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IRRIGATION EVALUATION, PERFORMANCE MEASUREMENT AND TRADE-OFFS BETWEEN PRODUCTION, EFFICIENCY AND EQUITY IN IRRIGATION INVESTMENT STRATEGIES

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TABLE OF CONTENTS

INTRODUCTION[1]

In an earlier paper[2] I provided information on the rise and fall of the rate of increase in food production over the last 40 years. One of the explanatory variables, for Asia in particular, is the parallel rise and fall in irrigation investment, because the success of the HYVs in rice and wheat is linked to good water availability and management.

The present paper takes the discussion about irrigation investments several step further.

First, I look at how broadly conceived reviews have tended to evaluate investment programmes in irrigation. The major approach used in such studies is to compare *ex ante* and *ex post* rates of returns of individual irrigation investment projects, in addition to which a number of other issues may be discussed in varying degrees of detail.

This evaluation format considers investments in irrigation just like any other investment project. In many production sectors of the economy the investor as entrepreneur has control, or believes to have sufficient knowledge of his market position to be able to judge the viability of the proposed investment decision. Investments are therefore judged in a framework of (subjective) notions of controlled economic environments.

In irrigation, however, one of the central features is the existence of multiple and persistent conflicts amongst many parties. There is therefore lack of unified control and hence a basic unpredictability in the irrigation investments results and effects. The many types of conflicts have been specified in some detail in the previous paper.

Moreover, reviewing irrigation development in historical perspective, as was also done in the earlier paper, a central conclusion was that the role of institutions in moulding appropriate water management practices would seem to have been a more important determinant of the success and sustainability of the irrigation-based mode of production than the evaluation of the investment stage of constructing physical irrigation infrastructure. The question therefore needs to be asked what are critical institutional factors and whether these factors are being given sufficient attention and in what perspective, when judging irrigation investment projects at the present time.

A review of shortcomings of the conventional model of irrigation investment evaluation would therefore seem to be in order, from the perspective of 'commission' and of 'omission'. Are the 'right' questions being asked, and if not, why not?

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1 I would like to thank Henk van Roosmalen for helpful comments on an earlier version of this paper.

2 Aart van de Laar, *Irrigation development, food production and the state in historical perspective*. CPR Discussion Note nr 13, December 1993.

Second. One of the more obvious shortcomings in conventional irrigation investment analysis and evaluation is the lack of direct causality between the items which enter into the costs and benefits streams. This oddity has been recognised and a more appropriate evaluative framework is clearly required. A decomposition of the contributing factors to the outcomes of the irrigation investment is needed. Recently such a more appropriate framework has been proposed, which at least allows the discussion of the effects of irrigation investment projects to be better structured.

The problem then is that the first step, the evaluation of the water delivery aspect in irrigation generally is not possible, as there are few published examples where water deliveries have been measured or are being monitored at field level.

The derivation of irrigation system design parameters tends to rely on irrigation traditions, rules of thumb, office work, textbook applications and computer simulations[3]. In reality, many of these assumptions may prove to be wrong or inaccurate. There is no reason to assume that all the many potential errors in basic design parameters will compensate each other, and hence, the question arises whether there are systematic biases in irrigation designs. A review of technical designs as more and better data become available, and experience with canal operation is gained, is thus in order. There is also a further question whether the systematic generation of better data, where initial data were 'abnormally' inadequate, have been made a component of the design and/or irrigation construction process[4].

It is also possible that the irrigation system is operated differently from the manner in which designers had intended. In that case the outcomes of the irrigation investment project will be different from designer intentions, due to differences between behavioral assumptions and practices of system operators or of intended beneficiaries. And this requires a different type of analysis with different skills and different questions to be raised.

There is thus sufficient reason to question whether irrigation can and does perform as per system designs. A discussion of some problems and issues is provided in section two if this paper.

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[3] I shall never forget an irrigation engineer in the rehabilitation study of 1981 of the Gezira Scheme in Sudan, complaining: 'Why did they not send us the technical materials, so that we could have done our calculations in the UK'.

[4] Initial information inadequacies tend to be obscured when the design process proceeds: initial assumptions become 'facts', to enable calculations to proceed. Public 'confessions' on weaknesses in underlying data are rare. An interesting example is the study by Rickard (1989) on *Regime Canal Design - Theory and Reality*. A regime channel is defined as one which, over a long period of time, neither silts up nor scours its bed. He notes that 'sediment transport theories are notoriously inaccurate (matched only by the inaccuracy of the field measurement of sediment concentrations).' He then presents the results of a measurement programme, on the Eastern Nara Canal, off-taking from the Indus River at Sukkur in Sind Province, Pakistan, to prove the point. He concludes that 'the design of regime canals nowadays is no easier than it was 60 years ago. Indeed, the proliferation of theories, none of which can claim great predictive accuracy, probably makes the design process more difficult' (p 397, 402).

Third. The discussion so far proposes to addresses issues and problems in the evaluation of individual irrigation projects or of a group of such projects, once they have been shaped and are being implemented. But there are wider issues of strategy in irrigation investment planning. I propose to look at a number of major trade-offs in irrigation investment strategies. These wider trade-offs tend to be neglected as most of the evaluative literature is concerned with the evaluation of specifically shaped irrigation investments at project or scheme level, at a stage in the planning process where major **prior options** may have been considered but were discarded in furthering the final project concept. Thus, the evaluation of the final project design may be 'too little and too late', and it then serves the function to legitimize the project concept as already shaped by the engineers (civil and agricultural) and natural scientists (hydrology and soils).

Production, efficiency and equity in irrigation strategies is to be discussed in respect of the following issues:

1 government vs. private;
2 expansion vs. intensification (rehabilitation);
3 large-scale vs. small-scale irrigation.
4 wet-season vs. year-round irrigation;
5 irrigation vs. rain-fed production;

Some of these issues have been intensely debated in the past. But the debate may have to be reopened because the character of irrigation investment strategies is changing, as discussed in earlier papers on water resources development[5].

1 EVALUATING IRRIGATION INVESTMENTS.

In many contemporary evaluative studies of irrigation investment projects there has been a tendency to postulate a direct link between infrastructure investment to rural development indicators such as cropping intensities and agricultural yields (Steinberg, et.al. 1983; Hotes, 1983, 1984; Van Steekelenburg and Zijlstra, 1985; Moris and Thom, 1990). Also in historical studies there often is no other option but to compare rough data on irrigation investment, with often equally rough data on irrigated area and agricultural production deriving there from, as other data are not available. For instance, available data often refer to public investments from government accounts. This is obviously inadequate because it cannot include the 'real investment' in irrigation by private parties or local communities in building and maintaining river diversion works and canal systems mostly through collective labour, paid or unpaid. Similarly, agricultural production figures are usually available, with varying degrees of accuracy, on a national or regional basis, but not necessarily on the basis of irrigated vs. un-irrigated, low-land vs. upland, or mono-crop vs. cropping system basis. Using published indicators as could be found, Booth (1977, 43) finds, for the *sawahs* in Java

5 See: *Water Development for Power and Irrigation, the Environment and Sustainable Development*, ISS Working Paper Series No 141, February 1993, and *Irrigation Development, Food Production and the State in Historical Perspective*. CRP Discussion Note no 13, December 1993.

and Madura, near constant yields between 1916 and 1940. But such figures tell us little about irrigation effectiveness.

In contemporary irrigation investment projects, as in many other investment projects one major, if not the decisive economic criterium, or test of acceptability by which a proposed investment is judged and project outcomes are measured, is the Economic Rate of Return (ERR). The investments in physical infrastructure and of irrigation operations feature on the cost side, often together with miscellaneous complementary inputs such as investments in roads, offices and, sometimes, of agricultural inputs/marketing related expenditure categories in more comprehensive, or integrated rural development projects, as are more common in Africa[6]. Increased agricultural production features on the benefit side of the equation.

While the nature of the construction components and other cost categories are usually reasonably clear from the initial appraisal reports, there are problems with measuring the agricultural benefits. It is not always made clear what agricultural production can properly be ascribed to the irrigation investment programme. There often will have been agricultural production in the project area before irrigation, and this production, if assessed at all, tends to have been underestimated at appraisal, especially in Africa (Van de Laar, 1993, p 50-58). In addition, it is important to distinguish (net) production effects of the expansion of the project area from cropping pattern and yield effects. The former may indicate delays in project implementation (shortfall in the irrigated command area), but the latter are a better indication of whether irrigation, as a technological improvement, really works. Thus, the former point at the relative smoothness of the investment process, but the latter asks questions of how farmers react to the creation of irrigation potential.

In doing the 'before' and 'after' ERR, it is often found that available figures do not seem to show the anticipated correlation between input costs and benefits as defined in this manner. Typically, *ex post* rates of return in different samples of irrigation investment evaluation studies are lower than *ex ante* rates (Tiffen, 1987, p 368, Hotes, 1983, Steinberg, 1983, Steekelenburg and Zijlstra, 1985, p 12). Hence negative judgements on the overall effects of irrigation investments are easily formed, and such judgements may have contributed to the decline in new irrigation investment observed in the 1980s.

While the evidence on the outcomes of the ERRs of irrigation investment projects is not in doubt, questions should be asked about the appropriateness of this approach to irrigation investment evaluation. As alluded to in the Introduction: how do we look at what is customarily done, to be followed by the question what is normally not, or only superficially, done in the major commissioned evaluative studies of irrigation investment projects being discussed here.

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6 A reason for this could be that the level and quality of agricultural input services and marketing facilities is so poor, compared to Asia, that irrigation project planners feel the need to make more comprehensive packages, all under one project or scheme management unit.

Shortcomings of the approach used

There are at least five things wrong with the conventional approach to irrigation investment evaluation:

(1) There is no direct causal link between irrigation investments and agricultural yields. Irrigation investments merely provide one input in agricultural production, but whether farmers then use the water for higher agricultural production depends upon a host of other issues, such as the availability of additional, short maturing crops, the profitability of more intensive cropping relative to other off-farm income opportunities, availability of inputs and output markets. A whole chain of follow-on actions is thus required for the postulated relation between irrigation investments and increased agricultural output to materialize.

One major problem, with far-reaching consequences for the extent and mode of operation of an irrigation system is whether or not farmers stick to the design cropping pattern or shift wholesale to different crops upon construction completion. Even if farmers stick to the design cropping pattern it is still possible for them to change the relative attention to be given to the different crops. In Asia, changes in cropping patterns have been common, e.g. from 'light-irrigated' crops to the 'wet' crops: paddy and sugar. In Africa, where usually schemes are designed with a much greater control of scheme management on farmers' behaviour, farmers can still switch the few production factors under their direct control, e.g. labour time or the application of available fertilizer, to private, non-scheme management preferred crops or to non-farm activities[7].

(2) Typically, project evaluations are undertaken shortly after the completion of the investment phase. This is easily understood. When the need for systematic evaluation of development assistance efforts began to be widely accepted in the 1970s, project (appraisal or approval) documents specified the requirement that a project evaluation be carried out. Initially this tended to be external evaluations, and for some agencies such as for instance UNDP this costly approach is still common practice. Other agencies, such as the World Bank, have shifted to a different format: it required that the Project Completion Report be at the same time a summary review of the whole project process. Large numbers of such project completion reports then often serve as the raw material, supplemented by other information and interviews, for the Operations Evaluations Department to write broader studies on 'strengths and weaknesses' of lending at sector levels, or of common components in types of projects, and to identify 'lessons that might be learned' for improved practice in future. Because most donors (co)-finance with governments the investment package, it will be obvious that the interest in evaluation was largely restricted to the progress and achievements of the investment stage.

[7] Examples will be given later in this paper, especially in Section 3.

One then, by default, focuses on project delays, cost overruns, and on the shortcomings in the capacity of executing institutions or of contractors in building the irrigation infrastructure. Benefits are then assumed to be reached as planned, but not yet experienced over a range of seasons, and the *ex ante* revenue (benefit) figures are adjusted to reflect new price projections for the agricultural commodities involved.

In this approach one does not, in a realistic manner, allow for the positive effects of learning: rising yield curves over time, or for a deterioration of the irrigation structures and/or the future effects of salinization, which would have negative effects on cropped area and/or yields (Van de Laar, 1993).

The outcome of the ERR calculations may yield curious results. For instance, Hotes (1983, p 139) reported for a sample of 40 World Bank-assisted irrigation projects that, despite an average cost overrun of 38 percent, 19 out of 40 projects exceeded their ERR. He then notes 'apparently this was mainly due to the higher than expected crop prices in half the cases, combined with higher output than projected in 18 of 34 projects[8]. On average, actual crop prices exceeded appraisal estimates by 38 percent'. But such information is then in large measure an **indicator of luck**, rather than an indication of whether production targets, efficiency of input uses and of equity in outcomes for participants are being reached.

A more relevant lesson for judging the investment progress is Hotes' statement (p. 128) that:

> 'beginning in 1981, the Bank has had a requirement, for all type of projects, that field investigations, engineering work, and detailed design should be well advanced at the time of loan approval, so that bidding documents could become available and that tendering could begin shortly thereafter. Generally this requires final designs for large monolithic structures such as dams and other major structures and canals, and detailed designs for the first year of work for other facilities. For irrigation projects, this means that plans, profiles and cross-sections should have been made for the main system and that detailed designs and estimates should have been made for representative areas of the project. There should be no major surprises in quantities during construction.

This statement more clearly reflects the Bank's wish to control cost estimates and to avoid unpleasant surprises of having to foot supplementary financing requests, and to reduce delays in project implementation. It also confirms a vision of irrigation investment projects as essentially comparable to building roads, or power plants: a civil engineering construction job. The same level of specificity is not, and often cannot be specified to the same extent for the agricultural implementation component of irrigation investment projects, as these requirements tend to be more diffuse and touch upon responsibilities of a range of other rural and agricultural support organisations.

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[8] This might be due to an under-count of pre-project agricultural production, as noted above.

(3) Commissioned evaluative studies implicitly assume that the irrigation infrastructure will be well maintained after investment completion, and that effective water management policies will be in place and will also be sustained by those responsible. These variables refer to system operations and maintenance. While often observations are made about shortcomings in initial maintenance, and sometimes of problems encountered in the way farmers seem to operate the water distribution system, these evaluation studies generally do not provide a solid analysis of the reasons **why** maintenance seems to be poor and **why** water management practices do not seem to conform to design expectations. Such analysis cannot be undertaken easily as the implementation experience is still limited at the time of *ex post* evaluation, and anyway, findings might be discounted as starting up difficulties, but with no indication whether things will improve or deteriorate over time.

It has been argued that, in historical perspective, water management practices and water management institutions are more important for the viability and sustainability of the irrigation mode of agricultural production than the investment stage (Vaidyanathan, 1984). Others, such as Coward (1990), have argued that irrigation investments should be organised and seen as a means for envisaged beneficiaries to acquire stakes in irrigation and water rights and **thereby** acquire a personal interest in the existence and functioning of effective water management institutions. The evaluative question then is not whether (external) contractors have built the structures according to externally determined professional engineering designs, but, rather, **who** has built the structures and to who's interest? Observed deviations from design could well be functional in that they may strengthen the probability that more effective water management institutions can be organised or emerge spontaneously.

Conventional irrigation evaluation studies thus appear to underemphasize the very determinants of effective and sustainable irrigation development, by focusing on externally determined technical yardsticks for irrigation investments, and on agricultural production, which is basically outside the concern or the irrigation engineering profession. The manner in which irrigation investments are to be evaluated should therefore be changed from an engineering and agronomic perspective to one which asks the question whether the manner in which irrigation investment is being generated and implemented contributes to effective collective action in water management institutions[9]. Effective water management institutions are the key determinant for the sustainability of the irrigation mode of production.

The apparent irrelevance of economists postulating causality between irrigation investments and agricultural production, to enable cost-benefit analysis to be applied, seems compounded by the irrigation engineers' somewhat misplaced focus on construction standards rather than on creating or contributing to the formation of viable water management institutions.

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[9] Complications arising from the scale of irrigation and collective action by beneficiaries will be taken up in Section 3.

(4) The ERR deals with quantifiable variables and cannot deal with qualitative information. Thus, it does not capture variables such as institution building or welfare to specific groups in different parts of irrigation schemes or intra-household effects where project policies may discriminate against women in allocating access to the new irrigation resource. A slight improvement might be made if income distribution weights were systematically applied for benefits to classes of the beneficiaries, but this raises further problems of determining first and second order effects of initial benefits[10].

(5) The Economic Rate of Return (ERR), which is routinely required by international financiers and by some governments, should also be under attack for its tendency to obscure rather than illuminate important determinants of project success. Basically, economists have argued in the past the benefit of **not** taking market-revealed values as the prices to be taken to value the specified costs and benefits in investment projects, but to adjust market prices, because of a number of 'distortions' in prevailing market prices. Specifically, adjustments were recommended for the exchange rate and the wage rate, through shadow pricing. Shadow pricing was argued to be justified to arrive at the 'true' value of proposed investments.

But the approval of projects on the basis of shadow prices in a context of persistent 'distortions' in actual prices leads to major problems in project implementation due to new distortions to incentives being created. When projects are accepted in economic analysis but should be rejected in financial analysis, elaborate cross-subsidization is required to bring actual behaviour of participants in line with the 'true' value of what they are doing. This 'better world' was defined by economists who see (national and international) prices as the outcome in a world where there would be no distortions. It meant, an ideal, perfectly competitive economy existing on a global scale. But this 'ideal and thus better' world was and is a counterfactual world.

In a major recent study on irrigation projects it was concluded that: 'financial analysis', defined as looking at costs and benefits from the point of view of (i) the individual, (ii) the agency or enterprise, and (iii) the nation was in many ways as important as, or more important than 'economic analysis'. This was particularly so because financial analysis focuses attention on the managerial capabilities, requirements and incentives of the principal actors in the project scene once completed (Tiffen, 1987, p 363).

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10 For instance, initial production effects may be high in physical terms, but if output prices drop, or input and consumer prices rise, net income gains for initial beneficiaries may be much reduced.

Proposals for improving current practice.

The decline in irrigation investment in the 1980s is causing considerable concern among those with vested interests in irrigation development, be they in governments, in the international financial agencies, or amongst consultants and contractors. One response has been to suggest amendments to the conventional evaluative framework as discussed.

One of the areas where a 'salvage' operation is being launched is in the area of adjusting rate of return calculations. Rising investment cost per hectare and projected low international commodity prices would lead to low expected rates of return and thus to a curtailment of new irrigation investments[11]. At the individual project level it is undoubtedly correct to treat international prices as **exogenous** variables. However, when the aggregate effects are considered of most major financiers simultaneously curtailing new irrigation investments, international prices should be considered **endogenous** variables, as the projected slow down in irrigated areas and related agricultural production would reduce aggregate supplies of rice and wheat relative to demands. This will then lead to rising commodity prices and further problems for the food economies of significant developing countries. These problems could then perhaps not be overcome or mitigated with recourse to international buffer stocks in view of the long lead times required for new irrigation investments to mature. The basic proposition is therefore to counter the sketched scenario by maintaining adequate levels of new irrigation investments and to at least stop the further sliding down of new investments.

Simulations with forecasting models incorporating expected world market prices as endogenous variables show a price rise of some 14 percent might be expected (cited in Rosegrant and Svendsen, 1993). This would then argue for an upward adjustment in projected future world market prices. Specifically, such reasoning provides a rationale for irrigation project economists to deviate from the regularly published world commodity price projections of the World Bank, which are used as shadow prices in most *ex ante* project evaluations undertaken by international donors and national governments.

Consequently, the rate of return calculations for current investment proposals would look better, and irrigation investment approvals may be rising again in the future.

It may be pointed out that the high grain prices of the early 1970s were projected to persist for the future without allowing for a decline, as most of the contributing factors to the food crisis at that time proved to be incidental and not structural. Thus, new irrigation investments projected inflated benefits. Now that prices are low, the suggestion is made that they cannot last and should be increased for calculation purposes, an example of a-symmetry in behaviour of those 'doing the sums': project economists in the service of pro-irrigation pressure groups.

The general problem is, of course, whether it is appropriate to judge the acceptability of large, long term and irreversible investment decisions in irrigation on the basis of volatile agricultural prices. The further question is whether using international prices as reference prices should be given such high weight, in a context where virtually all governments cannot

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11 See CPR Discussion Note nr 13, December 1993.

refrain from some form of intervention in agricultural markets for economic, social and political reasons, and whereby international markets in agricultural commodities are often markets in 'residuals', e.g. to off-load imbalances in domestic supply and demand relationships.

Fiddling with rate of return calculations, but made to look respectable, has its limitations and may not be enough to reverse irrigation investment trends. Postulating better and more normative management standards for implementers, and to be incorporated in the calculations, are as easy to make and pius to hope for as assuming favourable weather. Projections then in fact describe what may be technically possible to be achieved, but the gap with what is realistically achievable in a given socio-economic and political setting will be widening. In turn, the inevitable disappointments will show up in future *ex post* evaluative studies.

Other arguments to reverse the current decline in new irrigation investment relate to such issues as the need to incorporate greater allowance for asymmetric risks and uncertainty, and to assume probability distributions for several of the key variables. Cutting frills in the scope of the irrigation investment package is another option, even if such components may be important for the overall project success. Sometimes, such investments could be re-introduced later on in the investment process, under project modifications or in supplementary budgets. The secondary benefits of irrigation should be given more attention. Further sharp declines in new irrigation investments, it is argued, make it more difficult for the irrigation institutions to implement institutional and organizational adjustments and would lead to loss in human capital in irrigation studies.

Such suggestions[12] to beef up new project proposals for irrigation investments are to be expected if project documents are seen as sales documents rather than as objective appraisal documents. These 'tricks' are inherent to the 'hurly-burley' of project lending in practice, where each party to the process has a vested interest in high-lighting positive points from his own perspective, and in down- grading other, and from his partial point of view, negative aspects. This 'sales' aspect takes two forms. They have been termed 'the Mod Syndrome': making use of particularly attractive phrases or slogans that do not change the nature of what is proposed, but rather repackage it in the aura of development chicness; and 'the Pangloss Ploy': ensuring that the economic rates of return are as optimistic and as high as possible.

As Steinberg notes (1983, p 93):

> 'Project proposers know the immediate interests of the hierarchical bureaucratic structure, public or private, bilateral or multilateral. It is relatively easy for an astute development practitioner or academician to take an irrigation project and repackage it as one that fosters human rights, equity, exports, institution-building, participation, aggregate production, the private sector, improved market forces, technology transfer, or foreign exchange savings. It may, in fact, assist some or even many of these purposes, but the emphasis in presentation may also shift depending upon what is fashionable.'

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12 It is noted that Rosegrant and Svendsen are irrigation economists in IFPRI.

Issues not covered and questions not asked

Currently, there appears to be a much greater openness in recognizing past mistakes in development projects and in developing cooperation efforts, than even less than a decade ago. *Mea culpa's* abound, and were unavoidable as the results were published of systematic evaluation studies. These were generally introduced in the 1970s, and were the necessary innovations in international development cooperation to meet public accountability requirements of donor countries. This trend has been true for irrigation projects as well. But to what effect?

Diemer and Vincent (1992) review a recent spate of evaluative reports on irrigation in anglophone and francophone Africa (Barghouti and LeMoigne of the World Bank, 1990; Boda and Castellanet of GRET, 1991; Vennetier of CEGET, 1991 and Aviron Violet and his colleagues at ILRI 1991, for the OECD, the Club du Sahel and CILSS). They argue that all books are at pains to cite many of the technical and socio-economic issues causing problems for African irrigation development, but none of them systematically relates any of these problems to the dominance of certain forms of technical assistance and the role of engineers therein. The authors of the studies merely tend to reiterate problems long known in the field, and fail to back them up by any changes in their own approach that would make new interventions more successful. Past mistakes are presented, but with a sense that lessons have been learned, and that there are new management options in the public and private sector. Sadly, however, Diemer and Vincent argue (1992, p 132) the authors of the reports give little evidence of actual changes in management procedures, or of donor support for new initiatives, to justify this confidence.

To obtain improved information as a basis for judging the efficacy and sustainability of irrigation investment projects one cannot continue to operate within the primitive evaluation framework as has been employed in most studies to date. Though in evaluative reports one can find a fair amount of information on a range of issues relevant to linking irrigation investments, the resulting supply of water and other factors needed to obtain higher agricultural output, such discussions are uneven in scope and depth because this requires reflection on a rapidly widening range of issues. Each of these issues has its own framework of analysis, ranging from (sub)sector issues, to wider agricultural policies, to macro-economic policies and international policies in case of tradeables produced in irrigated agriculture.

Time constraints as well as conceptual issues are at stake. These also relate to the range of disciplines to be involved in the composition of the evaluative teams. At the present time, the composition of the evaluative team tends to shape the scope of the resulting study more than the Terms of Reference given. As long as irrigation projects are seen as technical construction projects, the dominance of engineers, agronomists, and project economists will prevail, also in *ex post* evaluations. But as we have seen they all have their biases and, worse, appear often unable or unwilling to step out of their professionally shaped biases. They would not feel confident whether they could adequately address other issues, or well known issues in a different light and perspective. Chambers (1988) would argue that they are 'prisoners of normal professionalism'.

The range of issues and questions which shape the scope of **ex post** evaluation report are in large measure determined by, and restricted to the kind of issues and problems signalled as potentially contentious in the **ex ante** project appraisal document.

In studies commissioned by directly involved parties, as have been the main focus of the present analysis, there will be limited interest in trying to answer different types of questions. Moreover, the evaluators, who are often put under severe time constraints, see no reason to, or scope for spreading their research interest wider, as other questions, such as those relating to whether the investment process has contributed to the establishment of effective water management processes, are inherently difficult to assess, and often unanswerable in a short visit.

Truly objective evaluation studies are sometimes undertaken by academic researchers. But such studies have to contend with three major issues: (i) what would be an appropriate evaluative framework; (ii) will they have adequate access to all parties relevant for and influential in the irrigation investment planning and implementation process, and (iii) will their report have impact at the levels where it may count?[13]

While academic researchers might well score better than evaluation studies commissioned by involved institutions on the methodological front, the latter generally appear to score better in respect to the other two items listed. So the question boils down to whether the evaluators can have or acquire sufficient 'room for manoeuvre'. This freedom has to be contested in each individual case.

Conceptually, the design of an appropriate irrigation evaluation methodology is not at all easy, especially when irrigation is seen as an arena of multiple and persistent conflicts over the mode of exploitation of a common pool natural resource in short aggregate supply, as has been the position taken in a previous paper[14]

Even when a broad conceptualization is intended and made possible (financially and in terms of guaranteeing access), it is nearly impossible to identify the **relative weight** to be given to several of the key factors involved. The outcome then is likely to be a mass of undigested information, rather than an analysis of the key determinants of success or failure in irrigation investment planning and implementation.

It could well be argued that the apparently single criterium of the Economic Rate of Return does need to be 'de-throned' (Tiffen, 1987), because of its multiple shortcomings as discussed in this section. Some form of multi-criteria analysis might be more useful, but this raises issues of what to include and how to interlink the criteria in weighing the partial

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13 Irrigation research undertaken in Egypt by staff of Colorado State University in recent years apparently labours under the yoke of severe restrictions on the publication and dissemination of their research findings. This may be a consequence of the fact that much irrigation research has in effect to be attached to irrigation investment projects to be permitted and be feasible at all.

14 See CPR Discussion Note nr 13, 1993.

indicators to be used. Moreover, how are the different valuations given to variables by different interested parties to be reconciled?

2 EVALUATING IRRIGATION PERFORMANCE

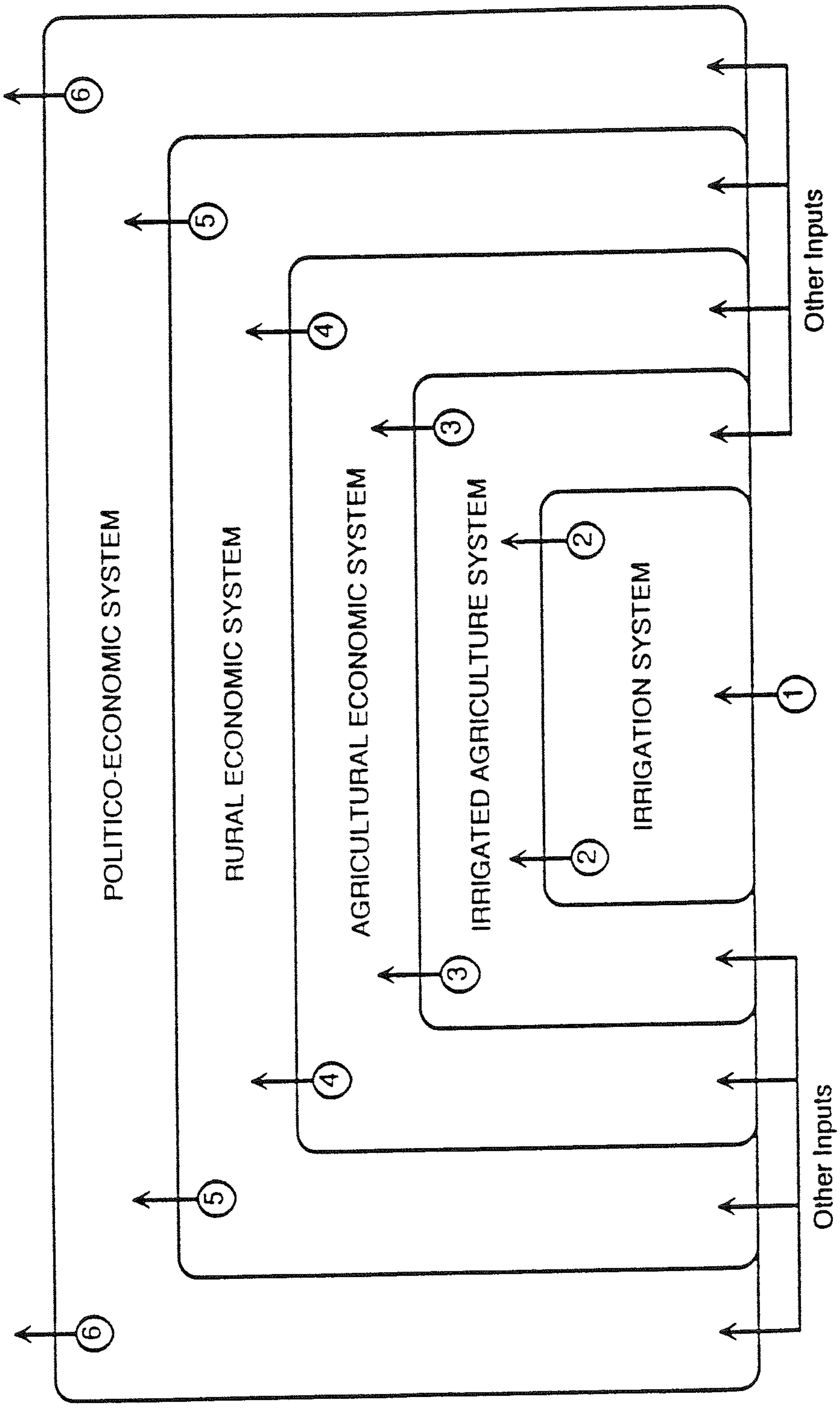
There is clearly a need for a more suitable conceptual framework for irrigation assessment studies. Recently, such a framework has been put forward by Small and Svendsen (1990, Small, 1991). It is designed to establish a context in which the great variety of different approaches to irrigation performance assessment can be understood and related to one another. As this framework has been developed in close collaboration between IFPRI and IIMI, it is likely to play a structuring role in future studies of irrigation performance. It has recently been used for the Philippines (Svendsen, 1992).

This framework takes a systemic view, in which irrigation is considered to be a system operating within broader agricultural and socio-political systems. Within this framework, performance measures are categorised according to whether they focus on the irrigation system's **internal processes** (in which inputs are transformed into outputs), on its **outputs** (the amount, timing, uniformity and quality of water delivered to the fields and provided to the root zone of the crops), or on the system's **impacts** on the larger agricultural and socio-political systems in which it exists. The framework also distinguishes between **achievement** measures of performances, where the focus is on some desired output or outcome, and **efficiency** measures of performance, where desired outputs or outcomes are related, usually in the form of a ratio, to certain inputs.

In addition to categorising the types of performance measures, Small and Svendsen emphasize the importance of **normative standards** in the assessment of irrigation performance. Regardless of which type of assessment is chosen, evaluation of performance can only proceed when it is possible to compare the observed value of the performance indicator against some standard that is established for the indicator. All such standards are derived from explicit or implicit value judgements (Small, 1992). After comparing actual with standard values indications can be given for policy formulation.

The systemic view of irrigation in the wider context is illustrated in Figure 1.

Figure 1—Inputs and outputs: irrigation in the context of nested systems



Key to Inputs/Outputs:

1. Operation of irrigation facilities
2. Supply of water to crops
3. Agricultural production
4. Incomes in rural sector
5. Rural economic development
6. National development

SOURCE: Svendsen, 1992

This approach to irrigation evaluation begins to fit a managerial approach to irrigation. Interest in **water management**, as distinct from technical aspects of irrigation construction engineering, began to grow rapidly from the mid-1970s, when an important workshop was convened at the Overseas Development Institute in London (1976). It led to the setting up of a new Network on Irrigation Management (ODI/IIMI). A Workshop in Hyderabad in 1978 led to the establishment of an Indian Network Paper (WAMANA). In 1984 followed the establishment of the International Institute for the Management of Irrigation (IIMI), in Sri Lanka, at present with sub-offices in several important irrigation countries. The work of Bottrall (1981) may be mentioned as one of the founding fathers of the irrigation management literature for large and jointly-managed irrigation schemes, and of Coward (1980), for the study of water management and local institutions in communal irrigation schemes.

Evidence on irrigation performance

The amazing fact is not that the study of water management emerged as a subject, but rather, that this interest emerged so very late: many decades after the construction of major irrigation works was undertaken in many countries. Also in countries where communal irrigation have dominated the irrigation scene for even longer periods, the interest in how such systems functioned and could be systematically improved remained remarkably limited.

What are some of the key findings emerging from studies of irrigation performance, which might provide a basis for better water management practices to emerge in future?

The degree of ignorance about irrigation performance is truly amazing. Lenton[15] (1986), for instance, noted that the managers of the Second Bhakra Main Circle (SBMC) in Northern India -- a project with a cultivable command area of some 760 thousand hectares, of which about 280 thousand hectares are actually irrigated, and some 400 thousand farmers, generating about twice the pre-tax profit of the largest multinational operating in India -- until recently had no way of obtaining specific information on how much water farmers were actually receiving and at what times.

The empirical literature on how irrigation systems perform at scheme and field level, in their goal to supply water to the root zone of crops, is quite limited. This should not be too surprising as the nature of the subject matter is difficult to do research on, and proper research is quite costly. But the problems are both wider and more deep seated.

The *warabandi* system, as a management system for distributing irrigation water has been used to serve millions of farmers in the North-Western States of India and Pakistan. Yet, hardly any written account of *waribandi* existed until Malhotra (1982) wrote a detailed description of the evolution of the concept and its application. There are historical reasons for this. The early large canals of Northern India and Pakistan were run-of-the-river diversions, and thus questions of storage and water management did not arise. Management of such canals is mainly a question of maintaining physical works.

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15 The current and second Director-General of IIMI.

The *waribandi* system has been passed down, from one generation of irrigation engineers to another, mostly by word of mouth. The Malhotra study was written to set the record straight, to answer the criticisms of various foreign and local experts, and to educate others, because the notion of *warabandi* was advocated to be applied elsewhere in India as well.

Several States in India like Maharashtra, Andra Pradesh and Gujarat were around 1980 at the threshold of changing over to *warabandi* system and had introduced pilot experiments. But, as Varma notes in his preface to the Malhotra book:

> 'their concepts of the system differ from one another, and all of them differ from the traditional one in Punjab, Haryana and Rajasthan. Lot of efforts now being spent by these states in trial and error, could have been saved had there been a written account of the traditional system'.

A number of diagnostic and impressionistic studies exist on proxy indicators of canal performance, through field visits, interviews, and a comparison of cropping patterns and cropping intensity in different canal sections (Chambers, 1988, p 105-32). These fall under what could be termed, following Chambers, 'development tourism', and they are the stock in trade of the evaluation studies discussed earlier, in Section 1.

Reidinger (1974 and 1980), is a still quoted source on water distribution and management, because so few other empirical, field-based studies have been available. He showed how irregular the water supply appeared to be in the Bhakra system (at Hissar), which around 1970 was a rather newly constructed system. Water rationing occurs at three principal levels: first, at higher levels, with the allocation of water available in the reservoir; second, at the middle level, with the rotation among channels of the preference to receive water; and third, at the farmer level, with the rotation of turns among farmers (*warabandi)* served by the same water course. The interaction of rationing at the various levels introduces a substantial degree of uncertainty in farmers' water supply, thereby contributing to the often disappointing performance in respect of yields, profits and the utilization of water.

The patterns of water supply as presented by Reidinger are illustrative only, though based on detailed and informed study of canal operations over a two year period in the early 1970s, but they are not the result of actual water measurement programmes.

An excellent example of an applicable measure of monitoring canal performance in a large system is the study on the Phabra Distributary in a subsystem of SBMC (Malhotra, Raheja and Seckler, 1984). The Phabra Distributary is 55 km long and has a command area of 20,800 hectares. A stratified sample was taken of 10 out of 50 water courses, each serving about 50 farmers. In each water course a sample of farmers was taken for detailed performance estimation.

The methodology is of the greatest interest, for it developed a procedure for irrigation performance measurement over a fairly large area with ease and objectivity, using only moderately trained people. It is based on 'action research', involving the irrigation management authorities as well as the farmers, with Malhotra being the former Engineer-in-Chief of the Haryana State Irrigation Department[16].

Nevertheless, the authors admitted that the process of data collection in their study has out-run data verification, editing and analysis. Consequently, the data were presented for a sub-sample only. Moreover and in retrospect, it was regretted that no measurements of flows were taken to verify the 'wetted area' indicator against respondents' recall, and to thereby discount for the effect of rainfall (p 240-242).

The results, perhaps surprisingly given the contemporary pessimistic mood about irrigation performances, showed that the performance of the distributary was 'probably as high as would be economically feasible for a system of its size, complexity and water control characteristics'. But this statement still begs quite a few questions.

Presumably the methodology could be improved upon and processing speeded up **if, and only if** there were sufficient interest amongst canal system operators to develop such monitoring data for managerial purposes.

Jurriens and Ramaiah (1988) report on the results of a measurement programme in the Tungabhadra Scheme in Karnataka State, where 10 measurement devices were constructed in the D36 area, along a secondary canal of 40 km and commanding about 18,200 hectares. Total volumes of water made available was only 10 percent below the theoretical allocation. But average daily inlet flows from the main canal were regularly much higher than target, at least in periods when sufficient flows were available in the main canal. Also there were considerable fluctuations, which jeopardize a proper distribution over the command. From about halfway along the canal, canal flows are **always** below target. The measurement results illustrate that attempts are made to implement a system of canal section rotation (warabandi) common for the Northern Indian Schemes, such as Bhakra, to irrigation schemes in South India where the practice was not previously applied (Chambers, 1988, p 92). Nevertheless,Jurriënsand Ramaiah note, one does not get the impression that the rotation system is effective in pushing water to the tail of the canal.

> 'Closing and opening the outlets on a rotation section takes about the entire rotation period to be effectuated, and off-takes by the outlets are never zero as they are supposed to be. The general picture of the water distribution is not only one of not realizing the targets, but also gives the impression of a lack of control, resulting in irregular and unreliable flows in all parts of the system. Remedial measures cannot readily be developed. In general terms the system should be operated on the basis of the limited available supplies and not on the basis of actual demands. In effect the system is demand driven by the vocal farmers in the top-end who force the canal operators to accommodate their wishes. The results are said to be fairly typical for many of the canals in India'.

An analysis, complementary to these results of a one-year water measurement program, is available on longitudinal changes in irrigation and cropping patterns. Satyanarayana and Srivastava (1989) made a performance evaluation of the Tungabhadra project covering the

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16 Seckler was an irrigation economist with the Ford Foundation, and Raheja a statistical consultant.

period 1970-85. They show how the area irrigated has never been according to target: during the first half of the 1980s a shortfall of some 30 percent. Moreover, cropping patterns developed in clear violation of authorised cropping patterns, with the area under unauthorized, but preferred 'wet' paddy crops rising in the upper end of the system. Further, in drought years the authorities should encourage the cultivation of light irrigated crops to offer insolation to a larger area, as the scheme was set up as a **protective** irrigation scheme. In reality, irrigation was provided to 'wet' crops in excess of the areas earmarked, with the result that the dry crop areas bore the brunt of the drought. In effect the system seems to have lost its major design characteristic of protective schemes, which have as their purpose the rationing of limited water over as large an area as possible, such as to provide a hedge against drought for the largest number of the rural population.

The inequity between head-enders and tail-enders is internationally widespread and well-known in the irrigation literature on India, as elsewhere. Systems are planned to be 'long and thin', but often end up 'short and fat' (Chambers, 1988, p 116).

Syed Hashim Ali (1984) reports in detail on the problems and issues of improving water management and in the interface between the Irrigation Department and farmers, from the perspective of management of the CADA[17] in Andhra Pradesh. It is a revealing account, by an insider and key policy maker, of the performance and prevailing attitudes in the Irrigation Department, vis-a-vis customers of the irrigation service.

As there was no canal performance monitoring, all field level development had to started without sufficient data:

> 'Whenever the question of inadequacies, unreliability and inequity of water distribution was discussed [in official and high level meetings between the ID and CADA], any inadequacies in the system were stoutly denied and the CADA had to waste time in trying to collect the information and prove the point'..... 'The introduction of *warabandi* brought out the point that no minor [canal] was capable of delivering the design discharge at every outlet.

Experience also showed that the distributaries (secondary canals) were themselves deficient; the engineers of ID were expected to work closely with CADA, but 'it was clear from the evidence that no one had really applied his mind to this work and the level of implementation in the ID was of a low order'.

On a more positive note it was found that systematic canal operation over a three year period had shown 'that it is possible to irrigate larger areas towards the tail-ends by curbing over-irrigation by top-enders. The level of success in different CADAs was different depending on the intensity of co-ordination between CADA and Operation & Maintenance staff of ID, the level of understanding of the deficiencies and behaviour of the system by the O&M staff, the craving for water by tail-end farmers specially in drought-prone areas, the length of time for which water was denied to them, and above all, to the level of dedication of the

17 Command Area Development Authorities (CADA) were set up in the late 1970s to promote irrigation development below the outlets in canal systems. They functioned therefore from the perspective of farmers facing the performance of the Irrigation Department in delivering water to the outlets.

administrative and technical staff to the ideal of Integrated Water Management (Ali, 1984, p 217-20).

This is a formidable list of necessary prerequisites for more effective water management practices to be implemented. For a recent policy perspective on CADA see: Sivamohan and Scott (1992), and Ali (1980) discusses the origin and initial expectations of the policy initiative. Wade (1984) has presented a case on the management of a drought with canal irrigation in South India, from an outside researcher's perspective. Chambers (1988, Chapter 6, has collected whatever information was available on main system management, which he considers the 'Central Gap' in the irrigation engineering practice.)

There is of course no reason to assume that canal systems will perform in reality in accordance to irrigation design parameters. Disregarding sometimes major inaccuracies in the many data underlying design characteristics, and numerous mistakes in system construction, due to low levels of technical capabilities of junior staff in land measurements and of construction staffs, the operation of large irrigation systems has major consequences for and impacts on stream flow characteristics, siltation, and the characteristics of the catchment area, under the impact of induced settlement, maintenance regimes for the canals and miscellaneous actions by interested parties along the canals in the irrigated areas (For a general discussion of some of these effects in environmental terms, see Van de Laar, 1993).

The, admittedly, limited information provided on aspects of canal performance should be adequate to expose a number of underlying problems and issues. The general point to be made here is that canal performance monitoring is rarely practised and appears to have low priority in Irrigation Departments, in India as elsewhere.

Chambers has put it succinctly, when he said:

> 'The information needed for tighter management [of water] by senior staff is not collected or does not reach them or is misleading; but as it is not used anyway, the errors do not matter' (Chambers, 1988, p 129).

The general disinterest in irrigation engineering for monitoring irrigation performance is perhaps the logical outcome of a professional ethos which defines professional prowess as being shown in head works construction and irrigation designs. In India, there exists no text book on techniques of water scheduling and water management (Chambers, 1988, p 105).

Policy issues in water management

The emerging interest in water management, and in investigating whether water from the canal systems actually reaches the root zone in the agricultural field, has had five major long term consequences, and each one of them has incurred multiple complications for the actual practice of water management in canal-based irrigation systems, and thus for the future of water management.

First, it implied that **governments extended their reach** when they took, what Ali (1984, p 215), called the momentous decision to construct field channels to each holding. Traditionally, developments below the outlet had been left by the ID to the responsibility of farmers, who were expected to organise themselves around the command area of each outlet point. The government's decision to step in resulted in the formal discovery that the IDs were not delivering the water to the outlets as assumed, as was noted above.

But the decision also tremendously expanded the scope of government involvement. Extending government action to 'below the outlets' means that the number of control structures and of operating staff increases exponentially and thereby the scale of investments needed, cost of operations and maintenance.

FAO (1975, p 2) noted that 90 percent of irrigation structures were small scale structures with capacities of less than 1,000 litres per second. The total number per unit area ranges from a few hundred to several thousand per thousand hectares.

Kraatz and Mahaja (in FAO, 1975) also note that:

> 'Secondary and tertiary canals and control structures are [sometimes] less carefully made, while smaller canals and those at the farm level and their structures are more often badly made or omitted entirely from engineering plans....Engineers have often neglected these 'minor' works, particularly those required at farm level; to contractors they do not mean much profit and they are dispersed and difficult to supervise; and last but not least, authorities have sometimes appeared to be less willing to invest in tens of thousands of such small scattered works than in larger works having greater prestige value.'

One should be somewhat cautious about generalised figures linking numbers of minor structures to irrigated areas. The extent of the expansion of governments' direct role depends also on the manner in which the irrigation system is (re)modelled. Horst (1987) gives an illustrative example for an existing project in Indonesia, between the number of regulating structures when the tertiary off-take structures at the secondary canals are adjustable (as was the existing situation), and what it would have been, had proportional divisors (which are fixed) been applied. He shows that the operation of movable structures would have decreased ten-fold as virtually all the cross-regulators would have been redundant, and thereby their operating staff.

The key decision for governments, not only in India but also elsewhere such as in Indonesia, to involve themselves in the tertiary systems could have been expected to lead to greatly increasing problems for (i) the future financing of the recurrent cost of irrigation services and (ii) the management of large numbers of lower level staff. These new staff occupy **sensitive** positions because, by implementing water management schedules, they do affect the prospects for survival of many small and poor farmers.

Second, the **irrigation engineering profession** has tended to respond to the new challenges by greatly increasing the complexity of technical irrigation designs at the tertiary level, sometimes going even 'deeper' to the quaternary level of individual farmers' plots. This was and is a response to the need to provide more flexible and more efficient irrigation services for more diversified cropping patterns.

Modern and flexible systems have two important aspects in common: (i) centralised management and (ii) adjustable structures enabling exact control over water distribution for complicated irrigation schedules. However, by these very characteristics, they cannot and do not enhance farmers participation in management decision making (Horst, 1987).

Interdependence between different parts of increasingly tight irrigation systems, and thus the effective operation of the expanded and theoretically refined regulatory systems, puts great demands on the integrity of system operators. Effective, accurate and timely communications between different sections in the systems is also a necessary prerequisite, and this means that system operators at low levels are not supposed to delay action in view of specific local wishes, as this would interfere with the operation of the main system.

This set of requirements is extra-ordinary difficult to incorporate in Irrigation Departments where there has been neither interest in, nor experience with the management of many subordinate operating staff.

The management task of operating low level technical structures cannot be devolved by government to farmers themselves in so-called modernized systems, as they will then tend to give priority to their own immediate water requirements. This will induce them to ignore or delay response if overall system management would require immediate action. Therefore, the trend towards sophisticated technical designs at lower levels within the irrigation system tends to induce near permanent conflicts between system operators and farmers in different canal sections.

Third. In the past, **Irrigation Departments** were usually responsible only for the main conveyance system, but with governments everywhere taking a much more active role in field development, it also extends government responsibility for a larger share of total water losses in the distribution system.
The paradoxical situation then arises that the more government succeeds in reducing water losses and increase water efficiencies in its, expanded, canal sections, the lesser the need for farmers to do 'their bit' to reduce water losses in field application: as beneficiaries of additional government action they receive relatively more water and this lessens the need for then to economize in their own water use. They become 'free riders', abusing the public good of better overall water availability. They may react perversely: using more water by switching to water-demanding crops.

Fourth. The requirements to bring about greater water efficiencies differ greatly in different irrigation system sections. In the conveyance stages it is mostly a matter of canal lining, e.g. an investment project for which a separate cost-benefit analysis can be made[18]. To improve 'on-farm' and tertiary-level efficiencies a major effort is required in agricultural extension to change farmers cultivation and water use practices, and this is an entirely different type of problem. At that level, Irrigation Departments have limited knowledge and no experience,

[18] See below, Section 3.2

and Agricultural Extension staff tends to have too little operational knowledge of irrigation. Therefore, somehow, Irrigation Departments and Agricultural Departments have to learn to work together much more than is within their historical-institutional and professional-educational experience.

Fifth. Irrigation Departments have come under attack for the many opportunities they provides for administrative corruption and rent-seeking behaviour. This has become a favourite theme in the wider context of Neoclassical Political Economy, where governments are being attacked for the ineffectiveness and inefficiency of whatever they do, and whereby the virtues of the market, market forces and of competition over (state) monopolies are praised for superior expected process outcomes. In extreme forms, it is then argued that states do not have more or better information than individuals and corporations, and that therefore there is little 'value added' to be expected from government action. It all boils down to an almost complete negation of all the arguments which have been espoused for at least half a century for governments, especially in developing countries, needing to play a leading role in development (see Colander 1984, for a convenient entry into these discussions).

In irrigation, Wade (1982, 1985) has been among the first to systematically describe and analyze *'The system of administrative and political corruption: Canal Irrigation in South India'*. See also, Jagannathan (1986). The analysis focuses on the higher managerial levels in existing, traditional canal systems. In a generalised sense the publication by Repetto: *Skimming the Water: Rent-seeking and the Performance of Public Irrigation Systems* (1986), has drawn much attention, and may have been influential especially in Washington, with the US government and fitting in with dogmatic neoclassical economics forces within the World Bank.

The thrust of this type of analysis is that irrigation operators at nearly all levels control vitally necessary resources for agricultural production. This gives them great power and they may well be enticed to exploit this power to their own benefit. One of the ways in which this can be most effectively done, is to stress unpredictability in water availability as this will solicit farmers' defensive response in bribing system operators. At the individual level this may be effective, but when the practice is generalised, it becomes self-defeating to the farmers as a group.

Fundamentally, there is perhaps a growing conflict between irrigation engineering professionals, who require system operators to act as 'robot-like machine operators' in implementing increasingly complex water distribution schedules, and the real world where system operators and farmers try to optimize their own and individualised benefits arising from control over a scarce resource.

Horst (1987), has already drawn a deeply pessimistic conclusion on recent developments in the irrigation engineering profession and its managerial implications when he summed up the combined result, and the implicit dilemma:

> 'The tendency nowadays of trying to increase irrigation efficiencies by increasing regulation and measurement of water, together with training of operators, should be considered a fallacy; it creates

more complicated manipulations, more sources of error and does not prevent mal-functioning of the regulation structures. The operations are often incomprehensible to the farmer, and many of the adjustments are hidden from view, thereby increasing the operator's opportunity of accepting bribes without discovery. Ironically, the search for higher water efficiencies through complicated operational systems with much regulation and measurement will in many cases eventually result in low efficiencies due to complicated distribution programmes and operational mismanagement (Horst, 1987, p 6).

Water management and the future

Wade and Seckler (1990) have done some stock-taking of where the management approach to irrigation currently stands, in trying to analyze what the implications of the water management approach are for the structure or irrigation organizations and on the contribution of management theory to better water management in practice. They note (p 14): 'for approximately the last decade there has been a growing awareness among irrigation professionals that the management factor is very important in canal performance. The 'management factor' refers to about everything but (i) 'technical' -- physical design and its translation into physical objects on the ground; (ii) water charges -- which economists have taken over for treatment by the techniques of economic analysis, and (iii) 'farmers participation', a subject that most irrigation experts willingly leave to someone else, such as sociologists.. Management, in other words, tends to be the residual factor, and the more intractable the problems of improving irrigation performance are seen to be, the more expectation is vested in the management residual to come up with the solution'.

The emphasis on improving the management of systems reflects a wish to have people at various levels of the hierarchy do what they are supposed to do. But the prior question is what, exactly the staff is supposed to do (i.e. **what** schedule of water delivery they should follow, **what** information they should be collecting, **what** maintenance procedures should be used). However, very little empirical evidence is available touching on these issues. There are only few studies such as Wickham and Valera (1978) for the Philippines, showing the effects of a change in water management procedures. In this case, curbing surplus water to top-enders in favour of pushing more water to the tail-enders. This was acceptable to the top-enders as they were assured that they would continue to receive needed water so they would not suffer production and income losses as a result.

But such studies do not touch the question of organization structure: the extent to which different organizational structures affect canal performance, or the extend to which changes in organizational structure could be expected to improve performance. There are virtually no studies on irrigation bureaucracies. Yet, national governments embark upon organizational changes, often at the prompting of donor agencies (ibid. 15).

In their view, the content of the management literature is not encouraging. 'It is filled with uninterpreted case studies, or discourses on questions such as how 'the environment' affects 'the organization' with environment specified only in terms of being 'simple' or 'complex', 'static' or 'dynamic' and no indication of how one might operationalize these terms. Or it discusses how to improve 'poor coordination', with the advantages of 'more coordination' taken as self-evident.

They then set out a list of important issues, which themselves could be a research agenda for another decade, but which will not be discussed here.

If water management is to be taken more seriously by Irrigation Departments in the future, it is necessary to investigate whether incentives exist or can be created which force these Departments to take a more active and direct interest in the performance of their water delivery function. A comparison between the Philippines and most other countries should be of interest to sketch contrasting contexts.

The transformation of the irrigation sector institutions in the Philippines has drawn considerable attention internationally. It is also an instance where from the beginning great emphasis was put on documenting changes and their effects (Korten and Siy, 1988, Bagadion and Korten, 1990, Svendsen, 1992).

From the present institutional and managerial perspective, only some of the key elements will be highlighted. In the conventional model of the Philippine government there existed an Irrigation Department. This was abolished in 1964, and a public corporation was created in its stead, but with little effect on its operations. A major overhaul of its charter in 1974 led to far-reaching changes in the National Irrigation Authority's (NIA) organizational values, structures and operations. At the core of these values was the presumption that, to be successful, **NIA must be financially viable.**

By 1979 it had achieved the goal of overall financial viability, and in 1981 the last operating subsidy paid out from the national Treasury was received (Svendsen, 1992, p 4). Svendsen notes that few other irrigation agencies in the developing world have been able to do this (ibid. p 6).

The major thrust of the 1974 charter amendments was that NIA was allowed to retain all revenues generated by it, including irrigation-fee collections. NIA responded by **(i)** devolving responsibility for certain operational, maintenance and fee-collecting tasks to farmers; **(ii)** increase corporate revenue by raising fees, improving collections and generating secondary income from ancillary activities; **(iii)** reduce operating costs through a series of minor economies and through major cuts in the personnel budget; **(iv)** provide financial incentives for superior performance to outstanding field units and to individuals in them.

What are major results achieved to date? A number of performance indicators have been specified and existing performance measurement data have been collected, (in the Small and Svendsen methodology discussed in the beginning of this section). A number of indicators improved in a 'before' (1981) and 'after' framework.

The volume of water made available in the sample schemes is a function of river flow, and thus outside the control of management. However, the equity of water distribution is under the control of the managing entity, here composed of NIA and farmers associations. Together they were able to spread a given amount of water more widely across the potential command area after 1981 than before, and they did this in a way that did not decrease average system yields. The efficiency of the overall irrigation delivery/agricultural production process relative to the system water input did not fall off as a result of the changes introduced

(Svendsen, 1992). The qualifications of the findings need not concern us here, as the focus is on the institution.

The **public corporation institutional model**, as adopted in the Philippines, may be contrasted with an alternative institutional model: the **government fiscal model** which appears to be the prevalent model nearly everywhere. This model rejects some of the key suppositions which may have been behind the seemingly successful transformation of the Philippine irrigation bureaucracy.

I approach this institutional comparison from the perspective of finance and cost recovery, a perspective stressed for many years by the World Bank (Duane, 1975). A typical case where the government fiscal model continues to prevail is the Government of India, which has stated in writing more than once that its policy is different from the Bank's and that it does not expect irrigation projects to generate revenues or recover costs to ensure sustainability after completion (O'Mara, 1989, p 62).

It therefore rejects the notion that the Irrigation Authority should become financially viable and it does not allow that requirement to be used as an instrument for the transformation of institutional values and operational practices in the Irrigation Departments.

But first some more generalised evidence on finance and cost recovery is provided. The historical record is clear. The capital costs of irrigation investments are never charged onto the direct users, and in many instances the direct Operation and Maintenance (O&M) costs are not, or only in small part born by direct users. The World Bank's Review of Cost Recovery in Irrigation Projects, of June 1986, by its Operations Evaluation Department, has the following succinct summary statement (O'Mara, 1989, p 58):

> 'Overall, the cost recovery record in irrigation projects has not been good. Frequently, the Bank's requirements as expressed in lending covenants, particularly with respect to recovery of investment costs, have been so vague that compliance or noncompliance is difficult to determine. In at least two-third of the projects reviewed the covenant requiring that cost recovery satisfy O&M funding has not been complied with. The proportion of O&M costs recovered was frequently between 15 and 45 percent. In addition, there were few cases where capital costs were recovered'.

The OED report goes on to note that O&M of irrigation systems was considered as satisfactory at audit in only about half of the projects. Compliance with cost recovery covenants was assessed as satisfactory in only 15 percent of the cases. When the pricing covenants required a socio-economic survey and it was implemented, the recommendations were 'generally not applied'. The response of Bank operations staff to noncompliance with cost recovery covenants has been quite variable, covering the gamut from refusal to consider further financing of irrigation projects to no reaction at all.

We clearly face a tricky and intricate economic and above all political problem. For example, a political leadership that assigns large irrigation rents to a favoured group of land owners may create a powerful supportive constituency that will ensure political control for many years. The ability to allocate irrigation resources is an effective instrument to establish and keep the political support of client groups, e.g. rural landowners, who, in turn, have considerable control over their tenants. The complexity of the economics of irrigation pricing cannot be discussed here, but see Sampath (1992), and further Section 3.1.

The government fiscal model, as opposed to the public utility model of irrigation, views irrigation as simply one of many services to be provided to agriculture, such as research, extension, marketing support, inspection and grading services. It finds no special merit in either financial or operational autonomy. Irrigation revenues are collected as any other government tax, and irrigation investments and O&M are part of the general government budget, and are to be subject to general guidelines for government expenditures. It then follows that no necessary connection between payment of irrigation service fees and the financing of irrigation exists.

But the implications of this line of reasoning for the functioning of Irrigation Departments seem to be fairly clear and obvious. When the IDs want to build fancy new projects, they lobby with government and not with farmers. They need not take an interest in actual system operation because they get no benefit. Instead, they will encounter messy problems and conflicts which they cannot, or do not want to address. They have no interest in collecting irrigation fees, as this will antagonize farmers, part of their lobby for new irrigation projects. Moreover, revenues collected do not accrue to them to enable better O&M performance, but go to the Treasury. Individually, the formal salaries and emoluments of ID staff are not affected by performance in water distribution, in fact mal-performance generates more incentives for bribes and corruption from farmers who need water to grow crops.

In such a context, mere exhortation and appeals to 'duty' and 'public service' in training programmes will be quite insufficient to change the values, operational styles and performance of traditional irrigation departments and irrigation system operators.

The **conclusion** to be drawn from this section is that little monitoring of irrigation performance takes place, but that the need for systematic monitoring is obvious as no system seems to perform according to initial design parameters, nor would there be any reason why systems should operate according to designs.

However, the initiation of monitoring itself is a problem where systems have only vaguely formulated objectives, which can also not be enforced. While the need for improved water management is accepted, there is very little factual and published information to assess managerial performance and to anticipate the effects of what type of management changes on water management practices and the resulting impacts on the wider agricultural system. Even the generation of information is problematic as such information on water delivery performance is 'socially generated', whereby those collecting it can, and often do have hidden agenda's to safeguard their personal interest and stake in irrigation water as a source of allocating favours.

In the 'nested' evaluation approach advocated by Small and Svendsen, and presented in the beginning of this section, 'filling' the irrigation box with meaningful information to enable better water management practices to be formulated and implemented is by itself problematic. While there is growing consensus of what should be needed, there is not yet sufficient evidence that decisive steps are being undertaken in different countries towards effective realisation of what is clearly highly desirable.

3 EQUITY AND EFFICIENCY IN IRRIGATION STRATEGIES

The literature on evaluation of irrigation planning and investment is more extensive than any other area of economic investigation of irrigation. It mostly focuses on individual project selection (cost/benefit analysis), but ignores many of the broader questions concerning irrigation planning and investment. Thus it may be of use to introduce here a somewhat more general discussion on equity and efficiency in irrigation strategies: e.g. it focuses on broader considerations **preceding** the choice of the specific projects to be developed.

Irrigation is concerned with redirecting available and limited water from relative surplus areas to deficit ares (water to land) and thus from one group of inhabitants to other groups of the population. Therefore, irrigation strategies inevitably have major efficiency and equity implications in a spatial setting. In weighing the options major value judgements have to be made, for the construction of irrigation infrastructure depend on decisions having been made at some level and by somebody powerful enough to prevail. **Irrigation involves trade-offs in hopefully non-zero-sum games.**

Major trade-offs among different types of investment include the following:

(1) government vs. private;
(2) expansion vs. intensification (rehabilitation);
(3) large-scale vs. small-scale irrigation.
(4) wet-season vs. year-round irrigation;
(5) irrigation vs. rain-fed production;

3.1 GOVERNMENT VS. PRIVATE

Numerous externalities in water development policies cannot be internalized, and the scale of operations needed in the contemporary setting is often quite large. Therefore, governments in many cases have seen fit to directly take the responsibility for the planning and execution of major public works such as dams and canals. However, individuals and local communities have developed and continue to be responsible for community level schemes which tend to be relatively small. In groundwater development we find mixed systems: governments have made available credit for pump sets, the operation of which is in private hands.

However, any simple classification of 'domains' for public and private irrigation is doomed to fail because of multiple interconnections between water institutions and the resource itself. In large irrigation schemes, government irrigation authorities are forced, for information and organizational reasons, to effectively decentralize system operations (Wade, 1981), and to involve, or be manipulated by, local social forces. This was already so when the large Indian schemes were first developed in India in the late 19th century (Stone, 1984, p 214, 237-8).

In tubewell irrigation government influence is still required to avoid over-pumping and well interference by private actors. Also in community schemes governments are currently interfering to assist local communities in upgrading and improving traditional systems. This external involvement will affect the balance between government and community institutional control.

In addition to increasing institutional interferences, further direct resource interference derives from the increasing interlinkages between surface water and groundwater development. Especially the rise of groundwater exploitation since the 1960s has had far-reaching consequences for institutional roles (public vs. private), competing legal frameworks and for designing operational water management policies.

For these reasons it is not useful to engage in abstract discussions on the virtues of public or private control over water resources, but the more useful discussion should be about the question of the appropriate mix of public and private parties. To this end, two wider **analytical perspectives** are highlighted in this sub-section: **(i)** the complexity of (re)designing a suitable legal and institutional framework within which water resources exploitation, by either public or private institutions, may be conceptualised, and **(ii)** the question whether a greater role for market forces and the price mechanism, as is currently being advocated at the level of national economic policy reform, can be expected to lead to better market performance also in the irrigation sector, where externalities are so pervasive and materially important.

None of the issues can be gone into in detail. There exists a wide ranging array of disciplinary-based literature in law, public sector economics and public choice and collective action theory. What is important here is to show the relevance of some of that general literature when applied to water resource development issues. It will be show that even thinking about what might be an appropriate 'mix' for the public and the private sector is bedeviled by the complexities of institutional failures and of market failures. Current legal and ideological preferences for the establishment of private property rights and for the introduction of market forces within the neoclassical economic paradigm are very problematic in the case of possible application to water resources.

Changing legal and institutional frameworks.

Where surface water is the only manageable source for irrigation[19] the government, through investing in irrigation infrastructure since the late 19th century, established rights over water utilization. Where, by the mid-20th century, waterlogging and salinity became problematic, the initial response has been to establish Salinity Control and Reclamation Projects (SCARP) also in public hands, to improve the provision of the irrigation service, and to maintain

[19] We disregard rainfall, and thereby the complexities arising from the conjunctive use of rainfall and irrigation. Thus, to focus the discussion, one should have in mind the more arid regions of the world, which include major areas in South Asia and North China as well as in the Middle East.

overall government control over irrigation water resources. This model was then also thought capable to plan the emerging new development: the conjunctive use of surface water with ground water.

This simple model of a public sector monopoly over all water resources has, however, broken down substantively and institutionally, under the impact of the wide-spread introduction of tubewells **within** the command areas of surface irrigation systems.

In the 1960s and 1970s more than 2 million small-capacity tubewells were installed in **North China** (O'Mara, 1988, p 2). In **India**, the number of public tubewells increased from 14,000 in 1968/69 to 46,000 in 1984/85, but the number of private tubewells jumped from 460,000 to 3.4 million in the same period (Cunningham, 1990).

In **Pakistan**, the number of tubewells increased from less than 5,000 in 1960 to more than 200,000 in 1980, supplying more than half the water actually available for crop consumption in the fresh ground water areas, but of course none of the water for crop consumption in the saline groundwater areas, which account for about one-third of the total irrigated land of the basin (Johnson, 1988). The separation of water pumping under the Salinity Control function, with the water used to augment canal supplies, and for productive agricultural use has become fully blurred. Moreover, the overall effects of all the public and private pumping has not helped much to reduce salinity. In fact, the situation has worsened. The Federal Government categorizes areas with a water table within 5 ft as disaster areas, and the disaster areas had actually increased in size between 1961 and 1981: from 2 to 7 percent of total area in the 0-3 ft range, and from 11 to 15 percent in the 3-6 ft range (Aklilu and Hussain, 1990, p 26).

A major bone of contention for over 15 years has been whether such SCARP tubewells should not have been more effective for salinity control if they were in private hands, and whether, therefore, public tubewells could or should be transferred to the private sector (Johnson, 1988). This issue now appears to have been resolved: the Government of Pakistan is fully committed to the transfer of the management of fresh ground water resources to farmers and to the privatization of public tubewells (Aklilu and Hussain, 1990, p 34). However, the effects may be doubted, because of the location of public tubewells, near canals and not near the fields, does not make them prime candidates for privatisation (Johnson, 1988, Van de Laar, 1993).

In general, decision making about water use in specific areas is in future to be effectively shared between governments and tens of thousands of individual pump owners, and the public monopoly model, which had prevailed for a long time period in these regions, has effectively as well as legally broken down. Only to create new problems, for the linking of surface waters and groundwater resources in an interdependent system means that water resources have become the classic example of a 'common pool', or 'joint-use' natural resource, subject to the threat of depletion and over use.

When crop water is to be seen as an integrated 'common pool' natural resource[20], different legal doctrines about water rights come into conflict, and thereby contribute to institutional reasons for inadequate resource use. For instance, in many situations water is appropriated on a 'first come, first served' basis. Along natural rivers water rights are based on historic use, stating that earlier users have preference over late users. Senior rights owners have precedence over junior rights owners. A characteristic of such rights is that they are usufruct and may be lost of not exercised.

When irrigation is developed, governments claim prior rights superseding established historic rights of riparians. Governments then proceed to establish new rights in the mechanism for allocating captured waters through the canal distribution system to the lands to be irrigated. Such distribution mechanisms are usually based on the criterium of land ownership, and irrigation water is then allocated in proportion to the size of landholding.

In other situations, still found in many traditional communal irrigation systems, water rights are held separately from rights to land. It has been argued that in some arid areas, where irrigation was essential, property rights to the use of water antedated property rights to land (Cantor, 1970).

Tubewell irrigators can, in practice, sink their wells indiscriminately and thereby infringe on various rights held or claimed by others: historical and traditional rights holders along stream flows, rights holders granted by governments through the provision of surface irrigation, and new right holders over ground water resources being established by tubewell owners, in disregard of all other rights holders. The upshot of all this is that Law itself becomes an obstacle to proper overall natural resource use.

In general, law contributes to institutional failure in three cases (Radosevich, 1988). First, there is the absence of law. Countries which may, for instance, have legal systems for surface water may not have any laws on groundwater use (example: Bangladesh). Second, there is the inadequacy of law, demonstrated by the examples given above. Different legal regimes embodying different legal principles may have been appropriate and applicable in specific segmented and separated contexts. But in the new situation of increasingly integrated institutional and resource development, such regimes inevitably come into conflict with each other. Thirdly, existing law might be inappropriate to present problems or may not give proper guidance. For instance, existing laws may authorize the imposition of water use charges, but the intended clientele is unwilling to pay as the water supply is highly uncertain. Water use charges are then not an instrument to regulate water use, but are merely a lump sum tax for services which may not be regularly provided.

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20 Natural resources are 'managed' under different institutional arrangements. They can be privately or publicly owned, or not-owned (open- access resources). Where property rights cannot readily be established, e.g. with low transaction and enforcement costs, effective joint-use may exist or may be established. Where previously effective joint-use management systems break down, the resources themselves tend to become open-access resources, which may lead to accelerated overuse and resource degradation. See further below. For a moree extensive, theoretical discussion, and a backdrop for the Management of Common Pool Natural Resources Project, see Van de Laar (1990).

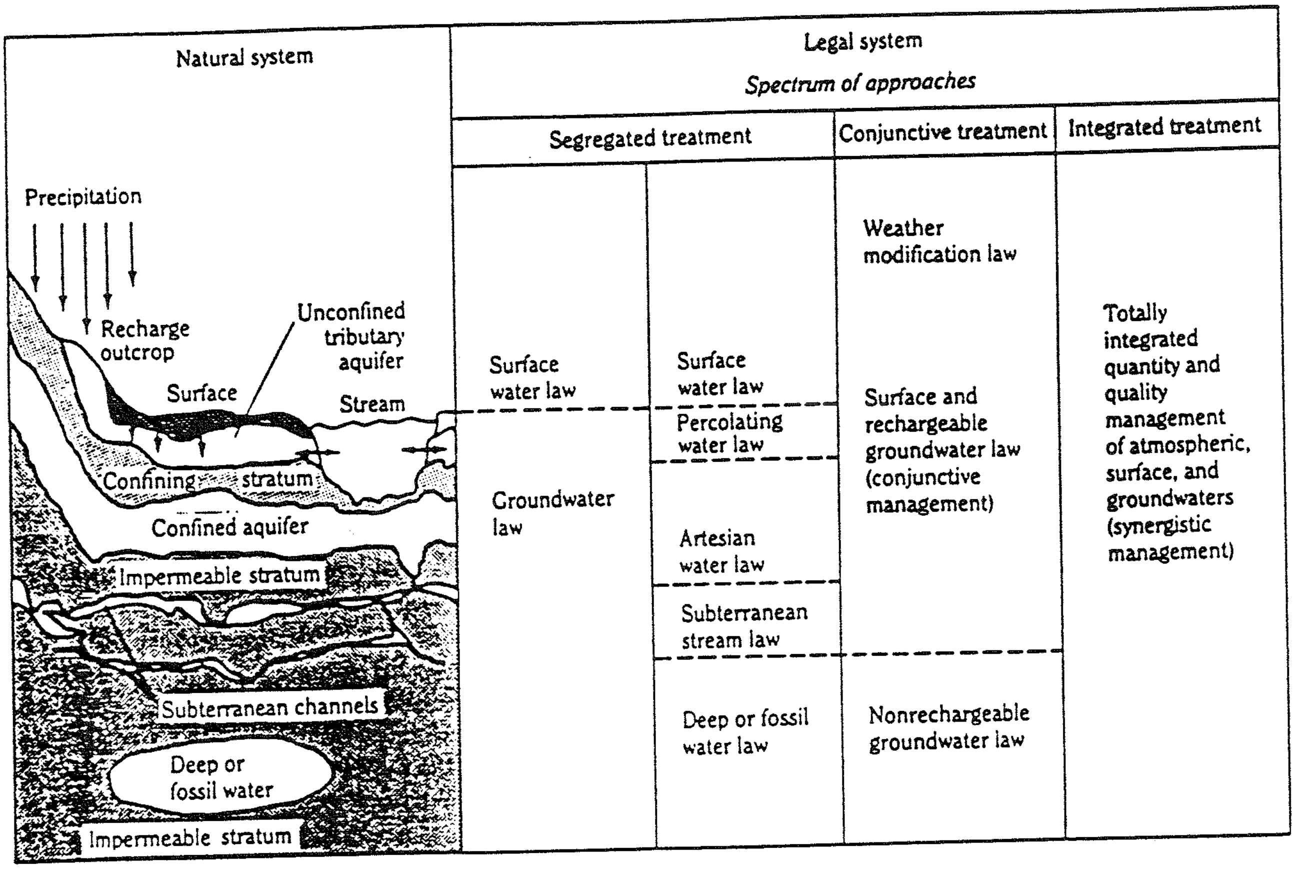
A precondition for unified resource use control would be the unification of water laws. This is problematic as existing legal systems in many individual developing countries have been influenced and shaped by different legal traditions: British, US, Spanish, Islamic (Radosevich, 1988; FAO, 1973, 1978, 1979; Van de Laar, 1993). Surface waters and ground water resources often fall under different legal regimes and are treated as separate 'realms'. Furthermore, it should be realised that historically established or acquired water rights are tenaciously defended by rights holders, and necessarily so as life itself depends on access to water permitting crop growth for human survival.

Establishing or reestablishing suitable laws for water resources management is currently being overtaken by technological change and the tapping into groundwater resources by hundreds of thousands of private tubewell owners. Thus the problems of designing new and more appropriate legal systems are compounded by the greatly increased complexity of having effective law enforcement of whatever water law regime might emerge.

The interfaces of the natural and legal systems in respect of water resources, and a summary presentation of the spread of different legal doctrines, are illustrated in the Figures below:

Figure 2

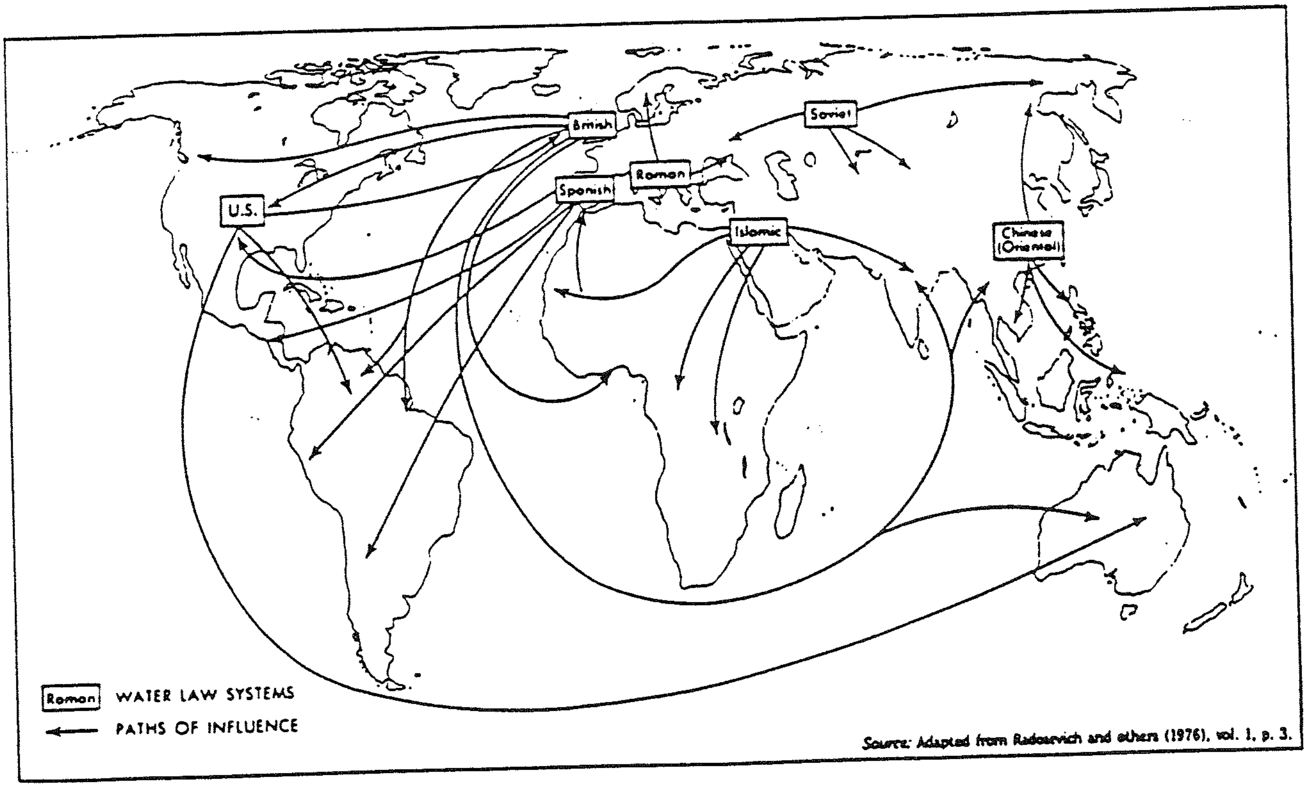
Figure 3-1. *Interface of the Natural and Legal Systems*



Source: Adapted from John Muir Institute (1980), figure 1, p. 36.

Figure 3

Map 3-1. *The World's Principal Water Law Systems and Their Paths of Influence*



Source: Adapted from Radosevich and others (1976), vol. 1, p. 3.

The critical institutional problem of managing a common property resource, or for managing a 'common pool' resource such as crop water, is to design, implement, and enforce rules of behaviour of users such as to overcome the private and individual incentives to 'cheat' on the rules in view of the large benefits which can be reaped individually and for the short run.

Unregulated common property resources have strong built-in pressures towards over-exploitation of the increasingly scarce resource. Effective **collective action** is required and institutional arrangements for water management ought to be assessed from the perspective of whether they enable, permit or distort effective collective action in water management. But the scale at which effective collective action might be organised is itself problematic. In general terms the larger the group the more difficult will be law enforcement. Small groups may wield effective collective power in respect of some part of the water resource, but in consequence they may strongly interfere with water rights elsewhere in the water system. They then cause new negative externalities: the classic case being head-enders vs. tail-enders.

A perspective on effective collective action is the opposite of assigning individual property rights as the necessary institutional precondition for exploitation and management strategies of water use, based on market forces and the price mechanism. For a common property resource such as water this is likely to be the most powerful instrument and the fastest road to water over-exploitation and thus doom. Also for land based assets questions can be raised about the appropriateness and effectiveness of assigning individualised private property right to what used to be called common property resources (BOSTID, 1986; Bromley and Cernea, 1989; Van de Laar, 1990).

Externalities and the price mechanism

Decision making about water use rates and the role of markets and pricing policy have to be rethought as well, as the preconditions for conventional models of efficient resource allocation via the creation of markets and the operation of the price mechanism in market processes do not apply, due to the presence of externalities.

Major externalities occur between tubewell owners and irrigation departments controlling surface waters for irrigation. When there was only surface water irrigation complex social interaction remained limited to land owners adjacent to the stream flow loosing water, and the joint interaction of farmers along the canals and with the irrigation authorities[21]. Integration of surface irrigation with groundwater use in conjunctive use systems generalizes conflicts between all parties involved.

A general prior point to be made on irrigation investments and water use, is that irrigation investment and maintenance cost refer to the cost of providing the water. Relevant cost categories refer to the utilization costs, or the extraction costs for natural resources. **They do not include the cost of water itself.** Investments intended to lower the cost of 'making

[21] The well-known book by Chambers (1988) only deals with such interactions in surface irrigation. He does not deal with the additional issues and complexities of conjunctive use of surface water and groundwater.

the water available for use' may thus in effect diminish a constraint on the wider and more thorough exploitation of water resources which are the natural resource conceivably in short supply in some of the major irrigated areas in the world. Greater efficiency in accessing water resources, through technological developments and cost reductions in extraction, may thus hasten the (over) exploitation of these water resources. For these reasons, investments to better access water resources for use **must** be accompanied by stringent rules, and their effective enforcement, to avoid over-exploitation of the resource itself.

To enable the valuation of water itself, it would be necessary to take the hydrological unit of the watershed concept as the only meaningful unit of analysis. Only at that level would it be possible to: **(i)** ensure that interactions between different users and purposes are fully taken into account; **(ii)** limit development to what is feasible with the water resource available; and **(iii)** create a framework within which allocations between competing users can be made in line with priorities to be established somehow. In the case of governments being unable to do this effectively, the alternative is anarchy or the imposition of power by some (Hart, 1978). There may then not be the possibility of having a non-zero sum game for water exploitation.

In the conventional wisdom of the market-failure-government fix paradigm (Randall, 1988), there are four kinds of circumstance in which even a fundamentally competitive economy would experience market failure. These phenomena are externality, public goods, common property resources and natural monopoly. And in irrigation all four are present!

Externalities are classified as 'pecuniary' or 'physical or 'technological'. For a pecuniary externality the interaction between outputs and costs comes about solely through changes in input prices. For a physical externality, the interaction is through output effects which operate on the physical production possibilities of the farmer.

For example, if some farmers with deep wells pump to lower the water table, owners of shallow wells may find their water supply disappearing. Where surface irrigation improvements are made, and more water is supplied to the fields by government action, the needs for pumping up supplementary groundwater by individual pump owners may disappear. However, if drainage is poor, through system design shortcomings or mis-management of canal water supplies, the need is for increased private pumping to get rid of surplus water. If pumping by some farmers leads to reduced salinity and waterlogging, the yields of other farmers would also increase, even though they do not incur costs. Tubewell pumping lowering the water table adjacent to a stream flow will induce increased seepage to groundwater or interrupt return flows to the stream, with the result that river flows are reduced to the detriment of down stream water users.

Thus, multiple interactions exist and investment strategies, as well as effective Operations & Maintenance planning, will become much more problematic than in the case of the government as monopoly controller over surface water irrigation, or private individuals owning pump sets. Similarly, changes in pricing and irrigation fee policies, and thus in the incidence of the charges to be levied can give rise to various avoidance strategies in response. The government may wish, or be pressured in conditionality covenants of foreign loans, to increase the charges for **its** irrigation services, but it cannot by the same mechanism control the behaviour of tubewell owners.

The important point to make here is that the old model of irrigation authorities establishing a natural monopoly over large scale irrigation, and setting new policies for water use, is no longer applicable and certainly not appropriate when major changes in the legal rights structure have taken place under the impact of tubewell technology.

Ironically, access to groundwater in part has been made possible in many places through the secular rise of water tables resulting from long periods of surface irrigation by governments. As a result, governments are now losing control over the irrigation policy itself. While engineering and hydrological problems are still important, the emergence of genuine 'common property' in linked surface and groundwater resources implies that especially **institutional issues** have to take on a much more important role in contemporary and future oriented decision making about sustainable irrigation policy.

Common pool resources such as irrigation crop water are a special category of goods. This may be illustrated in the following two step classification (Van de Laar, 1990). First, applying the two criteria of excludability and subtractibility, not as dichotenous but as scale variables, to distinguish different categories of goods, we obtain a simple scheme as follows:

	excludable	subtractible
public goods	no	no
private goods	yes	yes
common pool	no	yes

This classification of goods by these two criteria can be used to 'fit' institutional arrangements to these categories of goods.

Private goods, by being excludable ('separable') and subtractible ('more or less scarce') lend themselves to be provided by market processes. These are the goods most often discussed in standard economic theory.

Public goods should then be provided by government because they cannot be provided by the operation of market processes. The individual producer cannot create value because the goods are not individually separable (national defense) and their use does not lead to lesser amounts being available to others (knowledge).

Common pool resources have **mixed** characteristics, their subtractibility resembles private goods and their non-excludability gives them traits resembling public goods. Therefore, one could argue for a **sui generis** type of provision.

Theorists in the neoclassical tradition in economics and current ideology in major governments and in dominant international financial institutions favour the assignment of property rights since it minimizes the need for subsequent state intervention in the market processes which this institutional setting facilitates. Privatisation of public monopolies and deregulation are the buzz words of the contemporary rhetoric and it is implicitly assumed that these recipes are equally applicable for all countries and in all sectors of the economy. As is shown above, it does not apply to pure public goods but also not, or not very well to common pool natural resources, such as crop water.

Conventional remedies to cope with externalities are:

i. Corrective taxes or subsidies on private agents to the extent necessary to adjust private cost to reflect social costs.

ii. Centralised control over the resource so that the externalities can be internalised within the decision making context of the controller.

iii. Assignment of legal property rights so that the span of actual physical effects always coincides with legally recognised responsibility.

None of these remedial strategies is promising in the case of irrigation. It is practically impossible to set the basis for corrective taxes and subsidies. Diversity of conditions between different parts of the irrigated area, differences between cropping patterns and thus sensitivity to water volume and quality are significant. Discovery of damage done to others is problematic if not impossible where pumping hours and pumping depth cannot be controlled or inspected, and where also night-watering will lead to evasion of rules. Moreover, social interaction between lower level irrigation authorities and the prevailing economic and political power structure effectively preempts the possibility to assign the size and nature of negative external effects to design compensatory taxes and subsidies, leave alone implement and enforce such policies effectively.

We may put some flesh on the perplexities of water pricing as a policy instrument, when we look at the historical experience. The following discussion is also relevant when comparing the wider implications of the public enterprise model with the government fiscal model for improving institutional performance of irrigation bureaucracies, as was done in the previous section, where we contrasted the 'Philippines' with 'India'.

The issue of irrigation pricing has been much debated in India, from almost immediately after the early large canals were constructed in the mid-19th century. It centred on experiments in volumetric pricing, forms of pricing and the structure of water rates (Stone, 1984, p 180-94).

For instance, it was found that crop-acre charges were particularly unwieldy as a tool for encouraging economy of water use, as sluices (outlet structures): (i) did not give uniform discharges into the village channels; (ii) modules silted up due to insufficient water velocity, or (iii) modules were being interfered with by farmers. A second-best solution, sale of water by contract, was effectively rejected as arranging contracts necessitated making agreements with a few village representatives, who were usually the dominant cultivators, able to appropriate, in whatever form, more than their fair share of the benefits of irrigation, while the weaker shareholders find themselves called upon to pay up their share of the contract money...but do not receive their share of the benefit.

Historically, the spread of canal irrigation was in many places held back as a direct result of the entanglement of the canal and land revenue systems. Landlords prohibited their tenants from taking canal water to their fields in the years leading **up to** resettlement, so that their revenue assessment might be kept down and they might capture the whole amount of rent enhancement **after** the settlement. In addition, the owner's rate similarly restrained the spread of irrigation. If an occupancy tenant refuses to pay either the owner's rate or a higher rent, the land lord must bring an enhancement suit against the tenant; but after the rent has been raised it is to the interest of the land lord to prevent his tenant from irrigating, as the smaller the share of 'dry' field irrigated, the less the amount of owner's rate to be paid by the land lord.

In terms both of the water charge as a proportion of average crop values, and of the actual price paid per unit of water taken, there is no doubt that the adopted scale of charges favoured the commercial crops, but, according to Stone (1984, p 189) the evidence suggests that the differentials almost certainly did not affect crop choice. A more effective method of reducing the cultivation of rice in the late 1860s was when the previously copious water supply had been progressively cut back, and the timing of canal closures for repairs and maintenance had interfered with rice irrigation.

Canal pricing is unlikely to influence crop choice, as the level of charges is too low, and the differentials too small. The organisation of labour resources according to family priorities was more pertinent to the production decision. Price differentials proved irrelevant to the allocation between crops because supply conditions were the critical determinants of water use.

It is of interest to note that, despite these negative experiences in the Northern Indian canals with water pricing policies, Malhotra (1982, Chapter 10), and a former Chief Irrigation Engineer, almost a century later proposes a *warimetric* method of water charging as a variant of volumetric pricing for basically similar systems!

I would surmise that most of the neoclassical economists who currently advocate the beneficiary effects of markets and the regulatory power of proper pricing for improved and also environmentally beneficial resource use, probably have never been in an irrigation environment in a developing country. Even irrigation economists, such as Sampath (1992), for all his excellent analysis, makes conclusions and recommendations which are mostly *non sequiturs* from his own exposition. Working from a base in the Western USA he inexcusably seems to mix up conditions there with those in developing countries.

3.2 EXPANSION VS. INTENSIFICATION (REHABILITATION)

The expansion of irrigation through new systems has its special appeal.

> 'New systems present a sign of progress that has strong political appeal, both internally and externally; and which may have a more general psychological value. Potential benefits may be more easily identified and the requisite technical skills more easily mobilized than in the improvement of existing

systems, particularly when 'new' means large scale and external resources, both financial and technical, are available. High quality central design teams can be obtained and concentrated construction operations can be managed more easily' (Levine, 1980, cited in Easter and Welsch, 1986).

Rehabilitation, when improving water use efficiency, will benefit all farmers within the scheme; when resulting in greater water delivery, the command area could be enlarged as well if existing farmers do not switch from low to high water using crops, or switch to double cropping in part of the scheme. Within an irrigation system, rehabilitation could also improve the reliability of water deliveries and thereby reduce the risks to farmers to undertake complementary investments in agriculture. Smaller farmers, who would otherwise bear the brunt of water shortages, due to their lack of power, will also therefore benefit from improved reliability from irrigation water delivery, though probably not in proportion to their entitlement (Bromley, 1980).

Rehabilitation projects should therefore be **assessed** on their effects on water use, water volume and water reliability. One could add a fourth criterium of evaluation, e.g. effects on water quality. This variable is likely to become of increasing importance. Water contamination, through, for instance pesticides and insecticides traces, will have negative effects on water re-use in agriculture downstream and on ground water resources. In addition, initial irrigation water increasingly has multiple uses: for diversified cropping where crops have different sensitivity to variations in water quality; for human and animal consumption and excreta disposal; and, increasingly, for rural-located industrial activities. While externalities affecting quality of water should be approached at source, to internalize the negative consequences of polluting activities, and following the 'polluter-pays-principle', this may not be possible in many cases due to variability in the legal, policy and enforcement of regulatory mechanisms[22].

Unfortunately, the rudimentary nature of the manner in which irrigation investments are being evaluated, monitored and assessed at the present time (see Section 1 and 2), make it impossible to cite studies which systematically look at these variables in a comparative, before and after, analytical framework. In fact, irrigation performance monitoring and evaluation has been identified as one of the major research areas for strategy development in the International Irrigation Management Institute (Lenton, 1988).

A useful distinction here is between rehabilitation and modernization.

Rehabilitation aims to restore the functioning of the irrigation system as it was originally designed, and might have been operating for a while in the past: it involves restoring the *status quo ante*. Implicit in this view is the notion that that perhaps already distant past, represents a stable and desirable configuration between the parties in the scheme, where an externally acceptable and within-scheme accepted balance had been struck between the equity and efficiency objectives of agricultural production.

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22 Many of the case studies presented to the Second International Water Tribunal (Amsterdam, February 1992) referred to water pollution caused by such industries as mining or tanneries.

Key elements of rehabilitation are the desilting of canals, the repair of structures, upgrading and re-equipping system management and attempts to restore discipline amongst irrigators. It elicits a 'back to the old rule book' attitude. In addition, it may aim to improve the supply of external inputs, such as seeds and fertilizers to link improvements in water management closer to expected increases in agricultural production.

This view of irrigation rehabilitation implicitly assumes that the socio-economic and political context, and thus the environment in which the technical irrigation system functioned, has remained unchanged. This is rarely the case. The socio-economic and political context may have changed profoundly, making a return to the 'good old days' of the past neither possible nor desirable.

A case in point is the Gezira Scheme in Sudan which went into sharp decline in the late 1970s. The Gezira Scheme was based on cotton as the intended cash crop, and with farmers/tenants planned to growing subsistence food crops on the side. However, over time cotton suffered from high incidence of diseases affecting yields. The subsistence crops had become cash crops in their own right and the incomes to farmers from market sales of food crops to urban markets such as Khartoum, had become much larger by the mid-1970s, than income received from cotton, in income terms and in returns per labour day, leading to changing farmer personal interest in the cropping pattern, and away from cotton. This shift was also furthered by the operation of the 'joint account' system whereby miscellaneous costs incurred by scheme management for different crops were charged to, because to be recovered from, the cotton account. Tenants suffered from poor international but above all low producer prices for the original scheme crop cotton. The social structure in the scheme was changing as well, with an aging population structure, increasing numbers of tenancies in the name of widows or minors, and thus operated by care-takers, and increasing problems in attracting adequate seasonal labour for cotton picking at low cost due to much increased job opportunities outside the Scheme in urban employment (Van de Laar, 1982). Under these conditions the restoration of the *status quo ante* is a fallacy: neither desirable nor possible.

Unless many of these non-irrigation-engineering and water management issues are addressed first, the irrigation engineers will have no relevant and usable objectives and goals for the rehabilitation effort. But as these implications were only partially acknowledged, and, furthermore, seemed far from being decided upon one way or another at that time in 1980 and mostly continuing into the early 1990s (Wallich, 1988), the consulting irrigation engineers, by default, tended to look to the past: for guidance on irrigation objectives of that past and on how to go about rehabilitation[23].

Modernisation involves transforming an old irrigation scheme into something else, presumably taking into account the changing socio-economic context in which irrigation systems operate. A set of new decisions is required, on cropping patterns, water allocations

[23] One notable innovation was the recognition of the desirability of introducing in the crop rotation a special fodder crop for cattle. For decades, cattle in the scheme had been considered a nuisance and cattle holding had to be discouraged by all means. And this while many of the settlers to be were and still retain values akin to their semi-nomadic origins.

and water management, which may or may not be contrary to major irrigation objectives and design parameters established in the past. The new designs may then either accommodate current realities of farmer behaviour, where top-enders use too much water or grow water intensive crops to the detriment of tail-enders, or try to reestablish some new order in the spatial distribution of irrigation benefits to be pursued.

Depending upon the outcome of that new round of negotiations between government and farmers' groups, the un-used tail-reaches of the original command area will be repaired to receive water in future, or to be formally given up, as in practice they rarely received water prior to the modernization project.

The key issues about the **new** objectives of modernisation will be highly contentious, because the difficult trade-offs between equity and efficiency have to be explored. New decisions may not have crystallised and, even if taken at the formal level, will be contested during the modernization implementation stage, with further modifications being effectuated when the rehabilitation staff and contractors have moved away again. Moreover, the inheritance of the pre-existing irrigation infrastructure and the habits formed by people using irrigation may provide additional problems to the technical rehabilitation possibilities and to 'plan' further, and presumably more flexible irrigation management arrangements.

When modernization of irrigation is placed within a bargaining context between different parties, the technical objectives of irrigation modernisation cannot be simply and unilaterally formulated by the irrigation engineer, or by the government or by the farmers.

In this light, rehabilitation and modernization should not be seen as incidental and, on principle to be deplored because of revealing allegedly 'poor maintenance' in a static irrigation and cropping environment. Rehabilitation and modernisation could also be seen in a positive manner, as necessary technical re-designs to accommodate dynamic changes in cropping patterns and the socio-economic and political environment which have emerged in recent decades, and with other as yet unknown changes to be expected in future.

The physical deterioration of irrigation systems world-wide, which began to be noticed especially since the late 1960s, inevitably led to calls for irrigation rehabilitation investments. Returns looked promising, in view of the large sunk costs involved and when compared with investment in new irrigation (Bottrall, 1981).

However, these optimistic anticipated outcomes of rehabilitation could be expected only *ceteris paribus* and when a narrow and partial analytical framework was employed. But the particular mixes of rehabilitation and modernization activities undertaken often introduces a considerable amount of uncertainty in farmers adjusting themselves to changing water management practices, changing cropping patterns and to organisational and managerial interaction in larger groups if the command area is to be enlarged.

These extra, and sometimes unforeseen complications which arise in a wider framework for analyzing the changes inherent in rehabilitation and modernisation, could well be the explanatory variables for disappointing post-modernisation results. A 'quick-fix' approach is not enough and a wider scope of rehabilitation planning has to be adopted. Iterative planning systems are needed for the formulation of new objectives and for more appropriate designs of modernized systems.

Assistance should also be extended well beyond the completion of the investment stage, and should cover at least several cropping seasons under the new conditions. To the extent that social science and managerial assistance to assist farmers is provided at all in modernization efforts, this input tends to be terminated at the same time when the investment stage is completed, and before farmers and system managers have had enough time to learn to operate the system on their own. While in industry it is unthinkable that machinery suppliers do not provide training and post-delivery back-up services, in irrigation the case for justified and necessary follow-on activities still has to be argued[24].

The main long term significance of the modernisation vs. new irrigation trade-off is perhaps that in new irrigation schemes, in allegedly 'empty areas', irrigation engineers as professionals can continue to ignore farmers and the micro socio-economic realities, while in rehabilitation and modernisation they cannot, on penalty of becoming increasingly irrelevant. The assumption underlying many schemes when they were initially constructed, of settlement areas being 'empty' prior to new irrigation, has been crucial but was often incorrect in as far as land occupancy rights of shifting cultivators and/or of nomadic peoples are not recognised or acknowledged[25]. This has for instance been the case in many African irrigation schemes in recent decades (de Leeuw, 1985, Chambers and Moris, 1973, Bloch, 1986, Adams and Grove, 1983, Mortimore, et.al., 1987, Olofin, 1991, Scudder, 1989), but also in Asia it is not uncommon.

In the modernisation of irrigation schemes it is essential to take into account farmers' priorities, possibilities and constraints when thinking about the (re)design of irrigation systems and of water management practices. Irrigation engineering can then no longer be conceptualized as merely a hydraulic and engineering realm, obeying solely internal and technical laws and rules. Irrigation engineers can no longer hide in offices behind powerful computers making complicated calculations for water delivery schedules, but they will have to get out into the field to negotiate with farmers.

There is doubt whether this message has been absorbed by the irrigation engineering profession at large. Recently, Carruthers, in a keynote address at yet another major conference on *'Advances in Planning, Design and Management of Irrigation Systems as Related to Sustainable Land Use'* (Feyen et.al, 1992, p 709) still found it necessary to complain:

> 'The business of irrigation is farming. The impression gained from the titles and summary of the papers in this session is that irrigation project management is still seen to be a water engineering

[24] Examples of this can be found in studies of irrigation modernization projects, for instance Schrevel (1993) for cases in Indonesia.

[25] We leave out the displacement of peoples in the dam lake areas above major headworks. But see Van de Laar (1993).

activity. However, the engineering culture has changed from a hardware construction culture to a software water management support culture. This is a transformation over the last ten years. But water management is still narrowly focused on technical water issues, it is still obsessively involved with the process of water delivery and it is still therefore essentially an engineering tea party.... Irrigation is in essence a service industry not a production industry. A service has customers, in this case farmers. The hallmark and the mission of a service industry is satisfied customers. If irrigation managers are to produce satisfied customers then they must understand their needs as the customers themselves perceive them. Irrigation managers must have a good grasp of agricultural practice.'

While he, correctly, emphasis the change from construction[26] to water management, and pleads for a further needed change in the irrigation engineering profession to link up with agriculture, he does not here acknowledge that farmers have different objectives depending upon skills and resource positions. Such conflicts between farmers are inter linked through the interactions within the hydraulic unit, and these then present themselves as problems and dilemmas for the irrigation engineer in (re)designing a system. Moreover, governments, as investors in irrigation can, or at least try as a condition for their willingness to finance in irrigation at all, to attach objectives different from those of farmers, both in the cropping patterns they would like to see develop, and in the manner in which the benefits from irrigation are allowed to accrue to the farmers, through irrigation pricing and taxation policies, thereby affecting incentives for farmers.

Given unresolved conflicts of interests between farmers in each location, between farmers in different parts of the system, and separate government objectives, irrigation engineers often are forced to choose themselves, whereby the chosen option is presented as technologically required and dictated. Hence, political choices and dilemmas are hidden in a technical professional cloak. But more often than not such a technological 'solution' cannot be enforced in implementation of water management practices.

Rehabilitation activities

In rehabilitation/modernization projects water delivery to the fields is improved through investments in canal lining, land levelling, control structures, field ditches and measurement devices to increase the water delivered to the fields and provide for more efficient water utilization.

For instance, the spread of high-yielding varieties in the Philippines increased the relative advantage of improving the irrigation infrastructure over opening up new land, because high-yielding varieties perform better under controlled irrigation. In contrast, under poorly controlled irrigation, local varieties were superior. The same need to improve water control has been expressed in respect of agriculture in Thailand. The Sri Lanka government has been criticized for investing huge sums exclusively in large development projects with little or no

[26] I refer to the remarks of Hotes (1983) of the World Bank, in Section 1, who still put overwhelming interest on the construction side of engineering.

attention given to teaching farmers improved management practices, and helping them level, terrace, bund, and drain at the field level (Easter and Welsch, 1986).

But such physical modifications in irrigation systems involve a **mixture** of actions to be taken by irrigation authorities and farmers respectively, and inaction by one party diminishes or negates the efforts of the other. Because two different decision makers are involved, separate implicit or explicit evaluations will have to be made of the various types of irrigation rehabilitation and modernization investments.

There are few studies which deal directly with the rehabilitation vs.new project issue, and the results are mixed, in part depending no doubt on the character and scope of the rehabilitation and modernisation efforts, particularly whether the construction activities did in fact lead to better water availability. When the effort is on desilting canals but not on improving water diversion capacities, little effect on agricultural production can be expected. Most studies consider only the value of individual rehabilitation projects, and from the perspective of the irrigation authorities (Easter and Welsch, 1986).

Investments to improve irrigation at the **farm level**, to complement the intended actions of the irrigation authorities, have shown a wide range of economic returns. Such studies by themselves are few and far between, because they refer to studies on the interaction between irrigation engineering and agricultural scientists in an 'action research' setting, e.g. they require novel approaches in research. For historical and professional reasons professional contacts between irrigation engineers, many of whom with a civil engineering background (Rydzewski, 1987) and agronomists who are not research station-based but with a farming systems research orientation have been limited (Chambers, 1988,Jurriënsand De Jong, 1989, Stone, 1984).

Examples of the type of studies needed, as collected in Easter and Welsch (1986, p 17-18), may be cited here[27], but with further comments, to get the drift of the type of studies needed and of the arguments involved. The economic return to investments in land levelling in Pakistan showed benefit-cost ratios of 1.7 and 1.9. The investment involved upgrading traditional land levelling to a precision level. The findings implied increasing returns to added investments in land levelling.

A study on the effect of land levelling and fertilizer applications on the physio-chemical properties of soil, water use and yield of wheat found that levelling significantly increased phosphorus, exchangeable potassium, and the infiltration capacity of soil. The researchers also attributed an irrigation water saving of 34 to 37 percent to levelling.

Returns on investment in terminal or farm level (tertiary level) systems will depend upon the numbers of farmers served by an outlet. If only one or two are served from each outlet, farmers can be expected to adequately allocate the water beyond the outlet. They will benefit directly from improved allocation, and government investments in farm level system

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[27] Much of what is being said here builds on the work of the Minnesota-Colorado State University project in Pakistan.

improvements will likely have low returns. However, if five to twenty farmers are served by the same outlet, individual farmers do not receive all the benefits from improved water allocation in the tertiary unit. Farmers impose externalities on other farmers served from the same outlet. In such cases, outside assistance and funds may be necessary to improve the farm level system and should offer high returns. But because of conflicting interests, it is likely to be difficult to get groups of farmers to build their own distribution system below the outlet. Water will tend to be distributed unevenly among farmers, and some farmers will benefit more than others from the distribution system improvements (Easter and Welsch).

In such a situation, one could argue, governments should be hesitant to undertake to construct tertiary level structures and ditches, lest it promotes inequality: the better farmers will have passed-on the investment costs to the government, while drawing most of the benefits in post-construction water management. One possible technical option to be considered is the redesign or subdivision of the tertiary unit in separate but smaller units such that homogeneity of the farmers within the sub-unit is greater. But Meyer (1989, 1992, 1993) has called the study of the interactions between (i) the size of the tertiary unit, (ii) the manageability for farmers to handle the incoming flow size, and (iii) fragmented holdings, for feasible and equitable water rotation systems in the tertiary unit, one of the neglected areas even in contemporary irrigation system design. The preferred option by most irrigation engineers is to redesign the plots within the tertiary units, but this involves complicated negotiations between land holders who may object to land consolidation for reasons of conflicts over location relative to the outlet and/or to seek compensation for changes in topography or soil quality differences.

The options suggested here are what may be called first-order technical options. But there are also second-order effects which generally cannot be influenced by engineering solutions. Many studies on the impact of Green Revolution technologies (new, fertilizer-responsive seeds with good water management) have shown that the fact that the profitability of farming increased, provided a powerful incentive for land-owners to start operating the farms themselves. Hence, crop-share tenancies were terminated and the proportion of owner-operator farming increased dramatically. Displaced tenants could reapply, as casual labourers, for peak-labour demand activities.

Canal lining.

One of the most frequently proposed rehabilitation methods for reducing transmission losses is canal lining. Yet current technologies for lining, particularly concrete lining, tend to be high in cost. Studies of concrete lining do not give clear-cut conclusions concerning profitability (Easter and Welsch, 1986). Several studies in India, where ordinary canals were concrete lined, found that such changes reduced water losses, increased the cropping intensity, and provided an assured supply of irrigation water to a larger area. Similar results were obtained from canal lining in the rehabilitation of the Subsidi Desa Scheme in Indonesia. But these are merely partial measures of increased water efficiency in the physical sense.

There is little doubt that properly lined canals can reduce water losses, but the real question is how much is added to the costs of providing water and what are the benefits?

Cheaper alternatives are often available to assure a water supply. One possibility is partial lining of the canals and field channels. An evaluation of several methods of watercourse improvement, including concrete and masonry linings and simple earthen improvements of the ditches with concrete control structures, found that the earthen improvements with concrete structures were the best investments in Pakistan where labour costs were low. Recent studies, however suggest that the life of earthen improvements may be substantially shorter than assumed in the earlier study: improved water courses in Pakistan's Punjab are said to tend to reach their previous state of neglect in one to three years!

In another study in Pakistan, where earthen improvements were assumed to have a three year life, lining of the upper reaches of improved water courses was just on the verge of being profitable under 1977 prices. This lining was done on the most heavily used and most porous sections of the watercourse. Higher energy prices or procedures for increasing the life expectancies of the earthen improvements would make improvements possible.

Fibreglass-reinforced polyester flumes to carry water above ground were shown to be superior to earthen channels in Malaysia. The flumes could be installed more rapidly and require less land and maintenance. These cost savings plus the savings in water more than off-set the capital costs which were two and a half times the cost of earthen channels (Ibid).

In densely populated areas, where farmers have too small or only marginally viable holdings, farmer resistance to give up land for the construction of separated, and sometimes parallel conveyance channels of different levels and for drainage channels is reported to be considerable in different parts of Indonesia (Schrevel, 1993, Jaspers and Jurriens, 1993). These factors might make a comparison with the Malaysia example worth investigating.

But there are wider problems in evaluating the effects of canal lining. In fact, the whole policy of canal lining can be called into question when the expected costs and benefits are put in a more appropriate economic framework and when wider aspects of water availability and distribution in the hydraulic entity is taken into account, especially the conjunctive use of ground water and canal water. The change in the methodology of analysis required is as yet of greater significance than the precision of the coefficients to be developed, in view of the experimental nature of the initial studies done.

The conventional framework for analyzing canal lining issues is to compare the cost of lining resulting in reduced water seepage, with the production effects of carrying more water through the improved canal system to the fields and the crop root zone. The initial focal point for planning canal lining is the low water efficiency in canal systems, where some 70 percent of water at the headworks does not reach the root zone, and is considered as water wasted.

Economists have stressed that groundwater development is more efficient than surface water irrigation. The arguments are that land productivity under canal irrigation is well below the corresponding levels under wells in general and tubewells in particular. Individually owned tubewells and pump sets are seen to be ideally suited for meeting the exacting water requirements of high-yielding varieties of wheat and paddy. The tubewell owner can also effectively plan for the conjunctive use of rainfall with pump water. In the crucial matter of timeliness, an irrigation source that is outside the control of a farmer can never match one that is wholly under his ownership. With regard to adequacy of irrigation, a protective canal by the logic of its conception cannot be transformed to spearhead high crop yields.

The result of these effects is that surface irrigation projects show low rates of return in comparison to groundwater projects, and that a powerful ground water lobby has emerged in competition with the traditional canal irrigation lobby. An either/or issue is construed: more groundwater development and less surface water development, with its attendant social and environmental side effects. But Dhawan and Satya Sai (1991) argue that this is a non-issue.

The conventional framework overlooks the beneficial economic effects of canal seepage on the recharge of groundwater which pump schemes utilize. Dhawan and Satya Sai (1991) show, for the Punjab and the Mula Project (in the Deccan), that groundwater recharge from seepage is quantitatively more important than recharge from rainfall. Seepage water enhance well-water yields substantially, and thereby canal systems contribute **indirectly** to agricultural output as well as directly through the distribution of surface water. Therefore, in economic analysis, the benefits of canal irrigation should be upgraded by including these indirect beneficial seepage effects, and those of groundwater projects should be down graded (see Dhawan, 1988, and Van de Laar, 1993, on similar issues in Pakistan).

It has been noted that since the 1980s groundwater sources in India are overexploited and that water tables in the Punjab are falling in the sandy soils. As rainfall is unpredictable, recharge from canal systems is indispensable to keep water tables within reach of the wells. But canals for the tertiary part of the Punjab were lined, in a major World Bank-assisted project in the mid 1980s: to increase water efficiency and water productivity from surface irrigation. Stopping the 'sieves' of the canals through canal lining, if effective, will reduce groundwater recharge, thereby undermine the yields of wells, and thus the productivity of groundwater projects.

It could then be argued that canal seepage is not a 'vice' as has hitherto been axiomatic in surface irrigation circles, but a 'virtue', and, paradoxically, the less water efficient canal systems become, the better the sustainability of associated allegedly 'efficient' groundwater development. In short: 'forget about canal lining!'.

As noted, it is above all necessary to change the methodological framework for analyzing certain types of irrigation investment problems, under the impact of the coming into existence of conjunctive water use systems in a truly binding common pool natural resource situation. The problem and the trade-off between canal lining in a combined surface-cum-groundwater environment may be generalisable, certainly towards the future.

In this specific case, refinements could be easily suggested. For instance, greater detail is needed in the spatial aspects of seepage and pump action, to see what redistributions of water in effect take place, and with what production effects.

Maintenance

Probably the cheapest method of reducing transmission losses, where labour costs are low, is by proper and timely maintenance of the canals. Inadequate organization of the water users is one of the major reasons for the lack of maintenance. This is a particularly thorny collective goods problem with strong incentives to shirk responsibilities and reap individual benefits from water theft.

The organizational difficulties of watercourse maintenance appears to be an important cause of divisiveness among Pakistani farmers, and although Lowdermilk and his associates felt (in 1977) that there was some evidence to suggest that water users organisations can effectively deal with these problems, in a recent external review of irrigation policy in Pakistan, cold water is thrown over that expectation, from experiences gained since.

The policy initiative for water course improvement with farmer participation (to combat sizeable losses in water courses), did have the positive effect that the immediately perceived benefits created a great demand for public support for the work. Yet, the water users' associations (WAUs) formed to get the improvements effected, did not prove to be viable. Subsequent physical maintenance suffered and benefits tended to be marginal (Bandaragoda, in Feyen, 1992 p 85). Aklilu and Hussain (1990, p 30) note that unrealistic assumptions had been made regarding farmers' incentives in efficient use of additional water supplies, and stress the difficulties for farmers along a water course to jointly organize O&M. They simply note that 'the bulk of Court cases originating in rural areas stem from conflicts over water and associated land'.

Maintenance is also a basic investment problem. Little or no funds are generally allocated for system maintenance when budgets and designs are made for irrigation projects. In fact, countries may find that they have constructed more irrigation projects than can be adequately maintained, and that many of them are not economically viable[28]. Some currently influential public choice theorists ascribe this state of affairs as the to be expected outcome of irrigation investment carried out by the public sector in a context of the 'political pressures of the pork barrel' (Repetto, 1986). Vaidyanathan (1984, p 46), in his broad comparative review of the history of irrigation in different parts of Asia, goes further when he observes 'that there is little evidence of conscious calculation behind much of water conservancy development in history'.

Solving the maintenance problem is not easy since it involves a number of interrelated problems: inadequate institutions, inefficient water delivery, lack of farmers participation and low rates of fee collection, which, in combination, lead to inadequate maintenance.

A 'solution' may operate in practice, analogous to the well known investment cycles in road construction. Donors and governments were perfectly willing in the past to finance new construction of infrastructure, but not maintenance. However, after a while, rehabilitation (defined as accumulated lack of maintenance) proved again popular with donor financing.

[28] See CPR Discussion Note nr 13.

This is in part for the high expected rates of return due to the 'sunk cost' involved, which may still be partially productive but which are not counted when rehabilitation proposals are reviewed.

In irrigation, especially when irrigation re-design is judged necessary to accommodate changing socio-economic realities -- presumably identified with dynamic rural change and development -- neglected maintenance becomes a virtue in that it speeds up the then needed modernisation of systems! In this fashion, irrigation project maintenance and the frequency of rehabilitation/modernization are linked in the conceptualization of overall long term investment strategy in irrigation infrastructure. To put it bluntly: irrigation systems investments are not intended for the long run, and should be constantly remade, and especially when the pace of socio-economic change is rapid.

The real question of course is whether foreign donors are willing to collaborate in this strategy of financing irrigation on the scale required. The massive irrigation investments in new projects of recent decades will lead to massive rehabilitation, modernization and maintenance investments in the (near) future. The share of external financing in this whole complex is likely to decline, even without the general lack of popularity of and support for foreign aid programmes in several major donor countries at the present time. Consequently, the investment problems involved will have to be resolved largely within the developing countries themselves.

3.3 LARGE-SCALE VS. SMALL-SCALE IRRIGATION

Large-scale irrigation

Within irrigation basic investment decisions need to be made between large- and small-scale irrigation systems, and concentrated vs. dispersed systems. In recent decades decisions have often been made in favour of large projects in many countries for several different reasons (Easter and Welsch, 1986, Howe, 1970, Petts, 1984, Mermel, 1991):

1. Large projects frequently may be necessary for the effective utilization of a relatively large but variable water supply, and changing technology has made large and complex headworks possible. In this century dams, increasingly with the added purpose of generating hydropower have increased in size (Van de Laar, 1993).

2. Large projects may permit more efficient and effective use of limited managerial and technical skills. This argument needs scrutiny as the levels and range of skills required in large and technically complex projects are of an altogether different order than the skills required for simple and small scale irrigation development. As shown elsewhere[29], major irrigation development in large parts of Asia have been built and operated by farmer action, and the small scale sector of irrigation continues to be important in many countries.

[29] See CPR Discussion Note nr 13.

However, the argument may be misplaced. The argument of better use of technical and managerial skills appears to be utilized largely in respect to the design and construction phase, and not to the operations and maintenance stage of irrigation. But, as has been argued repeatedly in this and in the earlier paper[30], the management of water becomes infinitely more complex for larger than for smaller systems, due to the complexity of organising effective collective action around a common pool resource as water. Effective water management is the necessary condition for the sustainability of irrigation development.

3. Large projects permit economies of scale in the physical elements of the scheme such as storage, diversion and conveyance capacities. However, as conveyance systems expand in size there are offsetting water losses from the canals. In general, only about 25 to 30 percent of the water diverted into large canal systems in developing countries actually becomes available to the crop leading to worldwide irrigation efficiencies less than 40 percent (Mohtadullah, in Feyen, 1992, p 5, and above).

4. Large projects have been more easily financed because it has been easier to obtain external financing for large projects than for small ones. The 'sex appeal' of spectacular projects to politicians, financiers and construction and engineering interests, readily outweighs any effective support for the 'small is beautiful' concept.

5. Large projects generate major benefits such as employment for skilled and unskilled workers during the construction period. Yet, this employment is only temporary and can cause problems if it disrupts wages, or leads to regionally concentrated problems in the food situation due to entitlement losses (Sen, 1980). The argument is also inadequate, as in the comparison between large scale and **equivalent** small scale irrigation development the aggregate employment effects of the small scale approach need to be considered, which is not normally done.

In retrospect, it would seem that in irrigation decision making the construction phase has been overemphasised relative to operation and maintenance, that the broader environmental effects of developing irrigation have been underplayed or ignored, and that a systematic comparison of the large-scale vs. small-scale trade-off has not taken place. Many of the environmental consequences have become apparent after considerable lapses of time (Petts, 1984, Van de Laar, 1993). The option of large vs. small has rarely been seriously considered because the planning process for irrigation development starts with the availability of a suitable dam site, rather than starting from a regional planning perspective in which options on the role of different resources and alternative development scenarios are to be systematically explored and assessed.

By building large dams and major canal systems the irreversibility of the decisions taken have to be taken for granted. Many important 'option values' in respect of (i) changes in technology, (ii) alternative water uses, (iii) alternative water management arrangements, (iv) alternative financial arrangements for construction and maintenance organisation and

[30] CPR Discussion Note nr 13.

financing, and (v) to prevent or mitigate negative environmental effects, have been foreclosed.

By comparison, the counterfactual, small-scale and dispersed strategy of implementation combined with structured and sustained research efforts, would have been more flexible and thus would have been the more 'prudent' course of action in the presence of so many unknown consequences of the major actions undertaken, and often on the basis of unreliable or incorrect information.

The trade-off between concentrated, large-scale developments and dispersed, small-scale irrigation development should not be confused with 'staging' investment. In staging investments, one adds different parts to a project as funds and/or additional information on the resources as well as on the demand composition of the expected outputs become available. Moreover, staging investments would allow incremental learning, as experiences gained in implementing early parts of irrigation projects could, it is suggested, be incorporated in further development stages of the scheme.

In irrigation such an approach is often not feasible: one cannot dam off half a river, or design canal systems of too limited capacity, should it later appear that the command area can be expanded. Irrigation investments are lumpy investments where the costs of unused irrigation capacities pending project completion at field level, and the benefits from economics of scale, or due to technical necessity at the investment stage have to be weighed. Irrigation development in larger systems is therefore a problem of stringing together lumpy investments, which are however interlinked by the common factor, a same source of irrigation water.

The issue of proper sequencing of investment is compounded by the, often not sufficiently recognised problems of the more than proportional increase in water management problems and costs, due to conflicts over water deliveries and of increasingly complex interactions between farmers groups and irrigation authorities in different parts of the scheme. One of the key problems is that in the early stages of scheme development water tends to be ample, and farmers adjust their behaviour accordingly, in water use and perhaps in terms of cropping patterns. When the scheme reaches its full potential, water availability will, inevitably, be more scarce, and early farmers in the head reaches would then have to adjust their water using practices, to enable the later expansions to receive water as per the initial overall irrigation scheme plan. Considerations of the commandable area relative to available water are the major determinants of the nature of the headworks and for the main canal specifications.

In irrigation investment planning one would therefore have to estimate the present value of the entire sequence of investments, including operations and maintenance, and of benefits tested under different assumptions in respect of different cropping configurations in different parts of the scheme and varying over time as the scheme is planned to have reached its full size. But of course, in large systems most of the relevant variables are surrounded by sizeable degrees of ignorance, such that one may legitimately wonder whether such a complex cost-benefit calculation could and should be a meaningful admissibility criterium, certainly when seen in the wider political economy of the planning and investment process in irrigation (Repetto, 1986).

The progress and shape of irrigation investment projects can perhaps be better understood when one considers the enormous powers which the most directly involved agencies have, be it the Irrigation Departments, the Water and Power Development Authorities such as in Pakistan or Bangladesh, or the Army Corps of Engineers in the USA.

India is now one of the largest dam builders in the world: by 1979 it had constructed 1,554 large dams. One indication of the apparent autonomy and power of the irrigation bureaucracy in India is that repeatedly construction activities have started well before the projects had been cleared for approval, thereby effectively foreclosing the option to disapprove the project. A study of 32 major ongoing and initiated in India in the Fifth and Sixth Plan, and studied by the Public Accounts Committee, showed that 8 projects had cost overruns of more than 400 percent, with an average cost overrun of some 250 per cent. No project had been completed within the approved cost estimates since Independence. Most of the cost overruns have been due to project modifications and not to inflation. Another sample of 15 dam projects showed an average gestation time of 13.8 years against an expected 5.9 years (Singh, 1990). With such figures at the initiation stage of irrigation development it cannot be expected that the initial cost-benefit figures have much validity.

Of more direct relevance for the present argument is the shortfall between expected and actual irrigation performance, for it has provided the impetus to two different policy lines in irrigation development policies.

It has been a characteristic of many large scale irrigation schemes in recent decades that major discrepancies exist between on the one hand the irrigations created, as per original designs, and the realized irrigated areas. Summary indicators for a sample of 37 Indian schemes is given in Table 1. The scale of the planned vs. actual irrigated areas is gigantic: of 5.88 million hectares of expected irrigated area, only 2.86 million actually received irrigation.

Table 1: Irrigation performance.

	Nr. of projects	Irrigated area: Actual/Expected (%)
	8	Below 20
	5	20- 40
	6	40- 60
	5	60- 90
	13	90-100
Total	37	Average 59

Source: Singh (1990)

The causes of this 'mismatch' could be several: misjudged water availability estimates or overoptimistic estimates of the expected cultivable command area, are among the technical factors involved. But of interest here are changes in cropping patterns and delays in field developments.

The policy reaction to delayed field development has been in **India** to set up the Command Area Development Authorities (CADA) in 1974, to assist local communities in field level development and in setting up water users associations. In implementing the CADA mandate, the situation evolved that government constructed most of the facilities and recovered little of the cost directly from the beneficiaries. CADA's also do not appear to have been effective in preventing large scale crop switching practices: e.g. in enforcing initial cropping patterns as established per the legal trajectory of the 'localisation' procedure.

To avoid that field developments are delayed, and to also avoid that early irrigators adopt 'undesirable' water management and cropping patterns, an alternative route to irrigation development, as initiated by government, has been to develop fully-fledged irrigation schemes. This has been a development particularly to be found in **Africa**. Such schemes as Gezira in Sudan, developed since the 1920s, or Mwea in Kenya, developed in the late 1950s have fully integrated designs up to field level. They resemble large integrated farms, with some sort of organisational partnership between the government as provider of the irrigation water, a scheme management to oversee scheme operations, and to engage also in input delivery and/or marketing arrangements, and the farmers as tenants, or rather as scheme labourers as they are highly regimented and have little or no freedom of action, at least in design (Barnett, 1977, for an assessment; Wallich, 1988, for developments in the 1980s).

In either case the consequence of this top-down approach is an extended role for government in influencing, shaping and/or managing rural development through an ever more intrusive role in irrigation development.

The choice between large-scale and small scale development operates at different levels. In some areas it may be possible to develop large scale irrigation, and in other areas there may be good prospects for small-scale development. The nature of this choice is **between areas**. If funds are limited and (external and local) funders have a preference for large scale ventures, a choice may need to be made. With donors becoming disillusioned with large scale development and show greater interest in small scale development, this choice in future may no longer be as obviously 'loaded' as it has apparently been in the past.

The choice between large and small scale development may also involve a choice of options **within a specific area**, and this is clearly a different choice. It involves a discussion about the nature of regional development within a watershed area, and the role which irrigation development may play in this broader development concept. It requires a more comprehensive and integrated planning perspective, rather than a mono-sectoral perspective, as seems to have been the overriding approach to irrigation planning in the past.

With so many large to very large irrigation schemes having been constructed, the problems of managing them in some coherent fashion tend to accumulate rapidly and in quite a few cases the irrigation authorities or scheme management have lost, or are loosing control over developments and over the use patterns of increasingly scarce water resources (Berkoff, 1990). In India, it takes the form that the irrigation authorities are losing control over water deliveries, whereby initial protective, and thus supply-constrained, irrigation projects become in fact (top-end) farmer-demand driven systems, while in Africa, the authorities are unable to control farmers' interest in allocating their labour time over different crops in the scheme and over emerging non-farm, income generating activities.

The various problems of large scale irrigation and the cumulative effects of operation and maintenance under the impact of dynamic rural change are increasingly being recognised, but the burdens of the past cannot be negated.

Small-scale irrigation

It has belatedly been found that minor irrigation schemes generally involved lower investment costs per hectare, and had a relatively slower depreciation and lower operating expenses than larger projects. The time gap between creation and utilization of irrigation potential is substantially less.

Studies in Bangladesh showed that smaller gravity projects had higher benefit-cost ratios than larger projects. Analysis of a wide range off irrigation projects in the Philippines suggests that communal run-of-the-river systems have had the highest pay-off. In a review of Sahelian projects it had been found that small perimeters are more efficient (Easter and Welsch, 1986 for sources; Diemer and Huibers, 1991 for Senegal).

But caution is needed, as it was found in studies of gravity-diversion irrigation systems in Malaysia that economies of scale exist in their construction. Large schemes had also higher annual yields per unit of water than smaller schemes. The cost estimates indicate that diversion headworks are generally less costly than pumping facilities.

These results suggest caution in policies to encourage small-scale irrigation at the expense of large scale projects. However, it should be pointed out that the schemes involved little or no resettlement, and since it was supplementary irrigation, there was no wholesale switch in cropping (Easter and Welsch, 1986).

A number of advantages have been cited which seem to favour that greater policy attention be given to small scale irrigation schemes. Yet, small scale irrigations have problems too, and these cannot be ignored. There are three different types of small scale irrigation projects.

Types of small scale irrigation

Tubewells have become quite popular in recent decades. Their virtues have been advocated because of the better matching with crop-water requirements they would permit, and the scope they give for the development of 'water markets', private entrepreneurship and the role of the price mechanism (See section 3.1).

Reviewing public and private groundwater development in Uttar Pradesh, India from a technical perspective, Cunningham (1990, p 35-44) notes that of the millions of private irrigation sources few are designed following sound technical standards. Overall systems efficiencies are quite low. The overall efficiency of a tubewell system has two aspects **(i)** wire-to-water efficiency, i.e. the ability of the pump unit to effectively use the power supplied; and **(ii)** irrigation or conveyance efficiency, i.e. the proportion of water supplied at the well that usefully reaches the field. Pertinent figures are given in Table 2.

Table 2: Percentage Average Efficiencies for Selected Groundwater Irrigation Sources.

Unit type	Wire to water	Conveyance efficiency to field	System Efficiency
Public tubewells			
Traditional design	50	40	20
Improved design	60	60	36
Private tubewells			
Traditional design	30	60	18
Improved design	50	60	30

Source : Cunningham, (1990, p 41).

Private wells are unlikely to be designed to improved standards in future if private groundwater development remains unregulated. Farmers investing in wells want to minimize their capital expenditure. Few will be able to analyze savings in annual cost that would result from improved efficiency, particularly since the main operating cost (energy) varies according to the government's wishes. While past rural electrification programmes enabled private operators to adopt preferred electric pump units (over diesel units), but irregular power supply became (and is now) a major factor in the deterioration in quantity and quality of rural water supply.

Key policy problems in respect of groundwater development are to control the rate of expansion and the rate of pumping under conditions of a rapidly declining groundwater stock. Both encounter extraordinary complex issues of policy design, and of policy implementation and enforcement, as individual pump developers and users are numerous, controlling pump capacities and hours of pumping physically and administratively cumbersome if not impossible, and because the rate of excessive water extraction hardly measurable in the short run to initiate restrictive policy measures.

The **second** type of small system is the **river diversion scheme**. Many of these diversions are indigenous systems which are either locally managed or receive only limited government assistance. These have been favourite objectives of study by anthropologists and sociologists (Bottrall, 1981, p 222). At the present time much of the work may be said to be in the Coward (1980) tradition. Compared to pump schemes, in this type of schemes one can at least see when over-exploitation is attempted: the stream flow dries up, and this will act as a constraint on use and as a signal for more effective collective action. Further problems can be expected when new communities get formed or emerge elsewhere along the stream flow, as they will under the impact of population dynamics, for then conflicts about access to river waters with established communities may become unavoidable.

Another major problem and study area is what would happen if government and/or donors attempt to assist such traditionally autonomous irrigation communities. Will such actions enhance or loosen the capacity for continued self-help and self-reliance in a modernising and developing perspective. In other words, what will then happen to returns to land and water, sources of capital, management of conflict and allocation rules.

The **third** type of small systems include **tank (small reservoir) schemes**. These have been in widespread use in South India and Sri Lanka for ages. Generally, tanks are associated with geological formations with low infiltration, so that surface reservoirs are the only available means to capture run-off in the rainy season. The unpredictability of rainfall introduces major operational complexities into the decisions concerning water releases and the size of the command area. Inter-tank competition due to catchment interference becomes a problem when population densities increase. Other major problems are silt accumulation in the tank beds and damages from heavy rain showers and flooding in the water shed.

In these respects, tank schemes resemble **'spate' irrigation schemes**, such as are found in NWFP, Pakistan, where powerfully destructive but unpredictable seasonal rivers cascade from the mountains and where the power of the flow is broken by spreading the water quickly over a wide area through the construction of dividing bunds. Also existing roads can act as bunds. When a flashflood occurs a reasonable harvest may result, even though many of the bunds and roads will have been seriously damaged or destroyed through the floods. When there is no rain than many of the bund repair work after the previous flood will have been in vain. It is a system were both the fate of land lords and of tenants fully depend upon unpredictable water, and where the land lords require the labour of tenants to construct and repair the bunds almost every year. Regulating such potentially destructive flows upstream in the foothills above the plain tends to be costly.

In recent times, over 500 tanks have been newly constructed in North-East **Thailand**, but their success has been below expectations in terms of increasing production and income. One basic problem seems to be that the tanks were originally built for political or local military reasons with little concern for cost or for potential irrigation potential. They served a number of purposes besides crop irrigation such as fish production and supplying water for livestock, household use, and gardens (Easter and Welsch, 1986).

These experiences with newly constructed tanks resemble the experience with small dams in **Pakistan** for which more information is available. A Small Dams Programme was initiated in the early 1960s in the Rawalpindi Division (of Punjab), where small dams were seen as providing a major boost to agricultural production in the barani (rainfed) agricultural areas. The programme, 14 completed dams and 5 under construction, was evaluated in the early 1980s (Shah, 1984) and was found not to be feasible, with financial and economic Benefit-Cost Ratios being 0.63 and 0.32 respectively. In terms of physical targets of irrigated areas, the achievements stood at 43 percent only.

The reasons for the shortfall were technical, socio-economic and institutional. In some cases proper engineering surveys were not done before the construction of small dams, which resulted in overstating the potential irrigable area. In other cases water courses have not been constructed over the entire dam command area. With two-third of farm household income coming from off-farm sources, the urge for intensive use of land and changing cropping patterns has been generally missing. There has been complete lack of follow-up institutional support in terms of metalled roads, agricultural extension and agricultural credit and legal cover for the water distribution system.

The greatest shortfalls were observed in all **new** crops (p.52); the net return from the livestock sector has not been significantly different in the project areas because green fodder has increased livestock costs more rapidly than livestock income (p.53); fish seed is the major cost component of fish production. It was reported that 75 percent of fish spills away due to the fact that the dam's design was not suitable for fish culture.

The evaluation report noted that promotion of soil and water conservation measures, such as contour cropping, terracing and deep-ploughing to conserve moisture, changing cropping patterns and evolving of crop varieties suitable for the rainfed areas are the strategies which can have impact on much larger areas than the small dams. Water was applied to all crops, including the traditional crops such as pulses and oil seeds which could grow under barani conditions.

Conclusion on small scale irrigation

These examples serve the purpose to show that there is still a great need for research into what practices and policies make some small-scale projects highly beneficial and others not? Operation and water allocation should be easier on small schemes as compared to large projects, since the distance between water source and irrigated areas is much shorter. However, the people living in the areas apparently had found combinations of on-farm and off-farm income earning activities which secured their livelihood. Whether they would be willing to make major changes in light of as yet untested results of the introduction of a small irrigation project remains to be seen, and it probably would take considerable demonstrated proof of success before the people would be inclined to give up what they have for something which they do not have much faith in. But how long and at what cost can such demonstration 'pilot' projects be justified?

3.4 WET-SEASON VS. YEAR-ROUND IRRIGATION

For a long time the major function of irrigation was to provide a basis to safeguard the harvest of a basic single food crop for the large rural population in (semi) arid areas. The notion of 'protective irrigation' as developed over a century ago for Northern India implied a rationing of limited water over as large an area as possible with a view to 'settle' large numbers of the rural people. Typically, water was supplied on a rotational basis, involving time shares in proportion to land holding, and sufficient for only a small part, about one-third, of individual farms (Malhotra, 1982). As rainfall was variable and limited, this supplementary irrigation water at least guaranteed one crop to be realised. It was the only insurance against drought, and the systems therefore had strong equity objectives embodied in their design.

This situation has been changing in recent decades. The development of crop varieties with shorter maturities has made it possible to grow a second crop in systems fed by perennial rivers or within storage-based irrigation systems. It implied that existing waters could be productively employed in the dry season as well, and this presents a dilemma. When more water can be made available, either through greater efficiency in the canal system or through the additional development of ground water resources, the water could be utilised to expand the irrigated area under a single crop by pushing more water down to the to be extended tail-ends of existing systems. Thereby it would benefit more poor people who could be settled in the dry zone (assuming that limits on soil quality do not play a significant role).

But conveyance losses in expanded irrigation systems would also be higher, in geometric proportion to the expanded canal system, and thus only a fraction of the extra water would reach the root-zone in newly irrigated areas. Moreover, the capacity of existing canals may have to be increased, or control systems have to be modified, to handle the increased flow (For Pakistan, see Johnson, 1988, and Van de Laar, 1993).

Alternatively, the extra water could be used for more intensive application on a smaller irrigated area and also for a dry-season crop. In fact, returns in the dry season will tend to be higher than in the wet season, because of higher temperatures resulting in lower pest damage, and such factors as higher radiation and thus better crop growth.

Expanding the irrigated area would involve heavy investments in irrigation infrastructure, usually at government expense, and a burden on government finances depending upon the existence of, or the effectiveness of cost-recovery policies from irrigation beneficiaries. On the other hand, double-cropping in more limited area would imply far better returns to existing irrigation infrastructure and to the already established farmers in geographically smaller irrigated areas.

In a cost-benefit framework, economics would argue for double cropping in limited areas as being preferable to single cropping in larger areas, as in the latter case the rates of return will probably be marginal at best (Easter and Welsch, 1986, Tiffen, 1987).

Changes in the size of the irrigation command area thus have major production and equity implications.

The development of double cropping does not imply that people in the deprived tail-end of irrigation systems will inevitably starve in periods of drought. Alternative instruments have become available to insure against drought, which were not available when the concept of protective irrigation was invented. It is conceivable that the extra-harvest derived from the double crop will lead to a proportionally larger increase in the marketable surplus, which could be used in government food redistribution programs. In that case, farmers in the tail-end of irrigation systems who cannot grow their survival crop will receive government hand-outs in food.

It cannot be assumed, however, that such redistribution policies will come about automatically. It is equally possible that the increased marketable surplus from double cropping in smaller areas is dissipated in urban food markets where higher prices can be obtained.

A related issue, which is not further considered here, is crop-switching from crops needing little water (grains, cotton) to crops needing more water (paddy, sugar). This crop switching can occur at the top ends of irrigation systems and sometimes independently of extra water becoming available or of double cropping. In such cases there may not be enhanced marketable surplus of food crop production for government hand-out programmes to 'scratch' farmers in the un-irrigated tails.

The dilemma would be the same: should one irrigate a larger area extensively or a smaller area more intensively, and who is to decide that? (See also the example given above on trends in Tungabhadra in India; also Berkoff, 1990, for similar problems in the Eastern sections of the Indo-Gangetic plain).

Crop switching by farmers may be induced by changes in relative private profitability of crops. The costs and benefits of such action may not conform to the water application parameters and the cropping patterns which shaped the original irrigation designs in the (distant) past. The relevance of and the enforceability of initially prescribed cropping patterns in irrigation designs is thus a major issue, as initial designs and subsequent realizations may be incompatible. But irrigation engineers **must** adopt notions of future cropping patterns and associated water requirements, otherwise they cannot design any system.

In general, therefore, one could make a case for expanding the irrigated area under a single crop, in favour of double-cropping in a more limed area, if existing government policies or bureaucratic and institutional inefficiencies calls into question the effectiveness of food distribution policies which will then become necessary to overcome the effects of periodic droughts on tail-end farmers.

However, if one has reason to doubt the willingness, the capacity or the effectiveness of government food redistribution policies to combat drought, one should equally doubt its willingness and capacity to prevent the introduction of dry-season cropping in the top-end of irrigation systems, in view of the high private returns to this innovation.

In effect, initial protective irrigation systems with significant equity implications may tend to, and have already in certain areas evolved into more productive, but highly unequal production systems.

Conceivably, partial double cropping could have been designed without depriving tail-enders, by increased water efficiencies. But if assumed improvements in efficiency do not materialize or do not prove durable, tail-enders will suffer nevertheless.

Contrary to the view of Easter and Welsch, who assert that the trade-off between wet-season irrigation and year-round irrigation may not be as important an issue in Asia as it once was, it could be argued that the issue will re-emerge, and in a much sharper form, under the impact of the slow down in food production and in irrigation investment and in view of the narrowing buffering margin between existing water uses and overall availabilities (Frederiksen, 1992, as discussed in CPR Discussion Note no 13).

3.5 IRRIGATION VS. RAIN-FED PRODUCTION

The issue concerning irrigation vs. rainfed agriculture poses similar problems and choices as in the previous sub-section. Again the spatial dimensions are important. The basic argument is that government should be investing more to help the poor rainfed farmers and less to help the higher income irrigated farmers.

However, it is not so clear in what type of activities specifically governments should then invest and past policy initiatives have not been particularly noteworthy or effective. Historically, research in rain fed agriculture, in India and elsewhere has focused on environmental protection and especially on water conservation measures, to stretch the period during which soil moisture might be retained (Kalkat, 1986). The results have been generally disappointing, for the policy recommendations invited farmers to invest heavily in soil conservation efforts. This implied major on-farm cost increases for uncertain gain as and when rainfall was below expectations (Davis, 1986).

In Africa, such policies have often led to the use of coercion by the colonial government and this made the policy unpopular. In fact, protests against this type of coercion proved a powerful mobilizing force in the political independence movement in the late colonial days, and this has carried over in a general aversion to pursue similar policies with the same vigour since.

Government policies promoting investments in infrastructure and in input supply are risky economically and socially, as it may lead to indebtedness when the hoped-for higher yields and incomes do not materialize. The basic question is whether and how investments can be made which stimulate better use of existing water wherever it is available (See: Mellor, Delgado and Blackie, 1987, for a number of relevant articles in the African context, and Asian Development Bank ,1989, for a collection of wide-ranging discussions of problems and issues in rainfed-farming in Asia).

It is also conceivable that off-farm income opportunities offer better prospects for income generation than 'muddling through' in rain-fed farming in low potential areas. Migration of people would then provide a survival strategy, though at usually high social costs.

Among the more hopeful recent research findings in rain-fed farming is the development of short maturing crops which better 'fit' the generally short rainy season. In this way crops will ripen timely rather than wilt late in the season due to moisture stress.

In view of these problems there are likely to be strong preferences to continue to invest relatively large shares of public expenditures for agricultural development in irrigation, for the links between water availability and outputs is much stronger due to yield responses to water and the reduction in uncertainty in crop production which will encourage complementary investment in irrigated agriculture. The fact that irrigation systems perform well below potential, by itself exerts pressures to continue to expand and intensify investment in irrigation to the detriment of investments in rain fed farming systems.

CONCLUDING OBSERVATIONS

Disillusion with irrigation seems to be increasing. Some of the major environmental critiques of large dams, which facilitate modern irrigation, have been extensively discussed and summarised elsewhere (van de Laar, 1993). While environmental concerns may in future block some new irrigation projects, it should be realized that irrigation development often derives from earlier strategic decisions regarding large dams, within a framework which is primarily concerned with energy policies. Where developing alternative energy sources, such as oil and gas-based systems and nuclear power, face a variety of other environmental, resource and strategic problems, the pressure to expand hydro power will intensify in future[31].

But it is apparently the disappointing economic performance of irrigation investment projects, as evaluated in the donor-instigated literature, which has contributed more to the sharp decline in new irrigation investment observable since the late 1970s.

The present paper has first looked at the rather primitive manner in which irrigation investment projects have been, and apparently are still are being evaluated. Yet, on the basis of such shaky studies apparently major decisions in irrigation investments seem to be made.

Irrigation construction institutions in key Asian countries are naturally quite powerful: they are seen as hard-core nation-building departments. They command vast prestige and attract large amount of resources. Yet, as demonstrated in section 2 of this paper, they have shown little interest in how they are performing in their main function of water delivery. Design and construction are of major concern, while Operations & Management received little attention, at least up to the 1970s.

By focusing on alternative investment strategies in irrigation it has been possible to identify a bewildering array of problems, issues and dilemmas. While the issues themselves were identified, unfortunately no attention could be given to the manner in which key strategic choices have ben made in reality. Of interest, and deserving more, but difficult research, would be to study the extent to which such key choices have been made at the political level, or, in practice, at the level of powerful irrigated and related dam construction technical departments. Usually, abundant information can be ifentified on what has been implemented, but not on the development options foregone in the process of identifying and elaborating irrigation projects.

It is obvious that in addition to new construction, other concerns will, and to some extent are already receiving major policy interest: such as Operations & Maintenance, irrigation financing, and cost recovery issues and increasing water use efficiencies. Yet, a major shift in resources from the irrigated to the rainfed sectors of agriculture is not imminent, for as

[31] See Van de Laar (1990a) *The Global Energy Crisis and international Development*, ISS Working Paper Series No 84, July, for a review of major past trends and an assessment of future scenarios.

has been briefly argued, it is not all that obvious where major investment opportunities would exist especially in areas of low average and often highly seasonal rainfall.

Thus, while social science irrigation studies tend to be concerned with issues within the irrigated area, there are strong arguments to take a wider perspective on the interactions between the irrigated 'enclave' and the wider implications for regional development, socially, politically and environmentally.

LITERATURE

Adams, W.M. (1992), Wasting the Rain. Rivers, *people and planning in Africa.* London. (Earthscan Publications).

-------- and A.T. Grove, eds. (1983), *Irrigation in Tropical Africa,* Cambridge, African Studies Center.

AsDB (1989), *Rainfed Agriculture in Asia and the Pacific,* Asian Development Bank, Manila, Philippines, April.

Aklilu, Petros, and Altaf Hussain (1992), *Pakistan: Public and Private Irrigation Development,* in Le Moigne, et.al. 1992, pp 23-34.

Ali, S.H. (1980), *Practical experience of irrigation reform: Andhra Pradesh, India,* Discussion Paper 153, Institute of Development Studies, Brighton, UK.

------- (1984), *Planning and Implementation of Measures to Ensure Productivity and Equity under Irrigation Systems,* in Pant (ed) (1984), pp 211-240.

Aviron Violet, J., Ido, B.D., van Steekelenburg, P.N.G. and Waldstein, A. (1991), *The development of irrigated farming in the Sahel: irrigation policy limitations and farmer strategies*, Wageningen, ILRI.

Bagadion, Benjamin U. and Frances F. Korten (1991), *Developing Irrigators' Organizations: a learning process approach*, in Cernea (1991), pp 73-112.

Barghouti, S. and G. Le Moigne (1990), *Irrigation in sub-Saharan Africa: The development of public and private systems*, World Bank Technical Paper 123.

Barnett, T (1977), *The Gezira Scheme: an illusion of development*, Frank Cass, London.

Barker, Randolph, E. Walter Coward Jr., Gilbert Levine, Leslie E. Small (1984), *Irrigation development in Asia: past trends and future directions*. Cornell Studies in Irrigation, Nr 1, (March).

Berkoff, D.W.J. (1990), *Irrigation management on the Indo-Gangetic Plain*, Washington D.C., World Bank Technical Paper nr 129.

Bhuiyan, S.I.(1989), *Irrigation and water management for diversified cropping in rice irrigation systems: major issues and concerns4,* ODI/IIMI Irrigation Management Network Paper 89/1e, June.

Blaikie, Piers (1985), *The Political Economy of Soil Erosion and Land Degradation*. London (Longman).

------ and Harold Brookfield eds (1987), *Land Degradation and Society*, London. (Methuen).

Bloch, P.C. (1986), *Land tenure issues in river basin development in sub-Saharan Africa,* Research Report no 90, and appendices, Madison, Land Tenure Center, University of Wisconsin.

Boda, P. and C. Castellanet, eds., (1991), *Le réhabilitation des périmétres irrigués*, Paris: Groupe de Recherge et d'Echanges Technologiques (GRET).

Bolin, Inge (1990), *Upsetting the Power Balance: Cooperation, Competition, and Conflict along an Andean Irrigation System, in Human Organization, Vol 49 (2), pp 140-148.*

Booth, Anne (1977), Irrigation in Indonesia, Part I, Bulletin of Indonesian Economic Studies, Vol XIII No 1, March, pp 33-74.

------- (1977), *Irrigation in Indonesia,* Part II, Bulletin of Indonesian Economic Studies, Vol XIII No 2, July, pp 45-77.

BOSTID (1986), *Proceedings of the Conference on Common Property Resource Management*, Board on Science and Technology for International Development, Office of International Affairs, National Research Council, Washington, D.C., National Academy Press.

Bottrall, A. (1981), *Comparative Study of the Management and Organization of Irrigation Projects*, Washington D.C., World Bank Staff Working Paper No 458.

Bromley, Daniel W, Donald C. Taylor, Donald E. Parker (1980), Water Reform and Economic Development: Institutional aspects of water management in the developing countries, in Economic Development and Cultural Change, Vol, 28, Nr 2, pp 365-387.

------- and M.M. Cernea (1989), *The Management of Common Property Natural Resources. Some Conceptual and Operational Fallacies*, World Bank Discussion Paper 57, Washington.

Brown, Lester R. et.al (1993), *State of the World 1993.* 10th Anniversary Edition. Worldwatch Institute, Washington. Earthscan Publications, London.

Cantor, L.M. (1970), *A World Geography of Irrigation,* New York, (Praeger).

Carruthers, Ian D. (ed) (1983), *Aid for the development of irrigation*, Paris, OECD.

------- (1992), *Irrigation project management,* in Feyen (1992), pp 709-716.

Cernea, Michael M. (ed) (1991), *Putting People First. Sociological variables in rural development.* Oxford UP for World Bank.

Chambers, Robert (1977), *Man and water: the organisation and operation of irrigation*, in Farmer (1977), pp 340-363.

------ (1988), *Managing Canal Irrigation. Practical Analysis from South Asia.* Wye Studies in Agricultural and Rural Development, Cambridge University Press, Cambridge UK, and New Delhi.

------ and Jon Moris eds. (1973), *Mwea: an irrigated rice settlement in Kenya,* Afrika Studien No 38, Munchen: (Weltforum Verlag).

Colander, D.C. ed. (1984), *Neoclassical Political Economy: the analysis of rent-seeking and DUP activities*. Cambridge Mass, (Ballinger).

Coward Jr., E. Walter, ed. (1980), *Irrigation and Agricultural Development in Asia. Perspectives from the social sciences,* Ithaca and London (Cornell University Press).

------ (1980), *Management themes in Community irrigation systems*, in Coward (1980), pp 203-218.

------ (1990), *Property Rights and Network Order: The Case of Irrigation Works in the Western Himalayas*, in Human Organization Vol 49 (1), pp 78-88.

------ (1991), *Planning Technical and Social Change in Irrigated Areas*, in Cernea (1991), pp 46-72.

------ and Gilbert Levine (1986), *Studies of farmer-managed irrigation systems: ten years of cumulative knowledge and changing research priorities,* Keynote paper. Workshop: Public intervention in farmer-managed irrigation systems, International Irrigation Management Institute, Kathmandu, Nepal, pp 1-31.

Cunningham, John F. (1992), *Public and Private Groundwater Development in India: the Case of Uttar Pradesh,* in Le Moigne, et.al. (1992), pp 35-44.

Davis, Ted J. ed. (1986), *Development of Rainfed Agriculture under Arid and Semiarid Conditions.* Proceedings of the Sixth Agriculture Sector Symposium, World Bank, Washington, D.C.

Dhawan, B.D. (1988), *Irrigation in India,* (Sage) London.

------- and K.J.S. Satya Sai (1991), *Economic Linkages Among Irrigation Sources: A Study of the Beneficial Role of Canal Seepage*, in Meinzen-Dick and Svendsen (1991), pp 124-133.

Diemer, G. and F.P. Huibers (1991), *Farmer-Managed Irrigation in the Senegal River Valley: Implications for the Current Design Method.* End-of-project Report WARDA Water Management Project, Wageningen Agricultural University, Department of Irrigation and Soil and Water Conservation.

------ and Jaques Slabbers (eds), (1991), *Irrigatietechniek en cultuur: opvattingen van boeren en ingenieurs over de verdeling van water.* Amsterdam (Thesis Publishers).

------, and ------ (eds), (1992). *Irrigators and Engineers.* Essays in honour of Lucas Horst. Amsterdam, (Thesis Publishers).

------ and Linden Vincent (1992), *Irrigation in Africa: The Failure of Collective Memory and Collective Understanding*, in Development Policy Review, Vol 10. Nr 2, June, pp 131-154.

Duane, Paul (1975), *A Policy Framework for Irrigation Water Charges,* Washington D.C., World Bank Staff Working Paper no 218.

Easter, K. William (ed) (1986), *Irrigation Investment, technology, and management strategies for development.* Studies In Water Policy and Management No 9. Boulder (Westview Press).

------- (1986), *Irrigation policies for future growth in agriculture,* in Easter (1986), pp 245-255.

------- and Delane E. Welsch (1986), *Priorities for irrigation planning and investment,* in Easter (1986), pp 13-32.

FAO (1973), *Water Laws in Moslem countries.* Vol 1, Irrigation and Drainage paper, No 20/1, **and** Vol 2 Irrigation and Drainage Paper no 20/2, (1978).

------- (1975), *Small Hydraulic Structures,* [D.B. Kraatz and I.K. Mahaja], Irrigation and Drainage Paper no 26, Vol 1 and 2. Rome.

------- (1979), *Water Law in Selected African Countries,* Legislative Study, no 17.1. Rome.

------- (1982, Repr. 1986), *Organisation, operation and maintenance of irrigation schemes,* [Sagardoy, Bottrall and Uittenbogaard], Irrigation and Drainage paper 40, Rome.

Farmer, B.H. (ed) (1977), *Green Revolution? Technology and Change in Rice-growing Areas of Tamil Nadu and Sri Lanka.* London and Boulder.

Feyen, Jan, Emmanuel Mwendera and Moussa Badji, eds (1992), *Advances in Planning, Design and Management of Irrigation Systems as Related to Sustainable Land Use.* CIE/ECOWARM, Leuven, September.

Field, W.P. (1990), *World Irrigation, in Irrigation and Drainage Systems,* vol 4. Kluwer Academic Publishers, Dordrecht, pp 91-107.

Frederiksen, Harald D. (1992a), *Drought planning and water efficiency implications in water resources management,* World Bank Technical Paper Nr 185, September.

------ (1992b), *Water resources institutions. Some principles and practices.* World Bank Technical Paper Nr 191, December.

Grove, A.T. ed. (1985), *The Niger and its neighbours: environmental history and hydro-biology, human use and health hazards of the major West African rivers,* Balkema, Rotterdam.

Harrison, Paul (1987), *The Greening of Africa; Breaking through in the battle for land and food,* Earthscan / IIED, London.

Hart, Henry (1978), *Anarchy, paternalism, or collective responsibility under the canals,* Economic and Political Weekly, Vol 13, nos 51 and 52, pp A.125-134.

Horst, L. (1983), *Irrigation systems - alternative design concepts,* Irrigation Management Network paper 7c, Overseas Development Institute, London. (April).

------ (1987), *Choice of irrigation structures, the paradox of operational flexibility, Asian Regional Symposium on Irrigation design for management*, Sri Lanka.

------ (1990), *Interactions between technical infrastructure and management,* ODI/IIMI Irrigation Management Network paper, 90/3b, December.

Hotes, Frederick L. (1983), *The experience of the World Bank,* in Carruthers (1983), pp 126-140.

------- (1984), *World Bank Irrigation Experience,* Irrigation Management Network Paper 9d, April, ODI, London.

Howe, Charles W. (1971), *Benefit-cost analysis for water system planning.* Water Resources Monograph 2, American Geophysical Union, Washington, D.C.

Hunt, Robert C.(1989), *Appropriate Social Organisation? Water User Associations in Bureaucratic Canal Irrigation Systems*, in Human Organization, Vol 48 (1), pp 79-90.

------- and Eva Hunt (1976), *Canal Irrigation and Local Social Organization,* Current Anthropology, Vol 17, 3, September, pp 389-411.

IRRI (1978), *Irrigation Policy and Management in Southeast Asia,* Los Banos, Philippines.

Jagannathan, N.V. (1986), *Corruption, Delivery Systems and Property Rights,* World Development, Vol 14, 1, pp 127-132.

Jaspers, Frank and Rien Jurriëns(1993), *The Rehabilitation and Upgrading Program in Aceh, Indonesia.* Lessons for Design and Management of Tertiary Units, ILRI, Wageningen, (mimeo), January.

Johnson III, Sam H. (1988), *Large Scale Irrigation and Drainage Schemes in Pakistan, in* O'Mara (1988), pp 58-79.

Jurriëns, M. and V. Ramaiah (1988), *Water Distribution in a Secondary Irrigation Canal: Results of a Measurement Program*, ILRI Reprint no 55, Wageningen

------- , and Kornelis de Jong (1989), *Irrigation Water Management.* A Literature Survey, Working Party 'Irrigation and Development', ILRI, Wageningen, November.

------- ed. (1993), *Irrigation Water Management Research in the Tungabhadra Scheme,* Karnataka, India. A Collection of papers on the 'Tungabhadra Irrigation Pilot Project' 1986-1992. ILRI, Wageningen, (mimeo), January.

Kalkat, G.S. (1986), *Role of Rainfed Agriculture in the Indian Economy,* in Davis (1986), pp 16-37.

Korten, Frances F. and Robert Y. Siy, Jr. eds. (1988), *Transforming a bureaucracy. The experience of the Philippine National Irrigation Administration.* Hartford. Conn. (Kumarian Press).

Laar, A.J.M. van de (1982), *Rehabilitation of Old Irrigation Schemes. Notes on the Gezira Scheme, Sudan*, Institute of Social Studies, Rural development Seminar, March.

-------- (1990), *A Framework for the Analysis of Common Pool Natural Resources*, Institute of Social Studies, Working Paper Series No 77, April.

------- (1990a), *The Global Energy Crisis and International Development*, ISS Working Paper Series No 84 July.

-------- (1993), *Water Development for Power and Irrigation, the Environment and Sustainable Development*, Institute of Social Studies, Working Paper Series, No 141, February.

Leeuw, Wiegert de (1985), *Het Bura Irrigatie- en Vestigingsproject: Zelfs geen Illusie van Ontwikkeling. Een analyse van de voorbereiding, besluitvorming, uitvoering en konsekwenties van een grootschalig irrigatieprojekt in Kenya*, Subfakulteit Culturele Anthropologie/Niet Westerse Sociologie. Free University, Amsterdam, Hengelo (not-published).

Lenton, Roberto (1986), *On the Development and Use of Improved Methodologies for Irrigation Management*, in Nobe and Sampath (1986), pp 47-66.

------ (1988), *Strategy Development in IIMI,* ODI/IIMI Irrigation Management Network Paper 88/1e, London, June.

Levine, Gilbert (1977), *Management components in irrigation system design and operation,* in Agricultural Administration, 4 No 1 (January), pp 37-48.

------ (1980), *The relationship of design, operation and management,* in Coward (1980), pp 51-69.

Lowdermilk, M.K., D.M. Freeman, A.C. Early, G. Radosevich, and D. Kemper (1977), *Organising farmers to improve irrigation water delivery: the problems and prospects for solutions in Pakistan.* Pakistan Economic and Social Review 15 (3/4).

Madduma Bandara, C.M. (1977), *Hydrological consequences of agrarian change*, in Farmer (1977), 323-339.

Malhotra, S.P. (1982), *The Warabandi system and its infrastructure,* Central Board of Irrigation and Power, Publication no 157. New Delhi.

------- , S.K. Raheja and David Seckler (1984), *A Methodology for Monitoring the Performance of Large-scale Irrigation Systems: a case study of the Warabandi system in Northwest India*, Agricultural Administration, Vol 17, pp 231-259.

Meinzen-Dick, Ruth and Mark Svendsen, eds (1991), *Future Directions for Indian Irrigation: Research and Policy Issues.* International Food Policy Research Institute (IFPRI), Washington, D.C., January.

Mellor, John W., Christopher L. Delgado and Malcolm J. Blackie (1987), *Accelerating Food Production in Sub-Saharan Africa.* Baltimore and London. The Johns Hopkins University Press, for IFPRI.

Mermel, T.W. (1991), *The World's Major Dams & Hydro Plants,* Water Power & Dam Construction, June.

Meijer, Theo K.E. (1989), *The size of the tertiary unit and its importance in the design of canal irrigation systems,* in Rydzewski and Ward (1989), pp 547-555.

------ (1992), *Three Pitfalls in Irrigation Design,* in Diemer and Slabbers (1992), pp 87-96.

------ (1993), *Design of smallholders' irrigation systems,* Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University.

Meyers, L. Richard, ed. (1989), *Innovation in Resource Management,* Proceedings of the Ninth Agricultural Sector Symposium, World Bank.

Mitchell, William P. (1973), *The Hydraulic Hypothesis: a Reappraisal, Current Anthropology,* Vol 14, 5 December, pp 532-534.

Guy Le Moigne, Shawki Barghouti and Lisa Garbus (1992), *Developing and Improving Irrigation and Drainage Systems,* Selected Papers from World Bank Seminars, World Bank Technical Paper Nr 178, July

Moris, J. and Derrick J. Thom (1990), *Irrigation Development in Africa. Lessons of Experience.* Boulder (Westview Press), Studies in Water Policy and Management, No 14.

Mortimore, M., E.A. Olofin, R.A. Cline-Cole and A. Abdulkadir (eds) (1987), *Perspectives on Land Administration and Development in Northern Nigeria,* Dept. of Geography, Bayero University, Kano.

Olofin, Emmanuel A. ed. (1991), *Prospects and Problems of Irrigation in Kano State,* Department of Geography, Bayero University, Kano.

Gerald O'Mara, *Issues in the efficient use of surface and groundwater in irrigation,* World Bank Staff Working Paper no 707, December. 1984.

O'Mara, Gerald T. ed. (1988), *Efficiency in Irrigation. The Conjunctive Use of Surface and Groundwater Resources,* A World Bank Symposium, 1988.

------- (1988), *The Efficient Use of Surface Water and Groundwater in Irrigation: An Overview of the Issues,* in O'Mara (1988), pp 1-17.

------- (1989), *Issues and options in irrigation finance*, in L. Richard Meyers (ed), Innovation in Resource Management, Proceedings of the Ninth Agricultural Sector Symposium, World Bank, pp 53-69.

Nobe, K.C. and R.K. Sampath (eds) (1986), *Irrigation management in developing countries: current issues and approaches.* Studies in Water Policy and Management no 8. Westview, Colorado and London.

Oomen, J.M.V., J. de Wolf, W.R. Jobin (1988, 1990), *Health and Irrigation,* 2 Vols. ILRI Publication 45, Wageningen.

Palanisami, K. (1990), *Tank Irrigation in South India: What Next?* ODI/IIMI Irrigation Management Network paper 90/2e, July.

-------, and K. William Easter (1984), *Tank Irrigation in India and Thailand: Problems and Prospects,* Irrigation Management Network Paper 10e, November, ODI, London.

Pant, N. ed. (1984), *Productivity and Equity in Irrigation Systems,* New Delhi, Asian Publishing House.

Petts, Geoffrey E. (1984, Repr. 1992), *Impounded Rivers. Perspectives for ecological management,* (Wiley), Chichester.

Radosevich, George (1988), *Legal Considerations for Coping with Externalities in Irrigated Agriculture,* in O'Mara (1988), pp 34-48.

Ramamurthy, Priti (1989), *State power and irrigation efficiency: theoretical expectations and bureaucratic practices in South India,* in Rydzewski and Ward (1989).

Randall, Alan (1988), *Market Failure and the Efficiency of Irrigated Agriculture,* in O'Mara (1988), pp 21-33.

Reidinger, Richard B. (1980), *Water management by administrative procedures in an Indian irrigation system,* in Coward (1980), pp 263-288.

Repetto, R. (1986), *Skimming the water: rent-seeking and the performance of public irrigation systems,* Washington D.C., World Resources Institute Research Report, no 4, December.

Reyes, Romana P. de los, and Sylvia Ma. G. Jopillo, *The Impact of Participation: an evaluation of the NIA's Communal Irrigation Programme,* in Korten and Siy (1988), pp 90-116.

Rickard, C.E. (1989), *Regime Canal Design - Theory and Reality,* in Rydzewski and Ward (1989), pp 395-404.

Rosegrant, Mark W. and Mark Svendsen (1993), *Asian food production in the 1990s. Irrigation investment and management policy,* in Food Policy, February, pp 13-32.

Rydzewski, J. R. ed. (1987), *Irrigation Development Planning: an Introduction for engineers,* Wiley, Chichester and Southampton.

------- (1992), *Irrigation development planning for sustainability,* in Feyen (1992), pp 17-33.

------- and C.F.Ward (eds) (1989), *Irrigation Theory and Practice,* Pentech.

Sampath, R.K. (1992), *Issues in Irrigation Pricing in Developing Countries,* in World Development, Vol 20 (7), pp 967-977.

------- and R.A. Young (eds.) (1990), *Social, economic and institutional issues in third world irrigation management.* Boulder, Colorado, Westview, Studies in Water Policy and Management no 15.

Satyanarayana, M. and Dru Srivastava (1989), *Performance evaluation of a protective irrigation project - the case of Tungabhadra project in India,* in Rydzewski and Ward (1989), pp 153-161.

Schrevel, A. (1993), *Access to Water. A Socio-economic Study into the practice of irrigation development in Indonesia.* Ph.D. Dissertation, Utrecht University, ISS, The Hague.

Scudder, Thayer (1989), *The African Experience with river basin development,* Natural Resources Forum, May, pp 139-148.

Sen, A.K. (1981), *Poverty and Famines: an Essay on Entitlement and Deprivation,* Oxford, (Clarendon).

Sengupta, Nirmal (1991), *Managing Common Property. Irrigation in India and the Philippines,* Indo-Dutch Studies on Development Alternatives no 6. New Delhi (Sage).

Shah, Haq Nawaz (1984), *An Evaluation of Small Dams Programme in Punjab, Lahore,* Punjab Economic Research Institute, Publication No 213, November.

Singh, Satyajit K. (1990), *Evaluating Large Dams in India,* Economic and Political Weekly, March 17, pp 561-574.

Sivamohan, M.V. and Christopher A. Scott (1992), *The Command Area Development Programme in India: a policy perspective,* ODI Irrigation Management Network paper 20, October.

Small, Leslie E. (1992), *Evaluating irrigation system performance with measures of irrigation efficiencies,* Irrigation Management Network Paper 22, October. ODI. London.

------ and M. Svendsen (1992), *A framework for assessing irrigation performance.* Working Papers on Irrigation Performance 1, Washington D.C., IFPRI.

Steekelenburg, P.N.G. van, and G. Zijlstra (1985), *Evaluation of Irrigation Projects sponsored by the European Economic Community.* Synthesis Report, ILRI, Wageningen (December).

Steinberg, David I., et.al. (1983), *Irrigation and AID's Experience: A Consideration based on Evaluations,* A.I.D. Program Evaluation Report No 8, U.S. Agency for International Development, August.

Steward, Julian H.(1978), *Initiation of a Research Trend: Wittfogel's Irrigation Hypothesis,* in G. L. Ulmen (ed) Society and History. Essays in Honor of Karl August Wittfogel, Mouton Publishers, The Hague etc, pp 3-14.

Stone, Ian (1984), *Canal Irrigation in British India. Perspectives on technological change in a peasant economy,* Cambridge UP.

Svendsen, Mark (1992), *Assessing effects of policy change on Philippine irrigation performance,* International Food Policy Research Institute, Working Papers on Irrigation Performance 2, Washington D.C., December.

Tiffen, Mary (1987), *Dethroning the Internal Rate of Return: the Evidence from Irrigation Projects,* in Development Policy Review, Vol 5, pp 361-377.

------ (1990), *Variability in Water Supply, Incomes & Fees: illustrations of vicious circles from Sudan & Zimbabwe,* ODI/IIMI Irrigation Management Network paper 90 1b, April.

Vaidyanathan, A (1984), *Water control institutions and agriculture: A comparative perspective,* The Indian Economic Review, Vol 20, No 1 (January-June), pp 25-83.

Vennetier, P. ed. (1991), *Eau et aménagement dans les régions inter-tropicales,* Vols 1 and 2 (Espaces tropicaux, Vols 2 and 3. Paris: Centre d'études de Géographie Tropicale (CEGET), Centre National de la Recherche Scientifique.

Voh, Jacob P. and T.K. Atala (1987), *Problems of resettlement in dam construction projects: the Tiga Dam experience,* in Mortimore et.al. (1987), pp 153-160.

Wade, R. (1981), *The information problem of South Indian irrigation canals,* in Water Supply & Management, Vol 5, pp 31-51.

------ (1982), *The system of administrative and political corruption: canal irrigation in South India,* in Journal of Development Studies, Vol 18, No 3, pp 287-328.

------ (1984), *Managing a Drought with Canal Irrigation: A South Indian Case,* Agricultural Administration 17, pp 177-202.

------ (1985a), *On the Sociology of Irrigation. How do we know the truth of canal performance?,* in: Agricultural Administration, Vol 19, pp 63-79.

------ (1985b), *The Market for Public Office; why the Indian State is not better at development,* in World Development 13.4, pp 467-497.

------ (1988), *The Management of Irrigation Systems: How to Evoke Trust and Avoid prisoners' Dilemma,* in World Development 16.4, pp 489-500.

------ (1990). *On the 'Technical' Causes of Irrigation Hoarding Behaviour, or Why Irrigators Keep Interfering in the Main System,* in Sampath and Young (1990), pp 175-193.

------ and David Seckler (1990), *Priority Issues in the Management of Irrigation Systems,* in Sampath and Young (1990), pp 13-29.

Wallich, B. (1988), *Irrigation in Sudan since Independence,* Geographical Review, Vol 78, No 4, American Geographical Society, New York, pp 417-437.

Wickham, T.H., and A. Valera (1978), *Practices and accountability for better water management,* in IRRI (1978), pp 61-75.

Widstrand, Carl ed. (1978), *Water and Society. Conflicts in development.* Part 1, The social and ecological effects of water development in developing countries, Oxford, New York (Pergamon Press).

-------- ed. (1980), *Water and Society. Conflicts in Development.* Part 2. Chapter 3, Manageability and Unmanageability of Water, and Chapter 5, Conflicts over Water, Oxford, New York (Pergamon Press).