it is used?
- what political interests are involved in water allocation and distribution?
- what water is available for distribution?
- which staff are permanent, and which are transferred and how frequently?
- why do some farmers not irrigate at all?

In making a list of this length there is no suggestion that all questions should be looked into in any one appraisal, but rather that it would be useful to have subroutine guide for the investigation of each of these, available for use as and when desired. A 'key questions' approach shows how diagnostic analysis has theoretical, ideological and methodological preconceptions built into the techniques. But the preconceptions or at least the preoccupations are explicit. If appraisers can pick the best questions, and if the subroutines are well worked out, a key probes approach should often prove efficient.

F. Future Steps

Diagnostic analysis for improving canal irrigation system performance has a long way to go. As a subject it is in its very early stages. Its development is a matter of some urgency, since delays are likely to mean delays in substantial potential benefits from its application.

To take things further, actions can be recommended:

(i) subroutines and modules

We have suggested that analysis can be broken down into routines, such as algorithms. Many of the linkages and key probes could be developed as independent methods of investigation and analysis to be part of an optional repertoire. For example, an algorithm for canal irrigation at night, or a farmer interview and farming systems approach for finding ways farmers could do better with less water, both appear needed, but do not yet exist. An advantage of this approach is that it breaks the subject down into manageable units, allowing the gradual build-up of experience and its systematic testing.

(ii) <u>workshops for analytical techniques</u>

Workshops for practitioners of promising techniques could be organised, inviting written contributions which would share experience. (see Conway 1985 for an illustration). Modelling approaches to improving performance is a strong candidate for this approach, and could lead to the early publication of a volume that could be of direct use to many irrigation system managers.

(iii) <u>irrigation management breifing papers</u>

As and when enough is known for there to be practical methods to disseminate, short irrigation management briefing papers distributed to managers could be a means of quick dissemination.

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[3]Shorter Oxford English Dictionary 1955 edition.

[4] See also Bottrall 1981:236-239.

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